THE REPUBLIC OF THE PHILIPPINES
NATIONAL IRRIGATION ADMINISTRATION

BASIC DESIGN STUDY REPORT
ON
THE PROJECT FOR
REHABILITATION OF ANGAT AFTERBAY REGULATOR DAM
IN
THE REPUBLIC OF THE PHILIPPINES

JUNE, 1996

JAPAN INTERNATIONAL COOPERATION AGENCY
SANYU CONSULTANTS INC.

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PREFACE

In response to a request from the Government of the Republic of the Philippines, the Government of Japan decided to conduct a basic design study on the Project for Rehabilitation of Angat Afterbay Regulator Dam and entrusted the study to the Japan International Cooperation Agency (JICA).

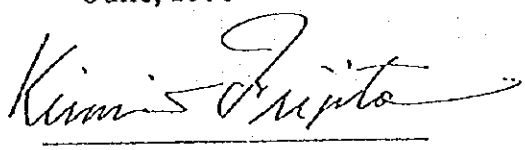
JICA sent to the Philippines a study team from March 7 to April 5, 1996.

The team held discussion with the officials concerned of the Government of the Philippines, and conducted a field study at the study area. After the team returned to Japan, further studies were made. Then, a mission was sent to the Philippines in order to discuss a draft report, and a this result, the present report was finalized.

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 the Philippines for their close cooperation extended to the teams.

June, 1996



KIMIO FUJITA
President
Japan International Cooperation Agency

June, 1996

Letter of Transmittal

We are pleased to submit to you the basic design study report on the Project for Rehabilitation of Angat Afterbay Regulator Dam.

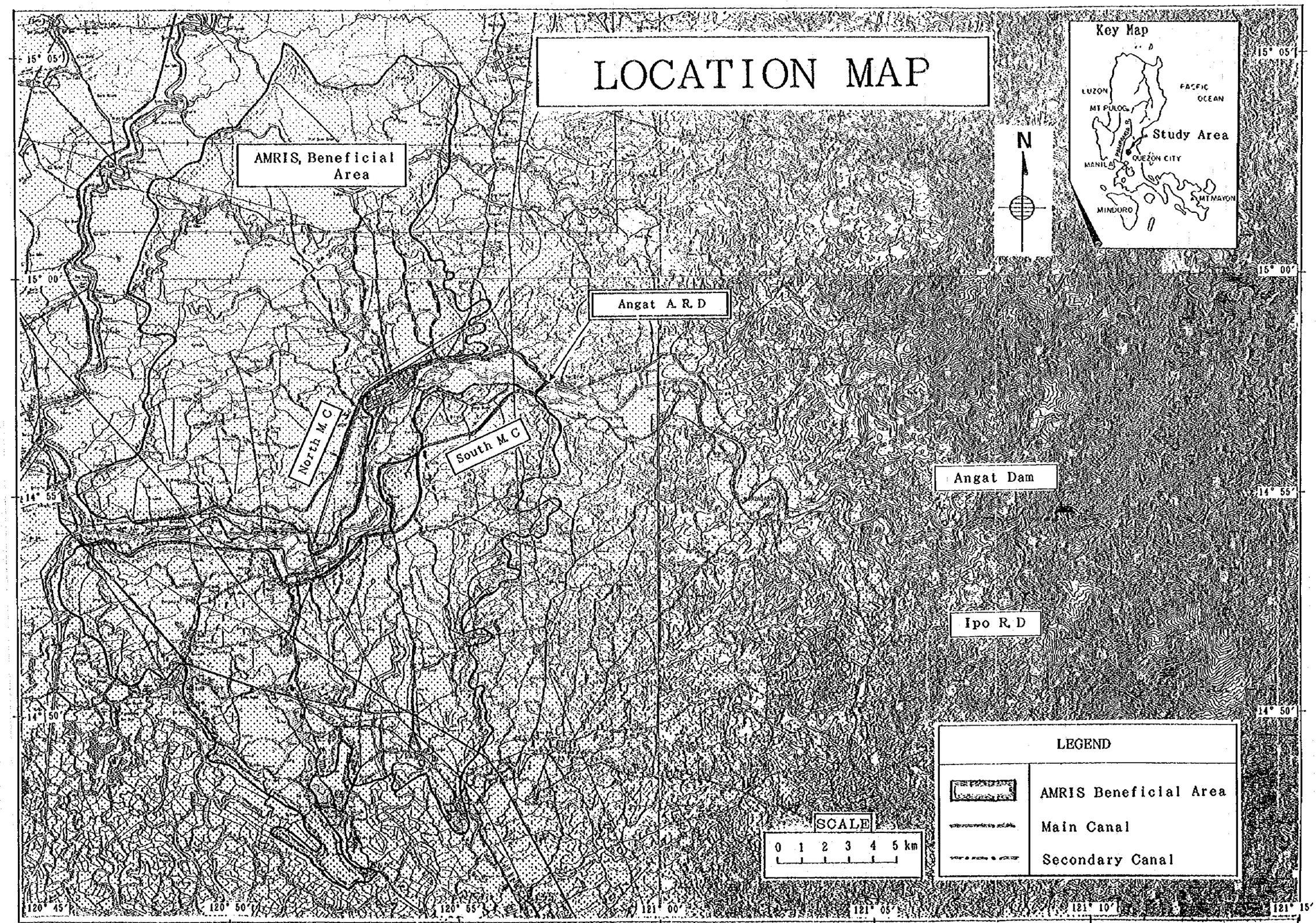
This study was conducted by Sanyu Consultants Inc., under a contract to JICA, during the period from March 1, 1996 to July 22, 1996. In conducting the study, we have examined the feasibility and rationale of the project with due consideration to the present situation of the Philippines and formulated the most appropriate basic design for the Project under Japan's grant aid scheme.

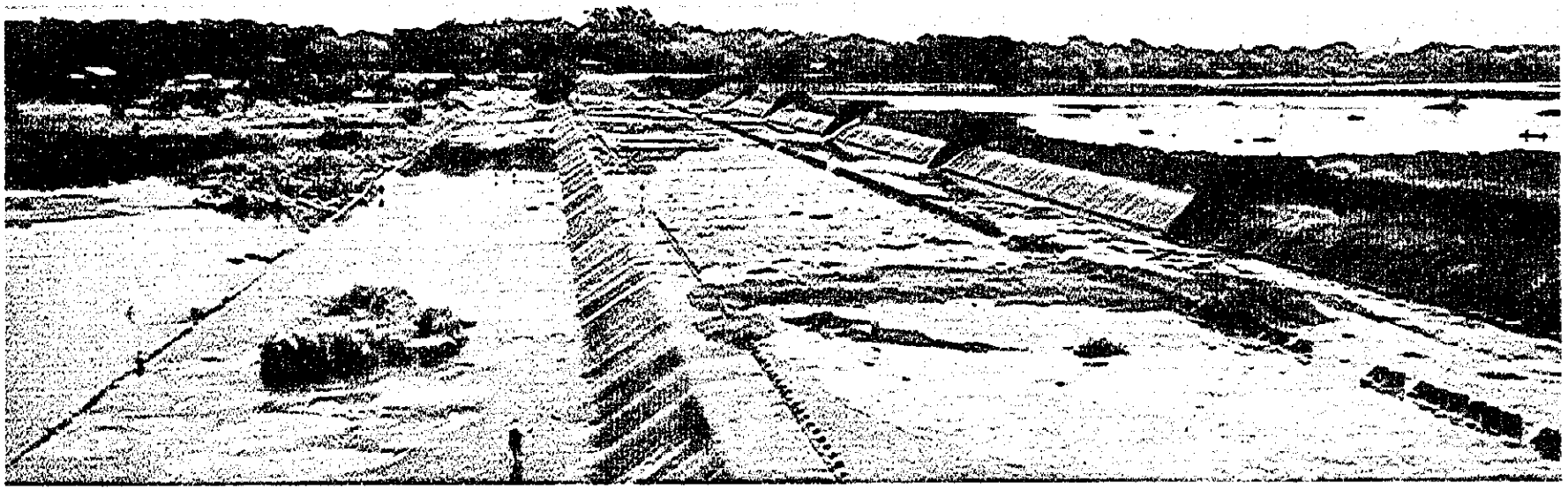
Finally, we hope that this report will contribute to further promotion of the Project.

Very truly yours,

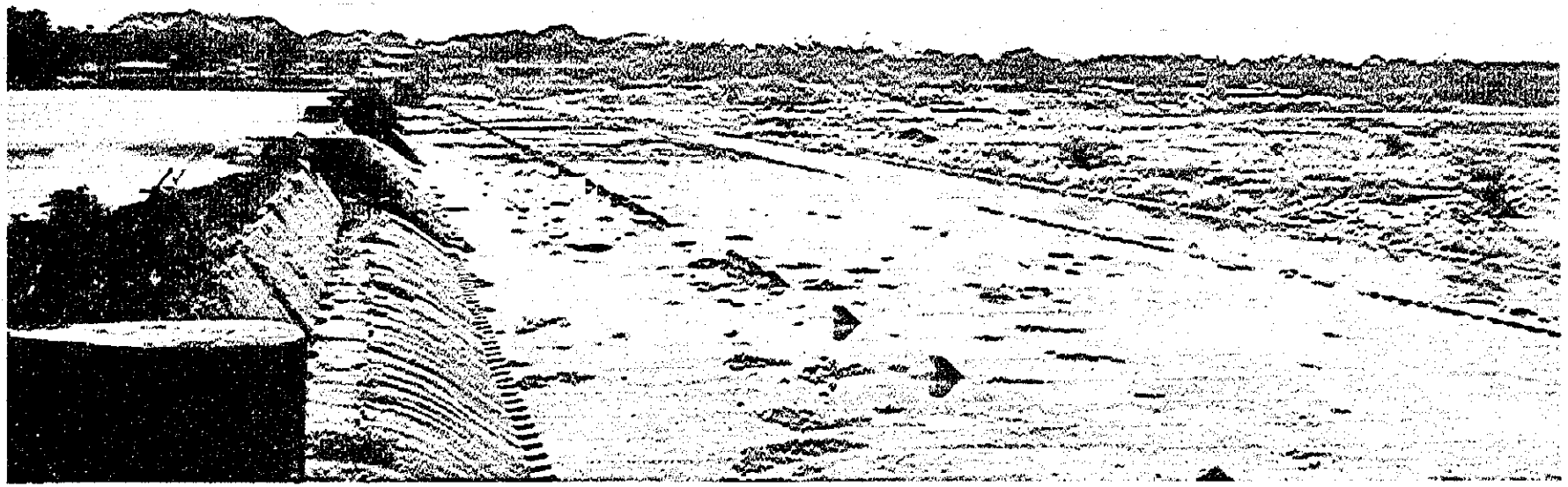
IKUZO IWAMOTO
Project manager
Basic design study team on Rehabilitation
of Angat Afterbay Regulator Dam
Sanyu Consultants Inc.

LOCATION MAP



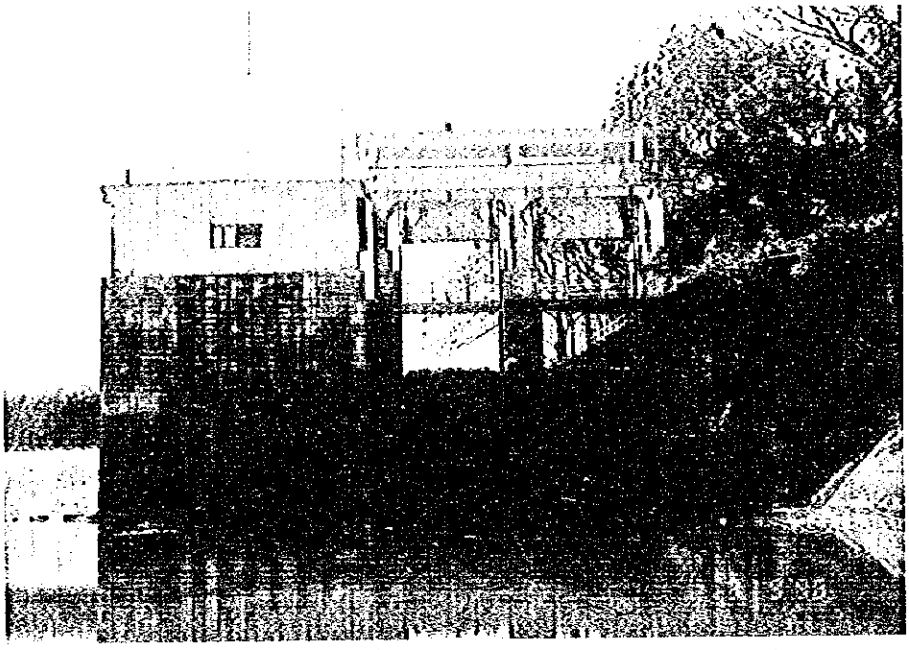


Existing sector gates,sub-dam and apron (Look at right bank from left bank)

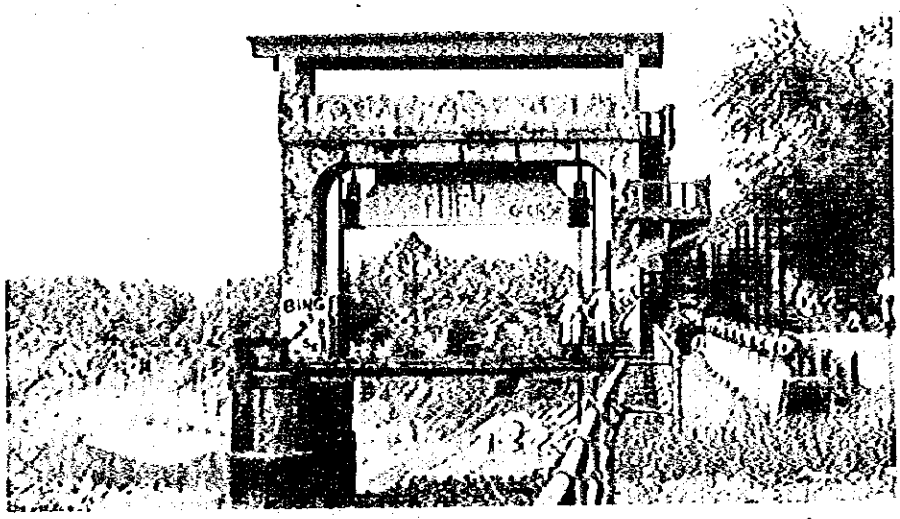


Existing sector gates ,sub-dam and apron (Look at left bank from right bank)

PHOTOGRAPHS FOR THE PROJECT SITE (2/4)

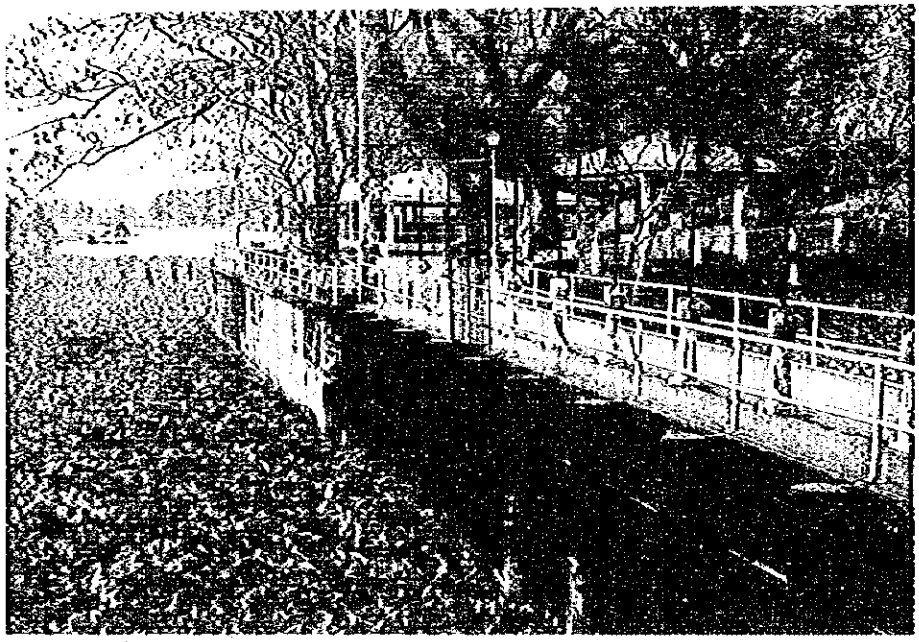


Washout gates and control house at left bank (Look at upstream from downstream)

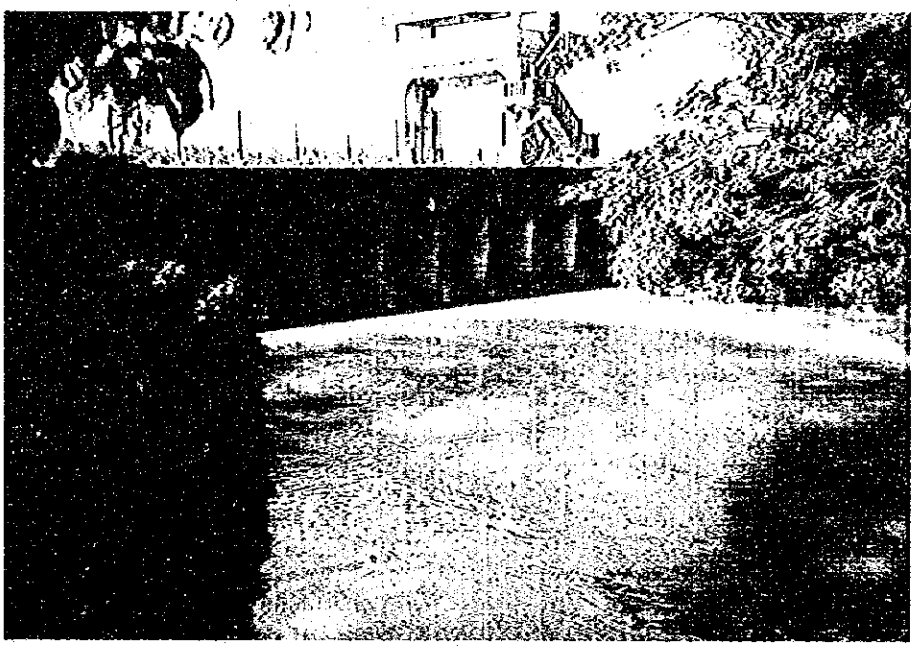


Washout gate and intake at right bank (Look at downstream from upstream)

PHOTOGRAPHS FOR THE PROJECT SITE (3/4)



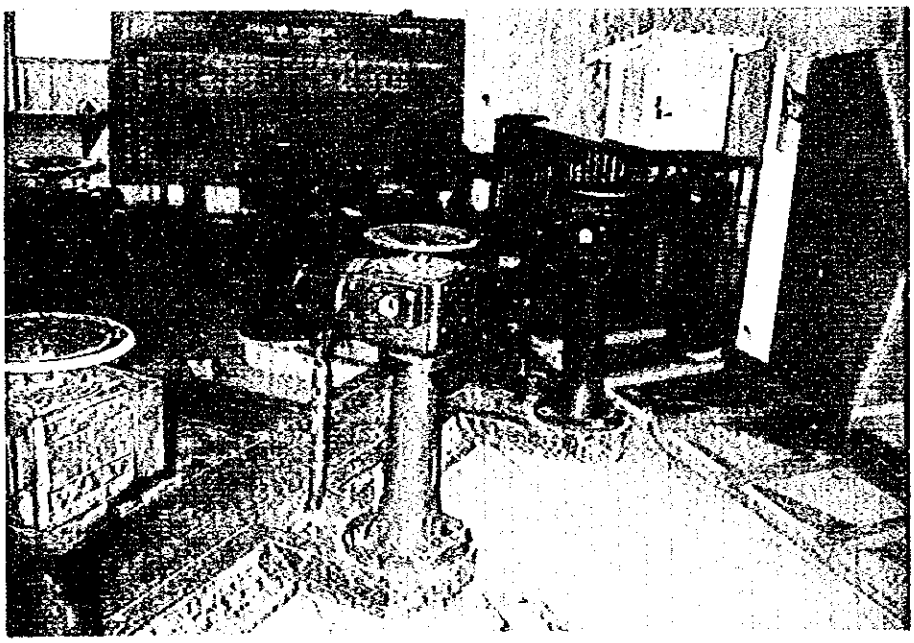
Left bank intake for South main canal from reservoir side



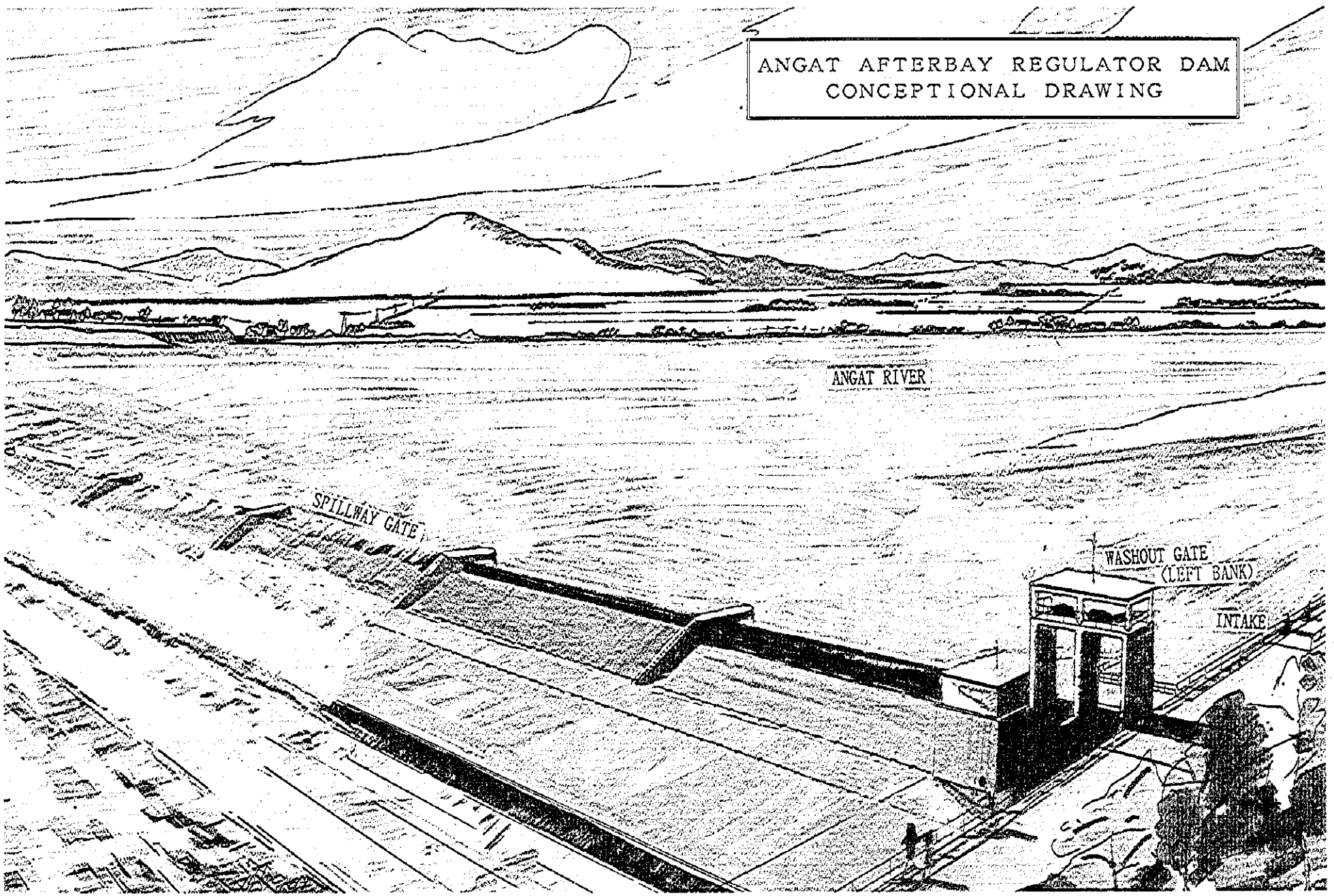
Right bank intake for North main canal from reservoir side.

PHOTOGRAPHS FOR THE PROJECT SITE (4/4)

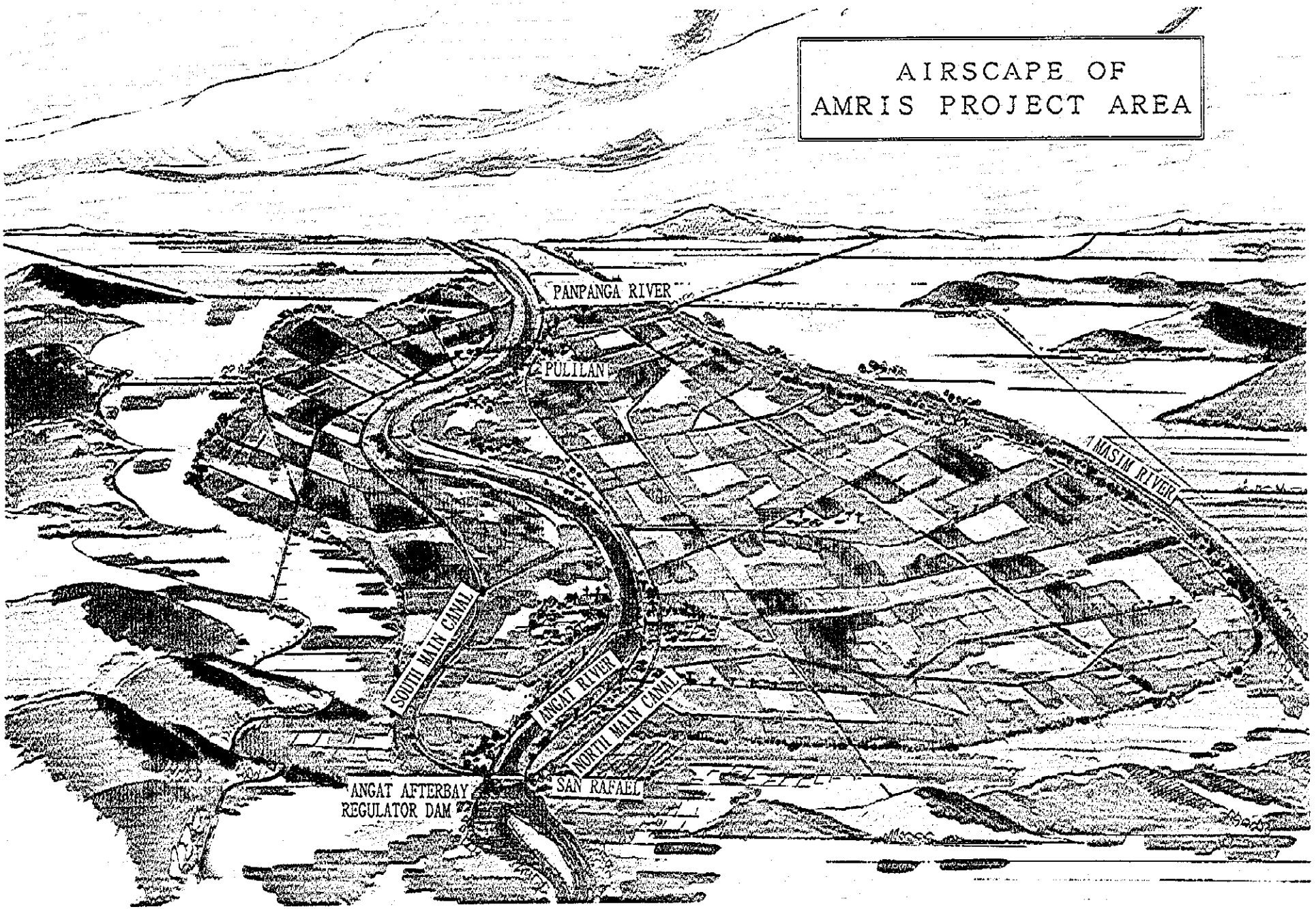
Erosion and scouring condition at the end of existing wall at downstream of right bank



The equipment for gate operation in existing control house


ANGAT AFTERBAY REGULATOR DAM
CONCEPTIONAL DRAWING
ANGAT RIVER
SPILLWAY GATE
WASHOUT GATE
(LEFT BANK)
INTAKE

AIRSCAPE OF AMRIS PROJECT AREA



ABBREVIATION

ADB	Asian Development Bank
AMRIS	Angat Massim River Irrigation system
CARP-IC	Comprehensive Agrarian Reform Program - Irrigation Component
CARP-SIP	Comprehensive Agrarian Reform Program - Small Irrigation Project
CB/CBP	Central Bank of the Philippines
DA	Department of Agriculture
IA	Irrigation Association
JICA	Japan International Cooperation Agency
MWSS	Metropolitan Waterworks and Sewerage System
NEDA	National Economic and Development Authority
NIA	National Irrigation Administration
NPC	National Power Corporation
NWRB	National Water Resources Board
OECF	Overseas Economic Cooperation Fund
PAGASA	Philippine Atmospheric, Geophysical and Astronomical Services Administration

GLOSSARY

LENGTH		
mm	:	millimeter(s)
cm	:	centimeter(s)
m	:	meter(s)
km	:	kilometer(s)
inch	:	inch(s) = 2.54 cm
mile	:	mile(s) = 1.6093 m

ACREAGE		
sq.mm	:	square millimeter(s)
sq.cm	:	square centimeter(s)
sq.m	:	square meter(s)
sq.km	:	square kilometer(s)
ha	:	hectares(s)

WEIGHT		
mm.gr	:	milligram(s)
gr	:	gram(s)
kg	:	kilogram(s)
ton	:	ton(s)
ounce	:	ounce(s) = 28.350 gr

VOLUME		
lit	:	litter(s)
cu.m	:	cubic meter(s)
gallon	:	gallon(s) = 3.785 lit
MCM	:	million cubic meter(s)
cavan	:	cavan(s) = 50 kg of palay

DISCHARGE		
lps	:	liter per send
cms	:	cubic meter per second (or cu.m/sec)
cu.fsec	:	cubic foot per second
lpd	:	liter per day

VELOCITY		
mm/sec	:	millimeter per second
cm/sec	:	centimeter per second
m/sec	:	meter per second
km/hr	:	kilometer per hour
knot	:	knot(s) = 1.86 km/hr

sec	:	second(s)
min	:	minute(s)
hr	:	hour(s)
Max. or. max.	:	maximum
Min. or. min.	:	minimum
%	:	percent
No.	:	number
°C	:	degree(s) centigrade
Hp	:	horse power(s)
w	:	watt(s)
KW	:	kilowatt(s)
MW	:	megawatt(s)
WH	:	watt(s) hour
KWH	:	kilowatt(s) hour

EL	:	elevation
MSL	:	mean sea level
FWL	:	full water level
HWL	:	high water level
LWL	:	low water level
FY	:	fiscal year
peso	:	peso = US$0.03827 (April, 1996)
US$	:	US$ = 26.13pesos (April, 1996)

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CHAPTER. 1 Background of the request

1-1 Details of the request

The Republic of the Philippines (hereinafter referred to as "the Philippines") consists of several thousand islands which is scattered in the range between latitudes 5°00' and 5°21' north and between longitudes 117°00' and 127°00' east. The entire area of the national land is 300,000 km^2 and the population as of 1992 is 64.27 million. Among many islands, Luzon island (102,000 km^2, population 25 million) where there is Metro Manila (population 1.8 million) and Mindanao island (860,000 km^2, population 14 million) stand 68% of the whole area and 60% of the entire population. These two islands play the central role of the political and economical functions of the Philippines.

The new Ramos administration has formulated a Medium Term Philippines Development Plan for the six years from 1993 to 1998.

This plan consists of two parts, namely (1) "Vision and the Philosophy of Development" and (2) "Development Plan". In Part (1), the following four items are listed as the objectives in order to improve the high increase rate of population, the trade loss, and the accumulated bond which constitute the problems of the Philippines.

- Poverty alleviation
- Generation of employment opportunity
- Promotion of equality and social justice
- attaining of sustainable economic growth

In Part (2) "Development Plan", the following five items are listed as the important subjects of the development.

- Macro economy
- Agro-industrial development
- Promotion of the capable people
- Development of infrastructure
- Management of development

As for the medium-term objectives, continuous growth and enlargement of employment as well as sound balance between income and expenditure are proposed. As for the long-term objectives, extermination of poverty and implementation of fair distribution of income are proposed.

Agriculture in the Philippines plays an important role in the economy of the country by standing 45% of the working population and 23% of the amount of production.

On the other hand, one of the big problems that the Philippines is confronting is how to secure the food supply to the population increasing at the rate of about 2% to 2.5%. In the past, with the goal of 100% self-support ratio, the Philippines has tried to improve the rate of land use, review the cropping pattern, and enlarge the irrigation facilities. However it has not been able to maintain 100% self-support ratio consecutively. Based on the above mentioned situation, the Philippines lists the fulfillment of irrigation facilities, preparation of farm roads, construction of harvest processing facilities, and preparation of market as the most important subjects by securing the self-support of rice and corn and by increasing the farmers' income as the basic policies of agricultural and area development project in accordance with the Medium Term Philippines Development Plan.

Central Luzon including the AMRIS area is one of the largest grain belts of the Philippines. It is not exaggerated to say that the rice production of this area gives significant influence to the self-support of rice in the Philippines.

The AMRIS area uses Angat and Masiim rivers as the water sources which is one of the largest irrigation systems in the Philippines and implements double cropping of paddy rice in about 31,000 ha paddy. About 80% of the water supply in this area depends on Angat river and the Angat Afterbay Regulator Dam is situated as a central facility in the AMRIS area. This irrigation project is the oldest projects of the Philippines completed in 1926. The Regulater Dam has been rehabilitated and repaired since then, but none of these rehabilitation have been sufficiently done. Above all, a multi-purpose Angat Dam was constructed in 1967 for the purpose of hydropower generation at about 50 km upstream of the Angat Afterbay Regulator Dam which is. At the same time, for the effective use of water at the Regulator Dam, a sector gate with six gates was constructed on the concrete weir of natural overflow type and the canals in the area were prepared. However, these facilities are being decrepit. Especially, the Angat Afterbay Regulator Dam received enormous damages by the typhoon that attacked this area in 1990.

Under these circumstances, the government of the Philippines requested the Japanese government to provide the grant aid for procuring the equipment necessary for the early realization of the rehabilitation and improvement of the main facilities of the Angat Afterbay Regulator Dam in 1994 as well as for the implementation of civil works necessary to install the facilities.

Based on the request, the Japanese government decided to conduct a study and the JICA conducted the basic design study on this project.

1-2 Objectives of the request

The government of the Philippines has been proceeding to reduce the number of poor people and secure the safety of foods in the farming areas through the expansion of irrigated farmland, improvement of seeds and agricultural techniques, and preparation of infrastructure in agricultural villages based on the Medium Term Philippines Development Plan. The National Irrigation Administration (NIA) has planned the improvement of present situation of the irrigated farmland and the development of new irrigated farm based on the Medium Term Philippines Development Plan. This project aims to improve the Angat Afterbay Regulator Dam which is considered as one of the most important facilities in the AMRIS area (irrigated area 31,485 ha) and the area is one of the large-scale national irrigation systems in the Philippines.

1-3 Contents of the request (main component)

The main components of the request and the contents of the facilities can be classified as follows.

(1) Rehabilitation of spillway sector gate

Rehabilitation of the six steel sector gates, which are the most important facilities for securing the intake water level for the irrigation and to eliminate the flood at the Angat Afterbay Regulator Dam (L = 79.0 m, H = 2.5 m for one gate)

(2) Replacement and rehabilitation of washout gates

Replacement of the three washout gates at both banks of the Angat Afterbay Regulator Dam and partial rehabilitation of facilities

Left bank	:	Stony type gate (2 gates)	B = 4.5 m, H = 5.5 m for one gate
Right bank	:	Stony type gate (1 gate)	B = 6.0 m, H = 5.5 m for one gate

(3) Rehabilitation of intake gates

Replacement of the gates at the intake of both banks of the Angat Afterbay Regulator Dam.

Left bank	:	12 gates
Right bank	:	10 gates
Total	:	22 gates (B = 1.72 m, H = 1.0 m for each gate)

(4) Rehabilitation of downstream apron

Partial rehabilitation of the apron at the downstream of the gates

(5) Rehabilitation of river bank protection

Construction and reinforcement of the river bank protection on both banks at upstream and downstream of the Angat Afterbay Regulator Dam

(6) Improvement of information system including the alarm system

Improvement of the alarm system and the facilities necessary to operate and maintain the Angat Afterbay Regulator Dam

(7) Rehabilitation of management office

The present management office, which is located on the left bank of the Angat Afterbay Regulator Dam and also used as the operation room, is mainly used to operate, maintain, and control the six spillway sector gates and washout gates. This office building must be rehabilitated accompanying the future rehabilitation of related facilities.

CHAPTER. 2 Contents of the Project

2-1 Objective of the Project

Based on the Medium Term Philippines Development Plan, the Government of the Philippines is proceeding to secure food safety and a decrease of the number of poor people in the agricultural area through preparation of agricultural village infrastructure, improvement of agricultural techniques and seeds, and expansion of irrigated land. NIA has planned the development of improvement of present irrigated land and the development of new irrigated land based on this plan. This project includes to plan the rehabilitation of the Angat Afterbay Regulator Dam which is the most important facility in AMRIS area

(irrigation area = 31,486 ha), which is one of the large scale national irrigation systems in the Philippines.

2-2 Basic Concept of the Project

(1) Contents of the Request

As for the confirmation of the request, the contents of the request at the preliminary study stage and the basic design study stage are shown in the Table 2-1 below respectively.

Table 2-1 Comparison of the requests before and after preliminary study

Request at preliminary study			Results of the basic design study		
Name of facility	Quantities	Specifications	Name of facility	Quantities	Specifications
Rehabilitation of sector gates	6 gates	L = 79.0 m H = 2.5 m	Rehabilitation of sector gates	6 gates	L = 7.9 m H = 2.5 m
Rehabilitation of washout and replacement of gates	3 gates	Left-bank sluiceway 2 gates B = 4. 5 m H = 5.5 m Right-bank sluiceway 1 gate B = 6.0 m H = 5.5 m	Rehabilitation of washout and replacement of gates	3 gates	Left-bank washout 2 gates B = 4.6 m H=4.5 m Right-bank washout 1 gate B = 6.1 m H = 4.5 m
Rehabilitation of intake gates			Rehabilitation of intake	22 gates	Right bank gate 10 gates B = 1.72 m for 1 gate H = 1.0 m for 1 gate Left bank gate 12 gates
Rehabilitation of apron at downstream of gates			Rehabilitation of downstream apron		
River bank protection			Right bank protection at downstream of apron		
Improvement of information system (alarm system)			----		
Rehabilitation of management office			----		

(2) Contents of the Basic Concept

The functions of the Angat Afterbay Regulator Dam (hereinafter so called as "Regulator Dam") by NIA can be summarized as follows;

a) Stable diversion of required irrigation water for AMRIS area of 31,485 ha for both dry and rainy seasons

b) Stabilization of hydropower generation through main power station of Angat Dam,

c) Stable allocation of drinking water to Metro Manila by means of effective utilization of the regulator Dam, and
d) Mitigation of flood damages by stabilizing the river course or mitigation of peak flood discharge.

Among the above mentioned four functions, the stabilization of hydropower generation on Angat Dam is necessary to have regulating storage capacity for the Regulator Dam. It can be considered that the function of regulating water was taken into at the reconstruction of Regulator Dam in 1967. However the Regulator Dam can not flush out the sedimented materials in the reservoir due to the non-functional gates after reconstruction, and has no function to store the water in the reservoir at present. After the improvement of spillway and washout gates under this Project, the function of the Regulator Dam is expected to recover the storage capacities.

On the other hand, stable domestic water supply to Metro Manila needs the development of the new water resources and the reallocation of the water right. Therefore, this project is not considered domestic water supply under the Project. However, the effective utilizaion of the water from river is expected by the recovery of the Regulator Dam function.

For the mitigation of flood damages, optimum gate operation during the flood time is possible after rehabilitation under the Project, accordingly mitigation of flood damages can be expected.

From the results of the above mentioned examination, the following were determined as the basic concept of this project: to secure the stable intake function of irrigation water, to mitigate the damages by flood, and to construct river bed and river bank protections necessary for the safety and security of main facilities.

(3) Priority of the works under the Project

Priority of the rehabilitation for each facility of the Regulator Dam have been decided from the importance and damage state of the structures as follows.

1. Replacement of existing sector gates: 6 gates (79.0m × 2.5m)
2. Rehabilitation of the washout gates and lifting mechanisms:
   - the left-bank washout gates: 2 gates (4.5m × 5.5m)
   - the right-bank washout gates: 1 gate (6.0m × 5.5m)
3. Rehabilitation of the downstream apron:

4. Additional bank protection at the right bank downstream of the existing dam:
5. Rehabilitation of the intake gates and lifting mechanisms:

the left-bank intake	12 gates
the right-bank intake	10 gates

6. Rehabilitation of the river bank protection:
7. Rehabilitation of the information system (alarm system)

2-3 Basic Design

2-3-1 Design Concept

(1) Concrete Structures

Concrete structure of the Regulator Dam can be judged to be durable even after the replacement of the spillway gate from the Schmit hammer test result and the compression test result by NIA. Therefore, demolition and new establishment of concrete structures are not considered. However, recovery, remodeling and chipping of the partial concrete structures together with the recovery and replacement of gates and shute block and bafile pier which have significant damages will be considered as necessary. Also, length of the river bed protection will be decided by hydraulic calculation at the design floods.

(2) Spillway gate

It is impossible to eliminate these causes from the existing gates with torsion. Therefore, concerning the rehabilitation works, it is necessary to consider the causes which generated the defect and incapability of operation of the existing sector gate and upon selection and designing of the gate, it is necessary to keep the following points fro the design of gates.

① It is easy for the operation and maintenance.
② It is not vulnerable to more power than expected (especially change in pressure). When hydraulic, oil and air pressure is necessary, consider limiter, etc.
③ The structure should not be vulnerable to distortion and torsion. In case of steel gate, consider proportion of the vertical and horizontal.
④ Prepare a maintenance and operation manual and to conduct training for operation.

In selecting the facilities of this project, the concrete structures and gate facilities are roughly determined based on the design standard of generally used steel gates and

rubber gates. Then the costs necessary to construct these facilities are estimated and compared from the economic standpoint, as well as the two types of gates are compared in relation to the difficulty in operating the facilities and the excellence in maintenance, and the final project will be formulated from the overall standpoint.

(3) Washout Gate

Concrete strength of the sluiceway is judged that it can sufficiently bear the replacement of the gate, so of the sluiceway will be improved using the present concrete structures. Therefore, improvement will be renewal of mechanical parts by replacing the metallic material and the gate including the hoist.

Space for removing the gate on the upper part of the already pier is not enough against the gate height, so the gate will be designed with considering the installation.

Because the existing gate uses the hoist method with counter weight, the gate axis is not located in the center of the pier. By considering these situations, when the hoist method of the new gate is designed, if the space for the top plating is not sufficient, it is necessary to design the widening of top by checker plate. Hoist of the sluice gate should be electric motor for flushing out of sand smoothly.

(4) Intake Gate

Intake gate is a small sluice gate with a width of 1.72 m and height of 1.00 m, and there are 22 gates located on both the left and right banks. Out of these 22, 3 gates are impossible for operation, and other gates are difficult for open/close operation All the gates were constructed more than thirty years ago and need rehabilitation. The inflow from both the north and the south main canals is adjusted at the mitre gate installed at the upstream of the canal. Thus the frequency to operate the intake gates is considered very low.

Therefore, type of the gate to be newly installed should be the same type as before, and hoist power would be manpower.

(5) River Bank Protection at right-bank downstream

The apron direct downstream at the right bank is scoured by flood, and is corroding in a shape of bend. Because this ground has the form of a bulging small hill farmland, if a large flood occurs, it is presumed that this erosion will proceed gradually to the downstream. In

addition, the corrosion extends to the top of slope of the existing right bank protection and the sheet pile cut-off wall is revealed. However, because private property is included in these grounds, it is necessary for considerate correspondence.

As the method of cofferdam, (1) single stage division method, (2) multi-stage division method (A), and (3) multi-stage division method (B) are considered. The results of the comparative examination of these methods are summarized as follows.

(6) Construction Period and Temporary Works

Rehabilitation works of the Angat Afterbay Regulator Dam is the works in the river, and the construction is necessary to be carried out within the cofferdam which will be made upstream of the Regulator Dam. From the scale of the works two dry seasons are necessary for the construction period.
For construction period, only one dry season is not enough, therefore following study concerning the cofferdam is carried out.

a) Single Stage Diversion Method
This construction method is to make cofferdam connecting from the right river bank to the left river bank at the upstream of the intake and the Regulator Dam. The Construction works is requested for dry season and rainy season. In this case, temporary canal conduit and a large cofferdam shall be made to flow the flood water safely during the construction period. If the flow rate of the river to install the temporary diversion conduit is assumed as 500 m3/s, there is no other way than to construct a temporary diversion conduit inside the river when considering the space for making a temporary diversion conduit (width of the conduit : about 100 m) on the land side and the crossing with the existing main canals. In addition, the size of the temporary diversion conduit would be the size of one gate of the existing spillway. Thus this method is very difficult to implement and uneconomical as the method of river cofferdam. Because this construction work is conducted at the river, the non-flooding period of the river (dry season) is the most appropriate for the work.

b) Multi-Stage Diversion Method (A)
At first step, temporary cofferdam will be constructed at the left half bank of the upstream of the intake and the Regulator Dam, and it will be removed before the rainy season. Then the temporary cofferdam for the right bank will be made in the second dry season. In this case, replacement of spillway gate, sluice gate and intake gate can be done within the temporary cofferdam.

With regard to the above mentioned construction method, the NIA has obtained the agreement on the resignation of planting for one dry season from the water use association and local public entities, which are the beneficiaries of the rehabilitation of the Angat Afterbay Regulator Dam. However when this method is used, the gravity irrigation in dry season cannot be conducted completely. In this case, there would be no production of rice from 25,000 ha (average area of gravity irrigation between 1983~1995), and there would be an increase in import of rice for the decreased amount (about 100,000 tons), and this will be disadvantageous for the Philippines national economy.

c) Multi-Stage Diversion Method (B)

It is the same method as above, but temporary cofferdam will made on just front of the spillway gate for installation of new gate and removal of existing spillway gate, however cofferdam for intake and sluiceway will not made.

According to the Irrigation schedule of AMRIS as shown in Figure 2-1 and 2-2, there is a non-intake month between the dry season and rainy season irrigation. If this non-intake period could be expanded to two months, April and May, it seems to be possible to rehabilitate sluice gate and intake gates by the same parties of workers group.

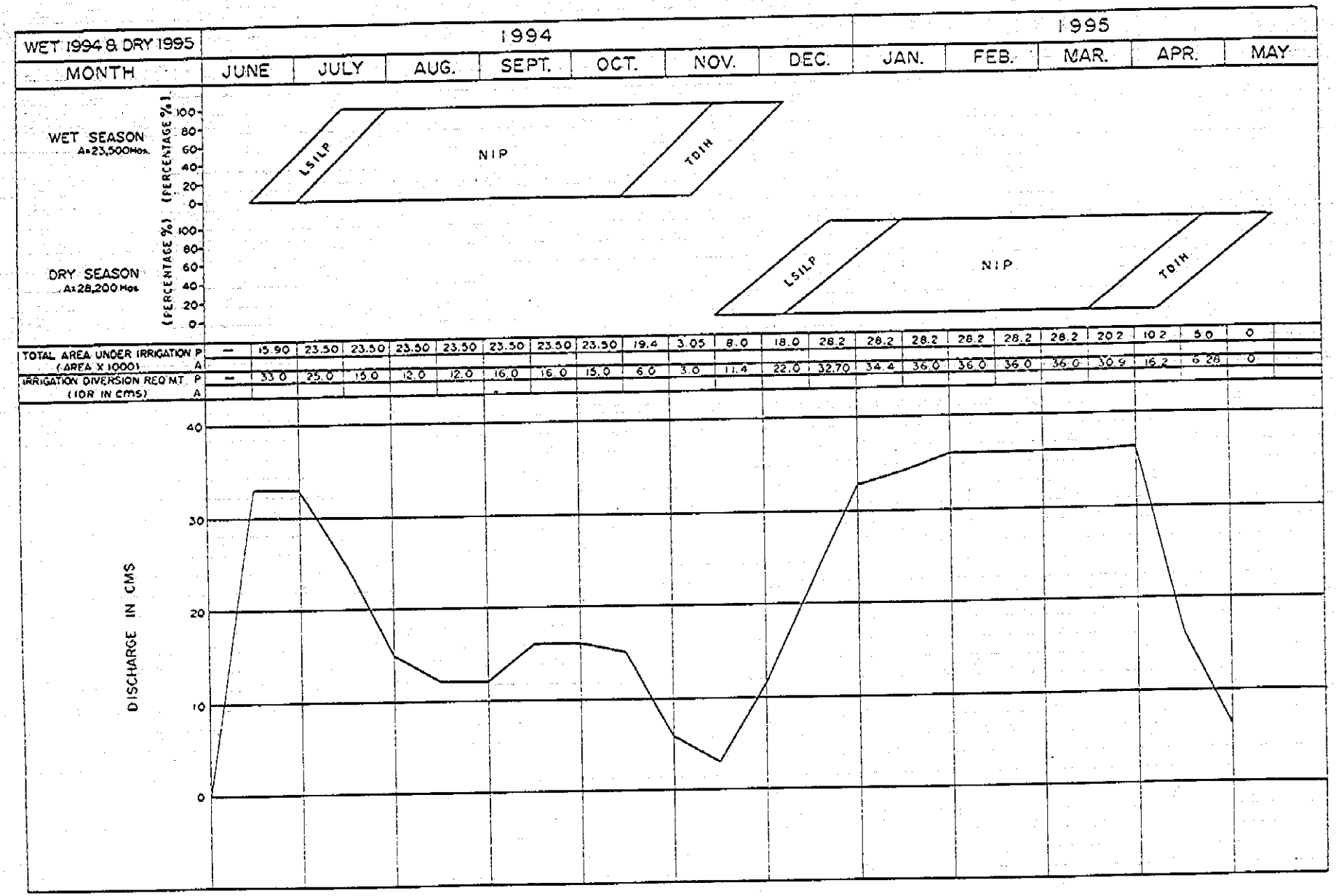
Because a production decrease of 5 to 10% of dry season paddy can be anticipated with the two months period of non-intake of irrigation water, an agreement from the farmers is necessary. Decrease of 5 to 50% dry season rice harvest will be a substitute proposal which can be accepted easily from the farmers compared with the resignation of rice of one dry season. The NIA has already explained on this proposal to related farmers and obtained their agreement as well as it stated the irrigation of rainy season for this year from June 1, half a month earlier than expected.

Based on the above results of examination and the progress, the construction period and the temporary construction plan are formulated according to (c) multi-stage division method (B).

d) Planned water level for cofferdam

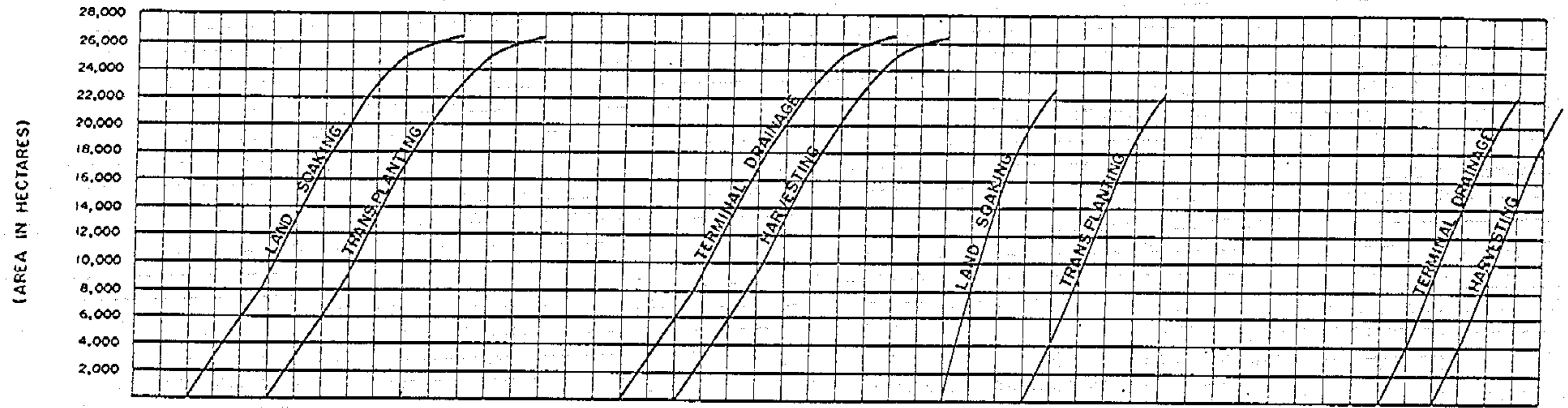
The planned water level for the cofferdam is determined EL. 18.00 m to maintain the irrigation intake level at 17.5 m as well as to add a margin of 0.50 m to the recorded water levels measured at the location of Regulator Dam in 1995, 1994, and 1990.

Fig.2-1 CROPPING PATTERN AND IRRIGATION SCHEDULE (1)



		JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	JAN.	FEB.	MAR.	APR.	MAY
TOTAL AREA UNDER IRRIGATION (AREA X 1000)	P	—	15.90	23.50	23.50	23.50	23.50	23.50	23.50	19.4	3.05	8.0	18.0	28.2	28.2	28.2	28.2	28.2	28.2	20.2	10.2	5.0	0
	A																						
IRRIGATION DIVERSION REQ'MT (IDR IN CMS)	P	—	33.0	25.0	15.0	12.0	12.0	16.0	16.0	15.0	6.0	3.0	11.4	22.0	32.70	34.4	36.0	36.0	36.0	36.0	30.9	16.2	6.28	0
	A																						

Fig. 2-2 CROPPING PATTERN AND IRRIGATION SCHEDULE (2)



YEAR		1995																									
MONTH		NOV.		DEC.				JAN.				FEB.				MAR.				APR.				MAY			
WEEK NO.		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
ACTIVITY: LAND SOAKING (Has.) (AREA X 1000)	P	3.0	3.0	3.0	4.0	4.0	3.0	3.0	2.0	1.0	0.6																
	A																										
ACTIVITY: LAND PREPARATION (Has.) (AREA X 1000)	P		3.0	6.0	6.0	7.0	8.0	7.0	6.0	5.0	3.0	1.6															
	A																										
ACTIVITY: CROP MAINTENANCE (Has.) (AREA X 1000)	P				3.0	6.0	9.0	13.0	17.0	20.0	23.0	25.0	26.6	26.6	26.6	26.6	26.6	23.6	20.6	17.6	13.6	9.6	6.6	3.6	1.6	0.6	0
	A																										
TOTAL AREA UNDER IRRIG. (Has.) (AREA X 1000)	P	3.0	6.0	9.0	13.0	17.0	2.00	23.0	25.0	26.0	26.6	26.6	26.6	26.6	26.6	26.6	26.6	23.6	20.6	17.6	13.6	9.6	6.6	3.6	1.6	0.6	0
	A																										
WATER REQUIREMENT TOTAL (cms)	P	5.6	7.7	9.6	13.9	16.8	17.8	20.2	20.7	20.5	20.6	20.1	20.3	20.3	20.3	20.3	20.3	18.0	18.7	13.4	10.4	7.3	5.0	2.7	1.2	0.6	0
	A																										
EFFECTIVE RAINFALL (mm/d)	P	1.0	1.0	0.5	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	A																										
IRRIG. DIVERSION REQ'MT. (cms)	P	9.0	11.7	15.2	21.8	28.0	30.0	33.7	34.5	34.1	34.4	33.4	33.9	33.9	33.9	33.9	33.9	3.0	26.2	22.4	17.3	12.2	8.4	4.5	2.0	0.7	0
	A																										

YEAR		1996																					
MONTH		JUNE		JULY				AUG.				SEPT.				OCT.				NOV.			
WEEK NO.		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
ACTIVITY: LAND SOAKING (Has.) (AREA X 1000)	P	8.0	6.5	5.0	2.9																		
	A																						
ACTIVITY: LAND PREPARATION (Has.) (AREA X 1000)	P		8.0	14.5	15.5	13.9	8.4	3.4															
	A																						
ACTIVITY: CROP MAINTENANCE (Has.) (AREA X 1000)	P				4.0	9.0	14.0	19.0	22.4	22.4	22.4	22.4	22.4	22.4	22.4	22.4	22.4	18.4	13.4	8.4	8.4	0	0
	A																						
TOTAL AREA UNDER IRRIG. (Has.) (AREA X 1000)	P	8.0	14.5	19.5	22.4	22.4	22.4	22.4	22.4	22.4	22.4	22.4	22.4	22.4	22.4	22.4	22.4	18.4	13.4	8.4	8.4	0	0
	A																						
WATER REQUIREMENT TOTAL (cms)	P	19.2	22.3	22.4	21.0	16.7	16.5	16.7	16.8	16.8	16.8	16.8	16.8	16.8	16.8	16.8	16.8	13.8	10.0	6.3	2.5	0	0
	A																						
EFFECTIVE RAINFALL (mm/d)	P	2.5	2.5	3.0	3.0	3.0	3.0	3.5	3.5	3.5	3.5	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	2.0	2.0	0	0
	A																						
IRRIG. DIVERSION REQ'MT. (cms)	P	30.7	31.1	28.4	24.1	16.3	15.9	13.8	14.0	14.0	14.0	16.3	16.3	16.3	16.3	16.3	16.3	13.4	9.8	7.9	3.2	0	0
	A																						

2-3-2 Basic Design

(1) Design Conditions

The design conditions concerning the hydraulics of the river are as follows:

Design intake water level ..... 17.50 m
Design flood discharge..... 3,300 cu.m/sec
Design flood level ..... 17.50 m

The allowable stresses of concrete and reinforcement are as follows:

- Allowable compression stress
  Concrete type-A ..... 3,000 psi ≡ 210 kg/sq.cm
  Concrete type-B ..... 2,400 psi ≡ 170 kg/sq.cm
  Concrete type-C ..... 2,000 psi ≡ 140 kg/sq.cm
- Allowable tensile stress
  Reinforcing bar (Deformed bar) .... 20,000 psi ≡ 1,400 kg/sq.cm

(2) Design of Spillway

a) Comparison of spillway gates

The types of gates applicable for spillway of the regulator dam are as follows:

Vertical lifting type	Roller type	Roller gate (girder type)
		Long span roller gate (shell type)
		Multistage roller gate
	Slide type	Slide gate
Hinged type		Flap gate
Rubber type		Rubber gate

Of those suitable as spillway gates mentioned above, the roller gate (girder) and the slide gate are not used if the gate is to have a span length of 15 m or more, and the multi-stage roller gate is used if the gate is to have a long span and the water control rate is small (therefore the opening must be adjusted in the order of centimeter). The Angat Afterbay Regulator Dam shall not adopt such gate because of the absence of restrictions on the water discharge rate, the complexity of the watertight parts, gate stop structure, opening and closing mechanism, etc., and the small H/L of single gate consisting of one stage, which may result in a problematic gate structure.

Considering the above reasons and the experience, the following three plans shall be examined through comparison to decide on the spillway gates for this regulator dam.

Plan 1 ..... Long span roller gate (shell type)
(hereinafter referred to as "roller gate")
Plan 2 ..... Flap gate
Plan 3 ..... Gate made of rubberized fabric ("rubber gate")

Figures 2-3 and 2-4 show the outline of those three plans.

① Roller Gate (Plan 1)

In the roller gate plan, the hoisting device is installed above the gate and the gate is hoisted up and down and thereby opened and closed using wire ropes, racks, spindles, etc. The roller gate, used as the long span gate, is highly reliable and has been used in many cases as a gate for regulator dam.

According to the "Dam and Dam Facility Technical Standard (Draft)" (March, 1994) published by the Dam and Dam Facility Technical Standard Association and the "Land Improvement Technical Standard: Regulator dam" published by the Ministry of Agriculture, Forestry and Fisheries, the high/span ratio of a steel gate is preferably 1/15 to 1/20 or less. Assuming that the gate height is 2.50 m, the clear span of gate is 37.5 m to 50.0 m or less. Therefore, according to the existing gate span and the pier width, there shall be twelve gates with the clear span of 38.0 m and thirteen piers with the width of 3.0 m. If a roller gate is installed, the lower end of the gate when hoisted must be higher than the flood level with a sufficient allowance. According to the calculation shown below, the height of pier for the roller gate shall be 8.20 m and the control room shall also be needed. (The following heights are as measured from the existing fixed-crest dam EL. 15.00 m.)

Gate height	2.50 m
Gate hoisting height	1.20 m
Gate height when hoisted ...	2.50 m
Lifting margin height	1.00 m
Thickness of control room .	1.00 m
Total	8.20 m

The existing piers are hollow reinforced concrete structures with space for maintenance of the pipes for conveying the water for controlling the sector gates.

The above gate posts cannot be installed in addition to the existing piers, as this would then put at risk the stability of the gate posts. All the gate posts, therefore, shall be planned as new installations.

② Flap Gate (Plan 2)

In the flap gate plan, the steel gate is rotated around the rotating hinge fixed in the concrete and thereby opened and closed. The flap gate, implemented many times as a long span gate, facilitates regulating the flow because of its overflow-based regulation and it also allows automatic tilting according to the water level.

The h/s ratio of the flap gate, like that of the roller gate, is preferably 1/15 to 1/20 or less. Therefore, the gate span and the gate post width shall be as follows.

Clear span of gates..... 38.0 m

Gate post width ..... 3.0 m

Since the existing piers and the underground part of the control room located on the left bank can be used, there shall be seven gates.

The dimensions of the piers shall be the same as that of the existing piers.

③ Rubber Gate (Plan 3)

In the rubberized gate plan, bags of rubberized fabric are installed and the gate is raised and lowered as the bags are inflated or deflated by feeding or releasing air or water into or out of the bags.

The "Technical Standard for Rubber Gates (Second Edition)" published by the Land Development Technical Research Center (August, 1983) does not especially set forth the span length of gates made of rubber gate. Therefore, plan 3 is to be replaced with rubber gates for all existing sector gates.

④ Conclusion

The results of the comparative examination on the spillway gate are summarized in Table 2-2, which shows that rubber gate is more suitable than others in the construction cost and the maintenance cost. As for the durability, the rubber gate shows no trouble from the past achievements. On the other hand, the relationship between the degree of opening of the gate and the flow rate must be understood for the operability, but the correlation between the above two is considered to be shown gradually from the results of the operation at site.

From the past examples, surface of rubber gate might be damaged by driftwood. In this case, the crack having the diameter of 10 cm or less or the pierced damage by the nail and so on can be repaired by inserting plugs or filling with self-curing rubber.

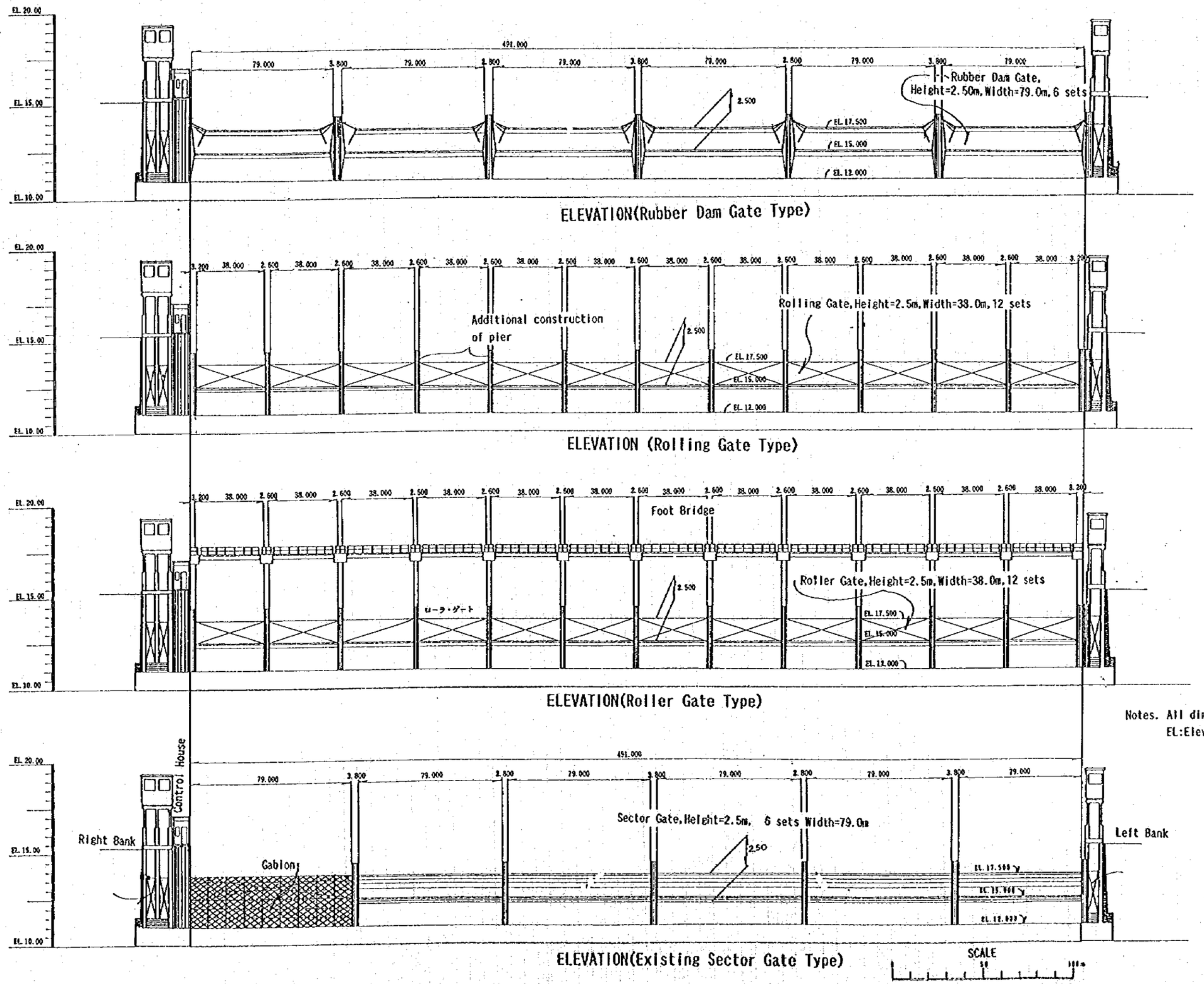
Even the pierced damage with the diameter of 10 cm or more can be repaired by the hot cure adhesion of raw rubber and canvas.

As a result of overall examination mentioned above, the rubber gate is determined most suitable for this project.

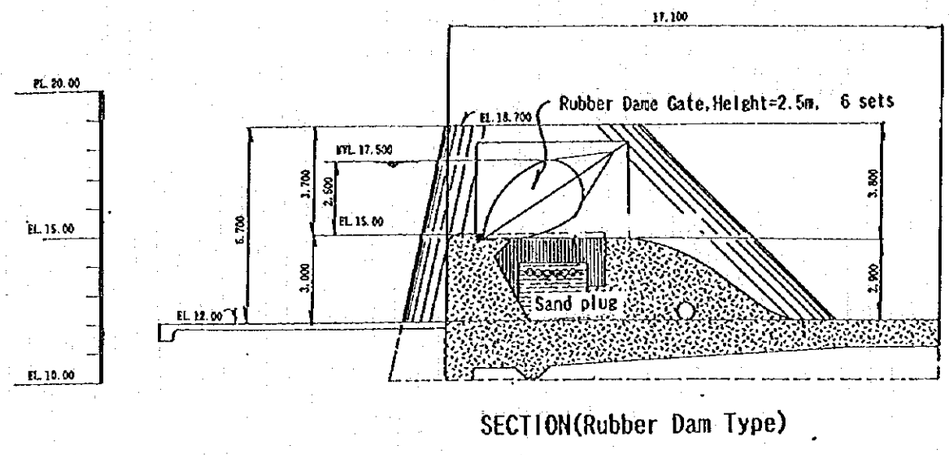
Table 2-2 Comparison of Spillway Gates

		Roller gate	Flap gate	Rubber gate
Hydraulic characteristics		If the water exceeds the planned level, it cannot be made to overflow but only to underflow the gate.	Since the overflow is regulated by changing the gate tilting angle, the water always overflows the gate.	The rubber bags are deformed to regulate the flow over the bags. The water always overflows the gate.
Durability		Durable for 30 years or more if the gate maintenance is regularly conducted, such as replacing the hoisting ropes, lubricating the drums and ropes, painting the gate, checking and replacing the water stop, etc.	Durable for 30 years or more if the gate maintenance is regularly conducted, such as checking and supplying fluid to the hydraulic system for opening and closing the gate, checking and maintaining the hinges, painting the gate, checking and replacing the water stop, etc.	The durability of this gate, consisting of rubber bags bolted to the dam concrete, depends on that of the rubber. It has been confirmed to be 31 years in Japan and 39 years in the U.S. The only example in the Philippines is the Baka Dam constructed in 1983, which has lasted for 13 years. The Baka Dam, according to its present condition, is estimated to have a durability of 30 years or more.
Operability		Can be remote-controlled from the control room. Care must be taken not to let the water overflow the gate. The gate can be automatically opened and closed via electrical means	Can be remote-controlled from the control room, and the gate can be set at any degree of opening Same as the Roller gate.	Can be remote-controlled from the control room, but the gate cannot be easily set at desired degree of opening. The bags can be automatically deflated via mechanical means.
Maintenance		Not so easy because of the many parts needing to be checked and maintained.	Same as the Roller gate.	Relatively easy because of the fewer parts needing to be checked and maintained.
O/M cost (yen per year)		5,800,000	5,400,000	2,000,000
Marking points in the construction stage		Three to four dry seasons shall be needed for the construction because everything including the foundation must be reconstructed, considering the gate pole stability. The upstream temporary works must also be large.	Since new gate poles are installed between the existing piers, temporary works for securing the work space on the upstream of the dam, which may influence the existing apron, shall be needed.	Since only little concrete is needed and most of the existing structures can be used, the construction shall take a relatively short time and the temporary works can be relatively small.
Construction cost	Structures	187 mill.	115 mill.	65 mill.
	Gates	2,760 mill.	1,668 mill.	1,174 mill.
	Total	2,943 mill.	1,783 mill.	1,239 mill.
Total evaluation		Inferior	Inferior	Excellent

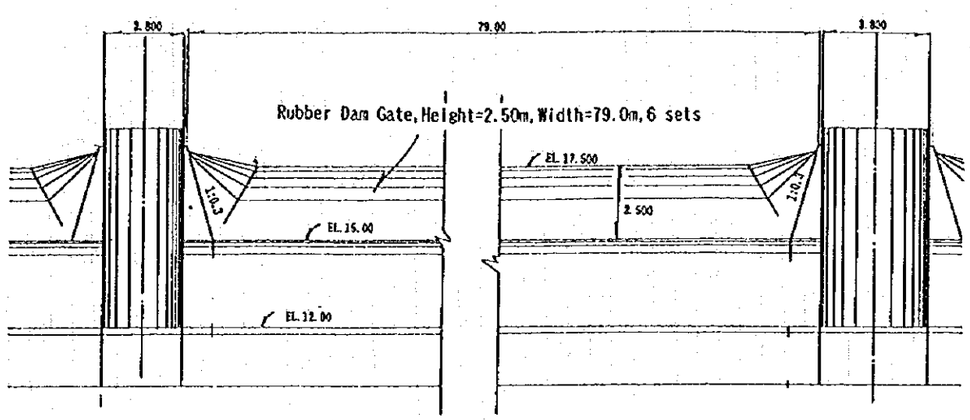
Fig. 2-3 COMPARISION DRAWING OF GATE TYPE (1)



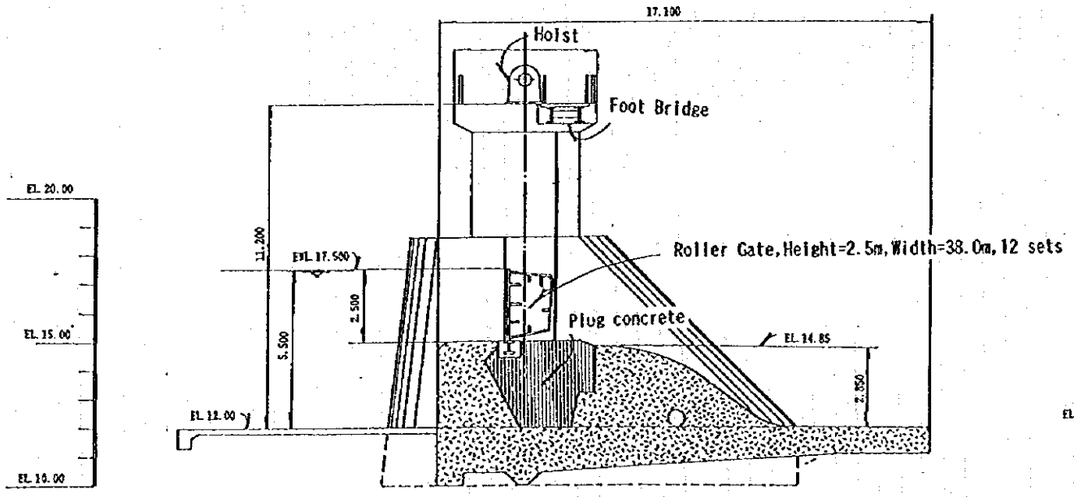
Notes. All dimensions are shown in meters.
EL:Elevation, WL: Water Level.



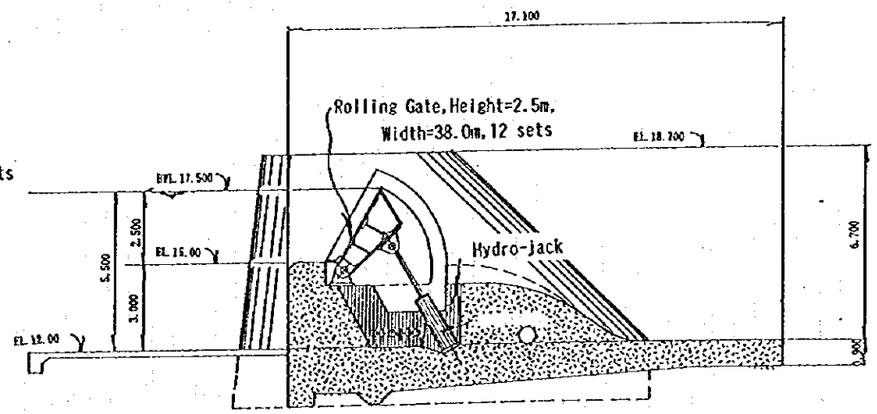
SECTION(Rubber Dam Type)



ELEVATION



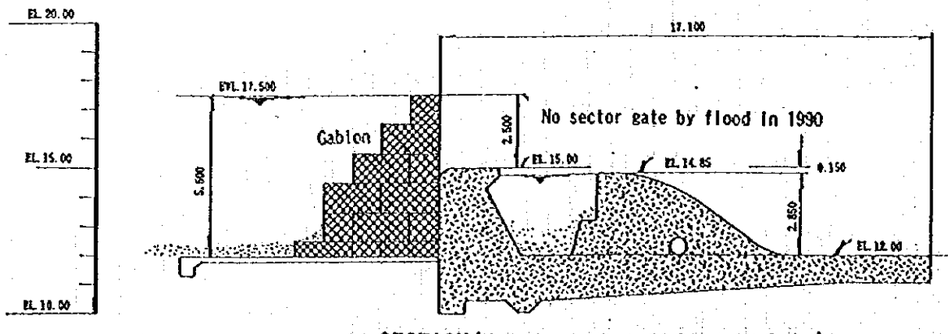
SECTION(Roller Gate Type)



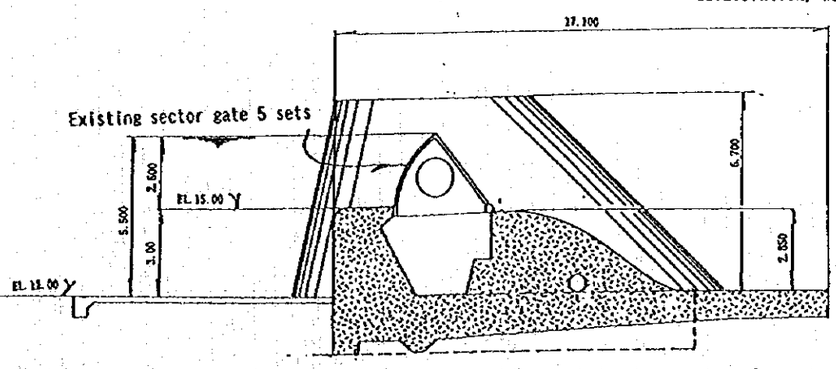
SECTION (Rolling Gate Type)

Notes. All dimensions are shown in meters.

EL: Elevation, WL: Water Level



SECTION(Existing Bay-1 Sector Gate)



SECTION(Bay. 2 to 6 Sector Gate)

b) Specifications of the Spillway Gate

With the rubber gate, either water inflation or air inflation can be used as the inflating medium for the rubberized bags, each having the characteristics as shown in the following table.

Table 2-3 Comparison of Expansion Methodes on the Rubber Gate

	Water inflation method	Air inflation method
Temperature	In cold areas, the water for inflating the bags may freeze.	In areas with significant temperature changes, the internal pressure of the bags may fluctuate.
Foundation condition		Superior to the water method if the gate is set on weak ground.
Securement of medium		This medium can be easily acquired.
Circumference of bag	The circumference of the bag is longer than the other since the sectional form of the bag is flat.	
Bag loading floor	For the above reason, also the bag loading floor is longer.	
Overflow depth	If the downstream depth is small, the water method can endure deeper overflow than the air method.	
Stability of bag form at the control area	The water uniformly overflows with a relatively equal depth.	If the internal pressure falls, V-notches are caused.
Water level control	Can regulate a wider range of water levels than the air method.	Cannot regulate the water level well when V-notches occur.
Bag deformation	Bag deformation according to changes in the water level is smaller.	
Characteristics concerning waves		The tensile stress changes and bag oscillations due to the waves are smaller.
Supply and drain time	For self-draining, the higher the downstream water level, the longer it takes to drain the water.	
Supply and drain duct	Dust and sand may accumulate in the duct depending on the withdrawal method.	Ducts with a smaller diameter than for the water inflation method can be used.
Other structures	In many cases, a settling basin and water tank are needed.	

As shown in the above table of comparisons, the water inflation method, despite its merit of easier water level regulation, needs a larger loading floor and ancillary equipment such as the settling basin, water tank, etc., may accumulate dust and sand in the supply and drain duct and take longer to drain the water. The water inflation method has lighter bags and smaller ancillary equipment, but does not regulate the water level well.

The above comparison can be summed up as follows:

① If the regulator dam is to be improved using the existing fixed-crest dam, the air inflation method is applicable.

② The water inflation method takes longer to drain the water. If a flood similar to the one in 1978 occurs, it shall be difficult to fully open the spillway gate.

③ With the air inflation method, it shall be difficult to regulate the water level if a V-notch occurs. A V-notch is generally believed to occur at 70% or 80% of the initial gate height. The rubber gate with a 30% opening has a runoff discharge of approximately 500 cu.m/s which can successfully deal with floods that are expected to occur every year. Therefore, the rubber gate with the air inflation method shall be employed as the spillway gate.

The new spillway gate must be such that the reconstruction can be carried out using the existing concrete structures and the following conditions that were learned from the shortcomings of the existing gate are met: ① maintenance is easy, ② the gate can endure greater pressure changes than expected, ③ strains and torsion do not easily occur and ④ the personnel on site shall be trained in the maintenance and operation of the gate. Therefore, the specifications of the rubber gate with the air inflation method used for the Angat Afterbay Regulator Dam are as follows:

Design gate height	2.50 m
Inflating medium	Air Expansion
Design internal pressure	0.26 kgf/sq.m
Drain time	60 min.
Lifting time	60 min.

c) Hydraulic Calculation of the Spillway Gate (Design Flood Case)

If the design flood discharge (3,300 cu.m/sec) is encountered, all the spillway gates and the sluice gates are opened to let the flood run off. The runoff discharge in such a case is calculated as follows:

If all the gates are opened, the flow is over a trapezoidal notch. Therefore, the flows through the spillway and the sluiceway are calculated respectively according to the following formula:

$q = K_0 \times b \times h^{3/2}$

(Quoted from the design standard on the Regulator Dam, p.163. formula (8.12))

Flow through the spillway (Section for when the rubberized gate is fully opened)

$q_1 = 1.70 \times 0.5 \times (79.00 + 77.50) \times 2.5^{3/2} \times 6 = 1.70 \times 78.25 \times 3.95 \times 6 = 3{,}153\ m^3/s$

Flow through the sluiceway

$q_2 = 1.70 \times (6.10 + 4.6 \times 2) \times 4.5^{3/2} = 1.70 \times 15.3 \times 9.55 = 248\ m^3/s$

Total discharge

$Q = q_1 + q_2 = 3{,}153 + 248 = 3{,}401\ m^3/s > 3{,}300\ m^3/s$

d) Checking the Apron Length

The longitudinal section of the existing regulator dam is illustrated in Figure 2-5. The length required for the apron (concrete area) is checked using the Bligh's formula as follows:

$W = 0.6 \times C_0 \times \sqrt{D}$

W: Apron length

C_0: Percolation path coefficient (Mixture of sand and gravel: $C_0 = 9$)

D: Height from the apron upper end height to the top of dam

For the spillway gate itself: D = 5.50 m

$W = 0.6 \times 9 \times \sqrt{5.50} = 12.66\ m < 42.60\ m$ O.K.

For the sub dam : D = 3.00 m

$W = 0.6 \times 9 \times \sqrt{3.00} = 9.35\ m < 25.00\ m$ O.K.

The apron length of the existing regulator dam is sufficient according to the above calculation using the Bligh's formula.

e) Checking the Setting Depth of the Sealing Works (Sheet Pile)

The setting depth of the sealing works is checked using the Lane's Formula.

$$C \le \frac{\frac{L}{3} + \sum \ell}{\Delta H} = \frac{\frac{36.26}{3} + (4.50 \times 2 + 3.502 + 4.50)}{8.50} = 15.3 > 4.0 \qquad \text{O.K}$$

C: Creep ratio (for fine gravel: 4.0)

L: Length of dam and apron (m)

$\Sigma \ell$: Vertical length of percolation path (m)

ΔH: Maximum lift between upstream and downstream (m)

The setting depth of the sealing works of the existing regulator dam is sufficient according to the above calculation.

f) Checking the Length of River Bed Protection

Since the river bed protection of the existing regulator dam is partially washed away, the required length of river bed protection is calculated and compared with that of the existing river bed protection.

The total length can be estimated by adding the lengths of the apron and river bed protection using the Bligh's formula.

$W = 0.67 \times C_0 \times \sqrt{Hb \times q} = 0.67 \times 9 \times \sqrt{5.50 \times 6.32} = 35.55$ m

W: Total length of apron and riverbed protection

C_0: Percolation path coefficient (Mixture of sand and gravel: $C_0 = 9$)

Hb: Height from the apron upper end height to the gate top

q: Flow per unit of width

The above calculations shows that the required total length of the apron and river bed protection is 35.55 m. Since the apron length is 25.0 m, the required length of the river bed protection is 10.55 m. However, 15.0 m of the river bed protection already exists, the length of river bed protection after the reconstruction shall be 15.00 m.

g) Controlling the Spillway Gate

The overflow rate of the spillway gate when the gate is not fully open can be obtained using the following formula:

$q = C \times b \times h^{3/2}$

$C = 1.77 \times h/H + 1.05$

Overflow depth h (m)	Gate door height H (m)	Flow coefficient C	Gate width b (m)	$h^{3/2}$	Overflow rate (one gate) m^3/s	Overflow rate (six gates) m^3/s
0.10	2.50	1.12	79.00	0.0316	2.80	16.8
0.20	2.50	1.19	79.00	0.0894	8.40	50.4
0.30	2.50	1.26	79.00	0.164	16.32	97.9
0.40	2.50	1.33	79.00	0.253	26.58	159.5
0.50	2.50	1.40	79.00	0.354	39.15	234.9
0.60	2.50	1.47	79.00	0.465	54.00	324.0
0.70	2.50	1.55	79.00	0.586	71.76	430.6
0.80	2.50	1.62	79.00	0.716	109.29	665.7
0.90	2.50	1.69	79.00	0.854	114.02	684.1
1.00	2.50	1.76	79.00	1.000	139.04	834.2

The rubber gate, because of its nature, cannot be expected to remain for a long time at any given degree of opening. However, if the opening is 20% to 30% of the gate door

height, notches are not likely to occur and the gate can remain at that degree of opening.

Since the water discharge from the Angat Dam in 1994 and 1995 did not exceed 500 cu.m/s, the rubber gate shall have a structure enabling to control up to 500 cu.m/s. However, the overflow rate for when the rubber gate is halfway open cannot be accurately calculated because of the gate nature. Therefore, during the gate installation period, the technicalities of operating the nature of the gate shall not only be conveyed to the organization managing the gate, but also put into the form of standards and procedures in cooperation with such an organization.

h) Spillway Concrete Structures

To install the rubber gate after removing the existing sector gate, the concrete structures shall be modified as follows:

① Removing the existing sector gate itself and hinged metals
② Filling the areas where the sector gate was installed
③ Concerning the rubber gate base
④ Treatment of gate base metal
⑤ Connection slope of the piers and the gate shall be 1:0.3.

Fig.2-5 LONGTUDINAL SECTION OF EXISTING WEIR

(3) Design of the Washout

a) Washout Gate

To install the gate without demolishing the existing concrete structures, the gate width shall be designed to be 10 cm shorter than the clear span of existing gate.

If the lifting method using a rope is employed, the drum for winding the rope shall be mounted on the existing pier, necessitating to reconstruct the upper concrete structure of the gate pier. In addition, the rope lifting method is difficult to maintain and manage as described in the section comparing the various spillway gates.

Therefore, the hoisting method of the sluice gate shall be the electric-motor rack method.

With the lifting method using the rack, the rack can be installed on the existing concrete but the space for control is secured on the upstream side.

Other design conditions of the gate are as follows:

	Right-bank washout gate	Left-bank washout gate
Type	Steel roller gate	Steel roller gate
Number of gates	One	Two
Clear span	6.10 m	4.60 m
Gate width	6.00 m	4.50 m
Gate height	4.50 m	4.50 m
Sill elevation	EL.13.00 m	EL.13.00 m
Top elevation of gate	EL.17.50 m	EL.17.50 m
Design water level	EL.18.00 m	EL.18.00 m
Operation water level	EL.18.00 m	EL.18.00 m
Sediment level	EL.13.50 m	EL.13.50 m
Sealing method	Rear three-way rubber sealing	Rear three-way rubber sealing
Opening and closing method	Electric-motor rack	Electric-motor rack
Lifting and closing speed	0.30 m/min	0.30 m/min

b) Sluiceway concrete structures

Since the new gate shall be installed after the existing sluice gate is removed, the sluiceway must be designed in such a way that the construction shall be done in the following procedure:

① Removing the existing gate and hinged metals
② Installing the new hinged metal of gate
③ Installing the gate
④ Installing the flour deck
⑤ Installing the lifting device

(4) Examination of the Intake Gate

For the intake, only the gate shall be renewed without changing the concrete structures. Other design conditions of the gate are as follows:

	Right-bank intake gate	Left-bank intake gate
Type	Steel sluice gate	Steel sluice gate
Number of gates	10	12
Clear span	1.72 m	1.72 m
Gate height	1.00 m	1.00 m
Sill elevation	EL.13.50 m	EL.13.50 m
Design water level	EL.18.00 m	EL.18.00 m
Operation water level	EL.18.00 m	EL.18.00 m
Sealing method	Rear four-way rubber sealing	Rear four-way rubber sealing
Opening and closing method	Manual	Manual

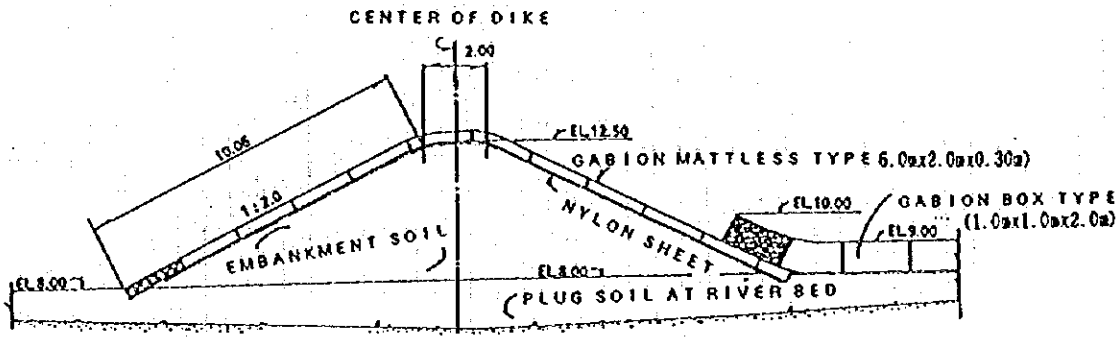
(5) Protection Dike at the right-Bank Downstream

a) Protection Dike of Regulator Dam

The protection dike of regulator dam at the right bank is made of concrete from the regulator dam itself to the apron downstream end. A steel sheet pile is used as the sheathing of the downstream end but most of the steel sheet pile is exposed. To protect this exposed sheet pile, banking shall be made and boulder concrete shall be cast on its surface. The boulder concrete shall have the slop gradient of 1:2.0 with a beam constructed at EL.12.00 m and extend to EL.15.00 m.

b) Protection Dike at Downstream

A protection dike as shown on attached drawings will be constructed in the river location.



TYPICAL SECTION OF DIKE

(6) Foundation

a) Boring Survey

The Basic Design Study Team conducted a boring survey for reconstructing the Angat Afterbay Regulator Dam at the locations shown in Figure 2-6. The results are shown in attached Appendix E1~E6.

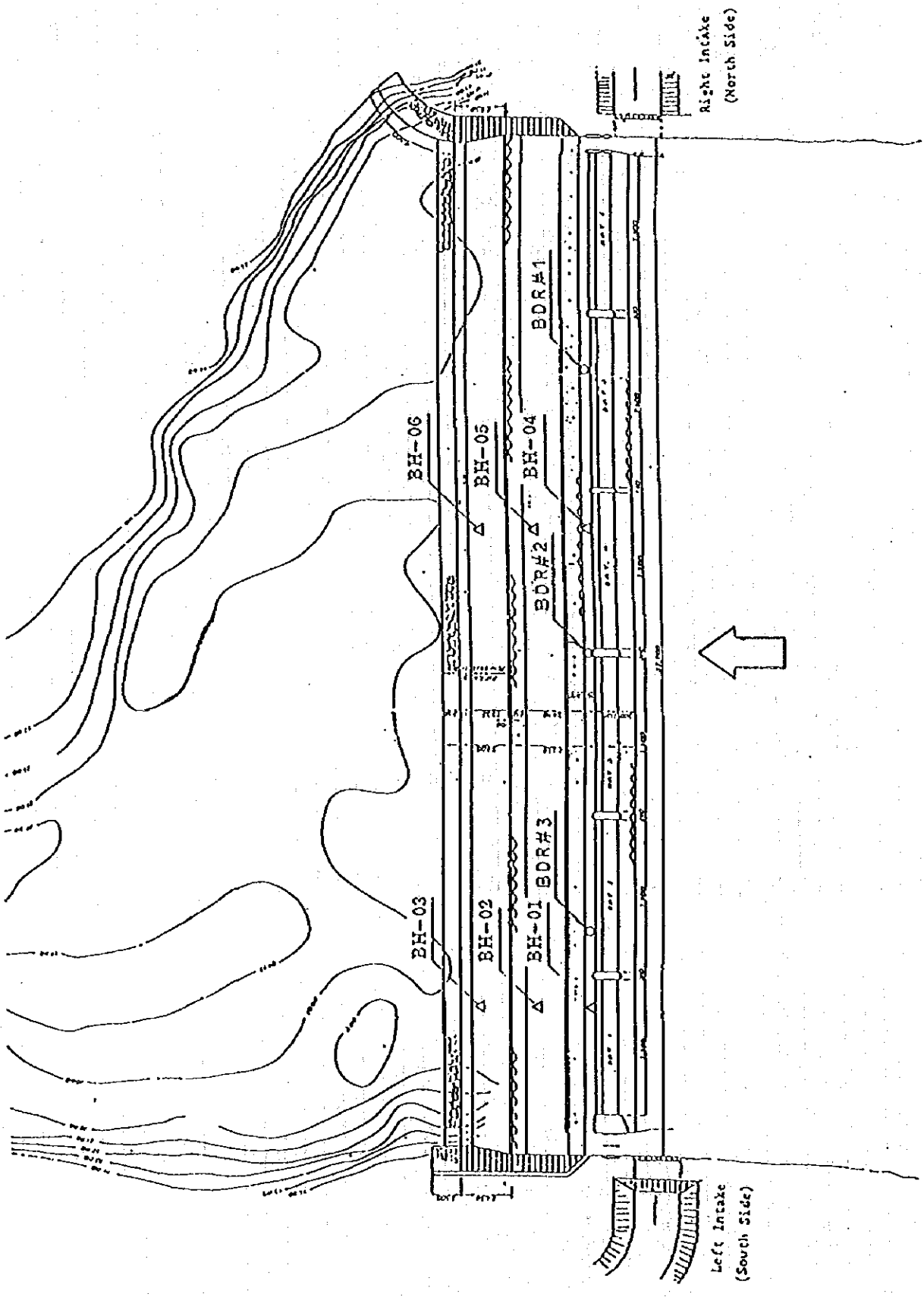
b) Checking Result

Based on "Technical Standard -- canal No.1", the allowable bearing capacity from N-value can be estimated as follows:

Boring hole No.	N value	Allowable Bearing Capacity
BH-01	36	30 tf/sq.m
BH-02	24	20
BH-03	27	20
BH-04	34	30
BH-05	59	30
BH-06	38	30

It can be said the foundation of the weir is suitable after replace the spillway gate, since allowable bearing capacity of foundation is more than 20 tf/sq.m.

Fig.2-6. LOCATION MAP OF BOREHOLE



CHAPTER. 3 Implementation Plan

3-1 Implementation Plan

3-1-1 Implementation Concept

The implementation plan can be roughly divided into the construction and the procurement of materials and equipment. To allow all the materials and equipment to function as intended, it is requested construction of large-scale temporary works, demolition of the existing structures and reconstruction of these structures. Therefore, the construction works will be carried out under the contract with general contractor with procurement.

The necessary materials and equipment, including rubber gates for spillway, steel roller gates for sluiceway, small steel sluice gates for intake and various ancillary equipment for controlling gates shall be procured in blanket orders including installations and adjustments.

In case the Project will be implemented under the Japanese Grant Aid, a Japanese contractor shall be given the contract in principle. Cooperation with the contractors in the Philippines must be implemented within the grant aid system.

Especially some of the equipment procured from Japan need adjustment at installation. Therefore engineers must be dispatched. The type of engineers to be dispatched, the number of engineers, and the period to dispatch are estimated separately.

3-1-2 Precautions for Implementation Condition

(1) Background Condition

The meteorology in this area, influenced by monsoon, is clearly divided into the dry season and the rainy season; the former to last from November to May and the latter to last from June to around October. Therefore, all the work is to be executed on the river of the Angat, the construction plan shall be studied through sufficient understanding of the different site characteristics in the dry and rainy seasons.

For the necessary materials for this construction, excluding the gates and other equipment to be obtained in Japan, the materials can be obtained in the Philippines. However, since the implementation period is short, sufficient attention must be paid to the arrangements for

obtaining the construction machinery, ready mixed concrete, formworks, material for temporary works, etc.

(2) Precautions for Implementation

a) Cofferdam Construction

The construction of the rubber gates and sluice gates, the main work in this project, shall be intensively done in the dry season from November to May. Since the irrigation in the dry season must continue as before, the intake water level of EL.17.50 m shall always be maintained. Therefore, the top elevation of cofferdam shall be EL.18.00 m with freeboad. On the other hand, the completed gates is to be able to properly deal with the floods expected to occur in the rainy season, and hence the entire cofferdam must be removed before rainy season. The sluice gates the intake gates shall be installed within two-month period from April to May.

b) Preserving the Existing Concrete Structures

The main goal of this construction is to renew the existing gate facilities. Therefore, the special attention shall be paid to preserving these facilities when the minimum chipping is done to install the new facilities.

c) Riverbed Protection at Left-Bank Apron Downstream

Currently, the steel sheet pile in downstream of the left-bank apron area is partially exposed because of scouring. This construction shall be done to prevent further scouring. It is only chance to complete this construction within the temporary cofferdam.

d) Right-Bank Apron Downstream Riverbed Protection and Revetment

When the reconstruction of three of the spillway gates (rubber gates) are completed, the apron riverbed protection and revetment construction shall be started and then completed simultaneously as the remaining three gates are reconstructed.

e) Operation of spillway gate

Concurrent with the completion of the installation of rubber gate from left bank, gate operation for flood is required. Therefore, the technical transferral of facility functions and the outline of operation to the NIA maintenance staff must be conducted concurrently with the installation of additional facilities necessary for the gate operation.

f) Securing the Electric Power Supply and Other Power Sources for the Construction
To maintain the electric power supply and other power sources required for the construction, auxiliary power supply must be secured to deal with the blackouts expected to occur frequently and not to cause any problems in the progress of the construction.

g) Quality Control of Materials and Equipment
In principle, ready mixed concrete shall be used for the construction. Here, sufficient guidance and monitoring shall be given to the quality control of this concrete so as to meet the strength specified in the design standard. Additionally, similar efforts shall be made on the quality control of other materials such as reinforcing bars and formworks.

h) Observing the Specifications
All the necessary instructions for the implementation of this construction are written in the construction specifications. Therefore, when doing any work related to this project, appropriate work specifications must be observed.

3-1-3 Scope of Works

(1) Buying or Compensating for the Land

Although the works related to this project are conducted on the river location of the Angat (national land), if the whole or part of the construction requires the use of private land, it shall be the responsibility of the Philippines to negotiate with the land owners and buying or compensating for the land.

(2) Transportation Cost and Trial Run and Adjustment Cost

For the materials and equipment to be procured in Japan, the Japanese side shall bear the costs for transporting to the project site those requiring installation, adjustment and trial runs. Additionally, the Japanese side shall also bear the costs required for adjustments and trial runs. On the other hand, the materials and equipment to be procured in the Philippines shall be turned over on site in principle, all the costs of which shall be borne by the Japanese side.

(3) Supplying the Power

For the power required on the construction site, some drop wires branching from the trunk line crossing immediately downstream of the site and extending to the locations requiring power shall be installed and the power shall be put through transformers to lower the voltage before being used. The Philippines shall bear the costs of installing the drop wires from the trunk line to the transformers.

3-1-4 Consultant Supervision

(1) National Irrigation Administration (NIA)

The National Irrigation Administration (NIA) shall select and contract with the consultant for the detailed design and the supervision of this project. The design documents and tender documents prepared based on the results of detailed design of this consultant shall be approved by the NIA.

All the facilities completed according to the above design documents, after having been inspected and approved by the NIA, are handed over to the NIA. More specifically, the facilities completed up to the trial runs, as soon as the inspection is completed, are handed over one by one to the Philippine side.

(2) Consultant

If this project is implemented under the Japanese Grant Aid, a Japanese consultant recommended by the JICA shall conduct the following operations related to the detailed design and site supervision based on the contract with the executive organization (NIA) of the Philippine government.

a) Detailed Design

- Preparation of detailed design and tender documents related to the construction and materials and equipment for it
- Conducting the tendering operation on the Philippines' behalf and analyzing and appraising the tenders
- Attending the negotiations for a contract between the Philippines and the contractor related to the above tendering and giving advice
- Other necessary consulting services

b) Implementation Supervision

The consultant shall delegate on-site representatives to the Philippines, who will conduct or assist the following operations.

- Approving the construction drawing
- Supervising the construction progress and the quality control
- Informing and coordinating the activities with the concerned Philippine organizations
- Supervising and approving the construction records
- Inspecting the construction progress and issuing the construction completion certificate

3-1-5 Procurement Plan

The materials and equipment required for the construction shall be procured by Japanese general contractor who has a general contract for it. The materials and equipment mainly required shall be handled as described below. However, sufficient caution must be paid to the procurement because there may be a case where a large amount of materials and equipment are required at one time.

- Construction equipment: In Manila, the capital of the Philippines, there are many lease companies of general-purpose construction machinery which supposedly have sufficient number of devices to meet the needs of each construction site.
- Concrete: Since the suppliers of ready mixed concrete are confirmed to operate around the site, these suppliers supposedly have sufficient quality and supplying capacity of concrete to meet the needs of each construction site. However, this point must be checked again in the detailed design stage.
- Reinforcing bars: Reinforcing bars are produced and supplied in sufficient quantity in the Philippines.
- Pipes: PVC and GI pipes that may become necessary in this project have large demand and are produced sufficiently in the Philippines.
- Hardware such as gates: The spillway gates, sluice gates and ancillary equipment will be manufactured in Japan because of special designs and technologies requested.

3-1-6 Implementation Schedule

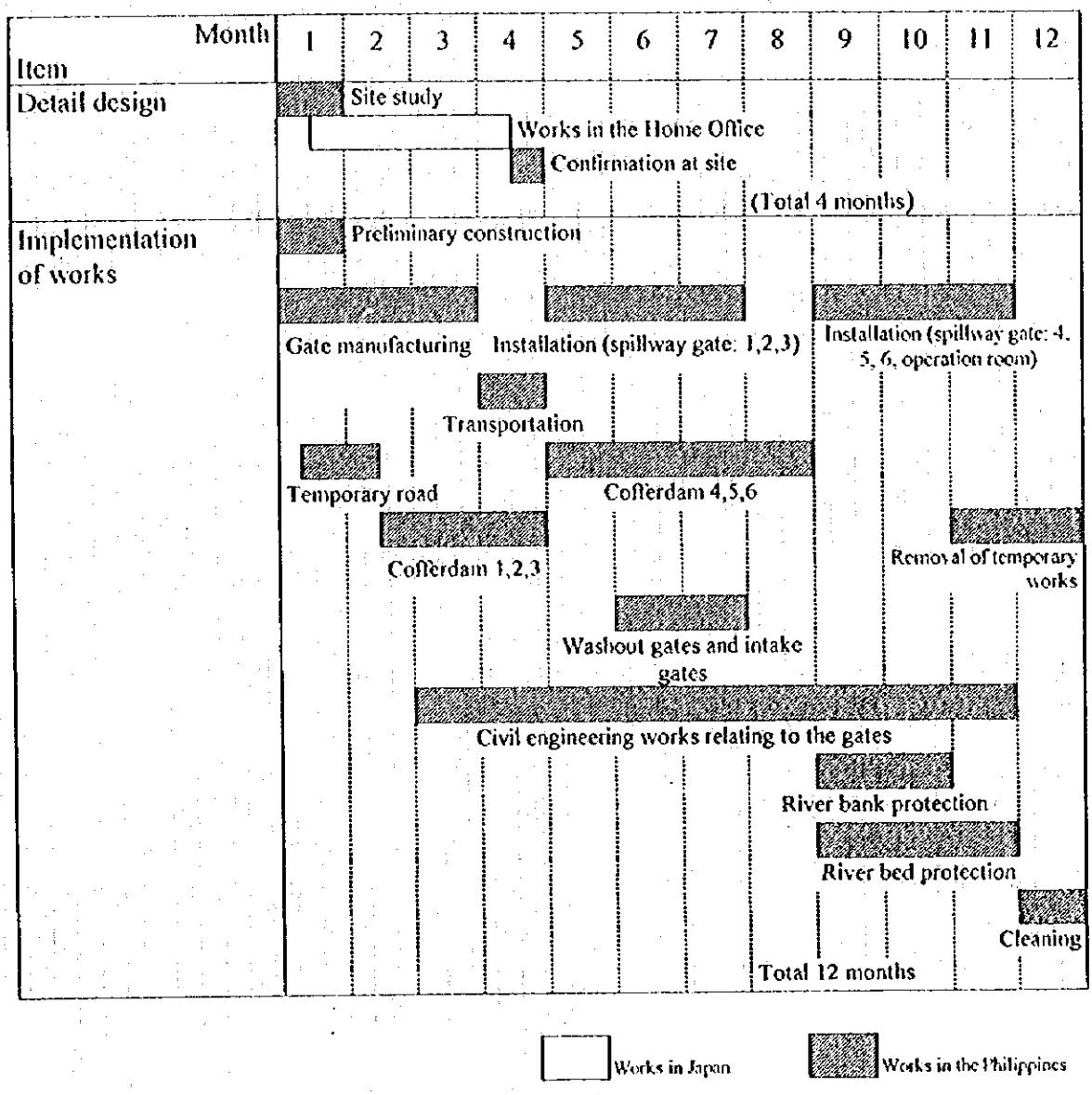
If this project is implemented under the Japanese Grant Aid, the consultant contract must be concluded after the E/N (Exchange of Notes) and appraised by the Japanese government. Then, it shall take four months to prepare the detailed design and tender documents and have them approved. After the construction contract with the contractor is verified, it shall take another twelve months to carry out the construction. Figure 3-1 shows the project implementation process chart (draft).

3-1-7 Items to be borne by the Philippines

If the grant aid is provided, the following items must be borne by the Philippines.

(1) After the implementation of this project is determined, necessary materials and information must be provided to the detail design study conducted by the Japanese consultant.
(2) The facilities necessary for the operation of the facilities in this project such as power source, water supply, and ventilation must be secured.
(3) Measures must be provided for the prompt unloading, customs clearance, and the transportation within the Philippines of the equipment to be delivered for this project.
(4) The taxes, the domestic taxes, and other financial surcharges charged to the preparation of equipment and the provision of services by the Japanese nation for this project must be exempted or borne by the Philippines.
(5) Necessary measures must be taken for the entry to and the staying in the Philippines of the Japanese nation to supply services for the implementation of this project.
(6) The permits necessary for the implementation of this project and the ratification of the said permits must be obtained in advance according to the laws of the Philippines.
(7) Based on the bank agreement, necessary commissions must be paid to the banks.
(8) The equipment prepared for this project must be maintained and operated appropriately and effectively. The operating situation of equipment must be reported to Japan as requested from Japan.
(9) All the other necessary expenses not included in the grant aid from Japan must be borne.

Fig. 3-1 Implementation schedule



3-2 Maintenance Plan

(1) Management organization

Organizations to manage the AMRIS area have been already completed at present and sufficiently fulfilling the functions. Even after the completion of this project, these organizations can be used continuously and are considered not necessary to be restructured into new organizations. However, the operation and the maintenance methods of newly updated facilities must have separate training courses.

(2) Operation and Maintenance Cost

The following shows the costs in the past five years for the operation and maintenance of the Angat Afterbay Regulator Dam.

Unit: Peso

Item \ Year	1991	1992	1993	1994	1995
1. Personnel costs	545,625	545,625	623,445	748,245	904,245
2. Other costs					
Levee repair	-	-	50,000	-	-
Sector gate maintenance	-	40,000	-	43,200	-
Lubrication and painting	7,200	8,400	9,600	10,800	12,000
Electric cost	5,400	6,000	6,600	7,200	8,400
Total	558,225	600,025	689,645	809,445	924,645
	(97.7%)	(90.9%)	(90.4%)	(92.4%)	(97.8%)

(%); Ratio of personnel cost to the total of annual costs

As shown in the above table, the personnel cost accounts for most of the costs for the maintenance and management of the Angat Afterbay Regulator Dam. Currently five gate-keepers are assigned, for whom this personnel cost seems a bit high, leading us to suppose that the cost for the personnel in the AMRIS office is included.

The differences caused in the maintenance and management between the current situation and this project are as follows:

- The sluice gate shall be improved to have an electric motor for the operation.
- The spillway gate shall be operated using a blower powered by a motor.

According to the above conditions, the maintenance and management costs after the project implementation are estimated as follows:

- Personnel cost: Approximately the same for the current personnel
- Gate maintenance: In ordinary situations, the rubberized gate is said to have a very small maintenance cost. In contrast, the spillway gates and intake gates supposedly need as much as the current situation; at least 12,000 pesos.

- Electric cost: Since all of the current facilities are manually operated, the electric cost shown in the above table supposedly corresponds to the general consumption in the control room, which shall also be required in the future. Therefore, the electric cost is expected to increase for the amount used by the rubberized gate and sluice gate. The electric consumption is estimated to be 2,400 KWH according to a separate calculation.

Electric cost = 2,400 × 14/KWH	=	33,600 P
Other costs =	=	8,400 P
Total		42,000 P

To sum up the above results, the annual costs for the maintenance and management after the project implementation is estimated as follows:

Personnel cost	904,000 P
Gate maintenance	12,000 P
Electric cost	42,000 P
Total	958,000 P

(3) Conclusion

The annual maintenance cost for this project has been estimated as 958,000 P as shown in the above, and this amount can sufficiently stand from the present capacity of the NIA.

CHAPTER. 4 Evaluation and Recommendation to the project

4-1 Verification of Suitability and Benefit to the Project

(1) Rehabilitation of spillway gates

The spillway gates at the Angat Afterbay Regulator Dam has the functions to smoothly flow down the flood occurring at the upstream of the Angat Afterbay Regulator Dam and to maintain the intake water level at EL. 17.50 m throughout the irrigation period of the area. Therefore if any accident occurs including the reduced function or the wash away of the gate, occurrence of the damage in the beneficiary area caused by the interrupted irrigation or the damage caused by the flood at the upstream or the downstream of the Angat Afterbay Regulator Dam could be anticipated.

As for the case in which the irrigation is interrupted, in the accident record document at the NIA management office on the wash out accident on No.1 sector gate in 1990, it was recorded that the intake level lowered to EL. 15.0 m and damages occurred to 70% of the entire beneficiary area.

Therefore, if only one gate is washed out in the future, the following damage is assumed to occur.

31,000 ha x 4.0 t/ha × 3,000 P/ton × 0.70 = 694.4 million peso = 2.8 billion yen

The amount of this damage can be assumed as the beneficiary effect to be expected from the present rehabilitation.

(2) Rehabilitation of washout gate

With the rehabilitation of washout gate, the storage effect planned at the time of construction as 3 to 4 million ton can be considered to be gradually restored.

(3) Mitigation of the damages caused by flood

With the recovery of the functions of spillway gate, it will be possible to prevent the rapid increase of water level caused by flood and the flood damage expected to occur at the upstream and the downstream of the Regulator Dam could be mitigated.

4-2 Recommendation

For the smooth implementation of this project, the following points must be considered.

(1) Before the commencement

It must be confirmed that the NIA has obtained the agreement from the farmers on the stopping of water intake for two months and the adjustment of planting period.

(2) During the rehabilitation

① Consideration to environment such as not to flow the muddy water caused by the work to downstream

② To prepare countermeasures to an unexpected deluge

(3) After completion

① For the prevention of the reduced functions of facilities, regular inspection and repair works must be securely implemented.

② For the safety of the dam body and the surrounding areas, regular repair works must be implemented to protect the river bank and river bed.

③ Operation manuals must be generated and on-the-site training must be implemented for the establishment of operating techniques for each gate. In particular, acquisition of the relationship between the degree of opening of the gate and the flow rate is extremely important for the water management.
Therefore, it is necessary to measure the inflow and the intake of the Angat Afterbay Regulator Dam, to estimate the amount of discharge from the gate, as well as to gradually clarify the relationship between the degree of opening of the gate and the discharge from the gate.