THE KINGDOM OF THAILAND

FEASIBILITY STUDY
ON
THE BANG NARA
IRRIGATION AND DRAINAGE PROJECT

EXECUTIVE SUMMARY REPORT

DECEMBER 1986

JAPAN INTERNATIONAL COOPERATION AGENCY

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PREFACE

In response to the request of the Government of the Kingdom of Thailand, the Japanese Government has decided to conduct a feasibility study on the Bang Nara Irrigation and Drainage Project and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to Thailand a survey team headed by Mr. Yasushi MIYAZAKI of Sanyu Consultants Inc. two times during a period June, 1985 to March, 1986.

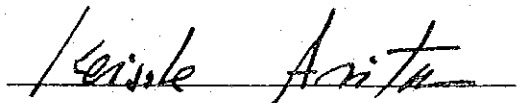
The team exchanged views with the officials concerned of the Government of Thailand and conducted a field survey in Changwat Narathiwat.

After the team returned to Japan, further studies were made and the present report has been prepared.

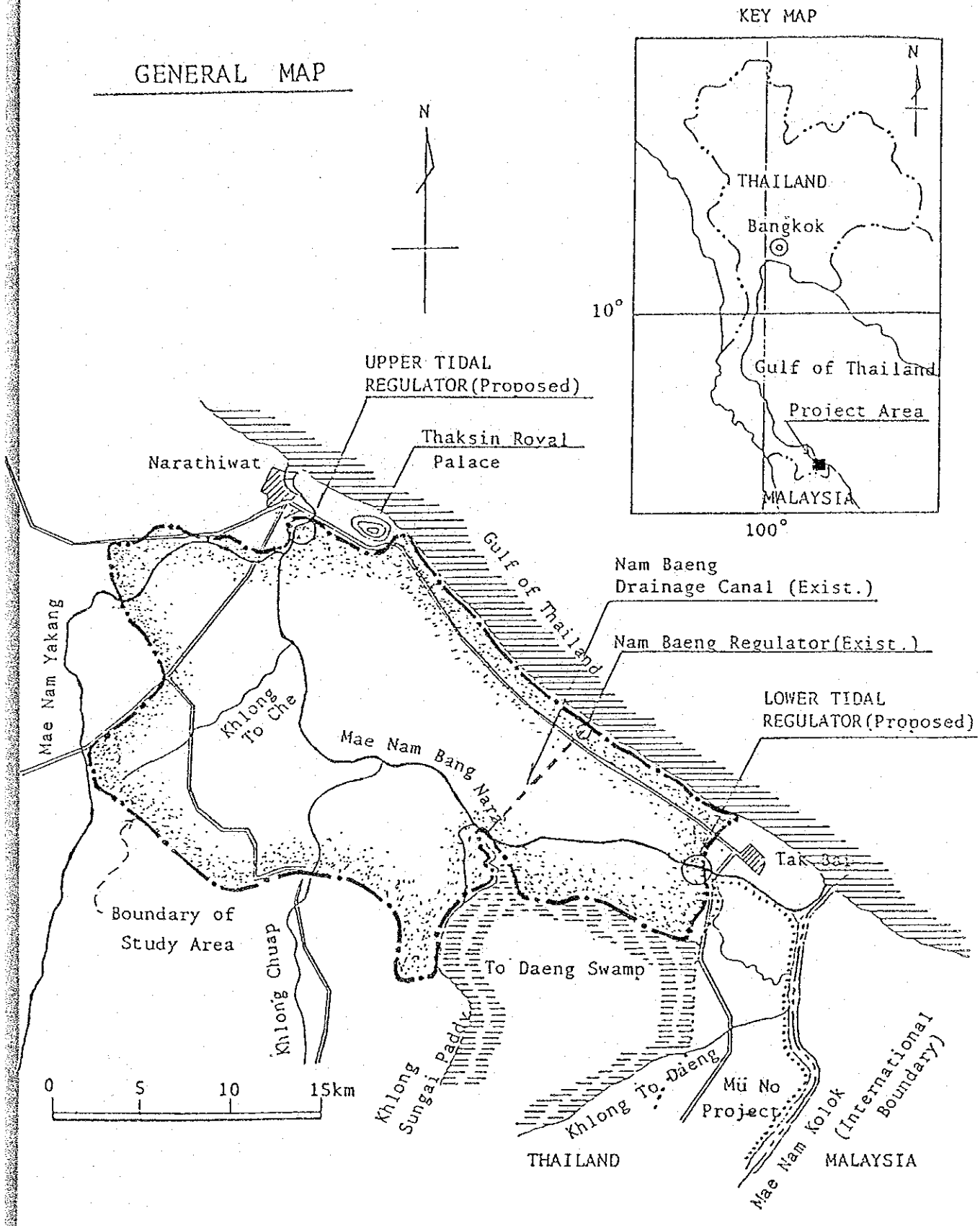
I hope that this report will serve for the development of the Project and contribute to the promotion of friendly relations between our two countries.

I wish to express my deep appreciation to the officials concerned of the Government of the Kingdom of Thailand for their close cooperation extended to the team.

December, 1986



Keisuke ARITA
President
Japan International Cooperation Agency


GENERAL MAP
N
KEY MAP
N
THAILAND
Bangkok
10°
Gulf of Thailand
Project Area
MALAYSIA
100°
UPPER TIDAL
REGULATOR(Proposed)
Thaksin Royal
Palace
Narathiwat
Gulf of Thailand
Nam Baeng
Drainage Canal (Exist.)
Nam Baeng Regulator(Exist.)
LOWER TIDAL
REGULATOR(Proposed)
Mae Nam Yakang
Khlong
To Che
Mae Nam Bang Nara
Tak Bai
Boundary of
Study Area
Khlong Chuap
To Daeng Swamp
Khlong
Sungai Padi
Khlong To Daeng
Mu No
Project
Mae Nam Kolok
(International
Boundary)
THAILAND
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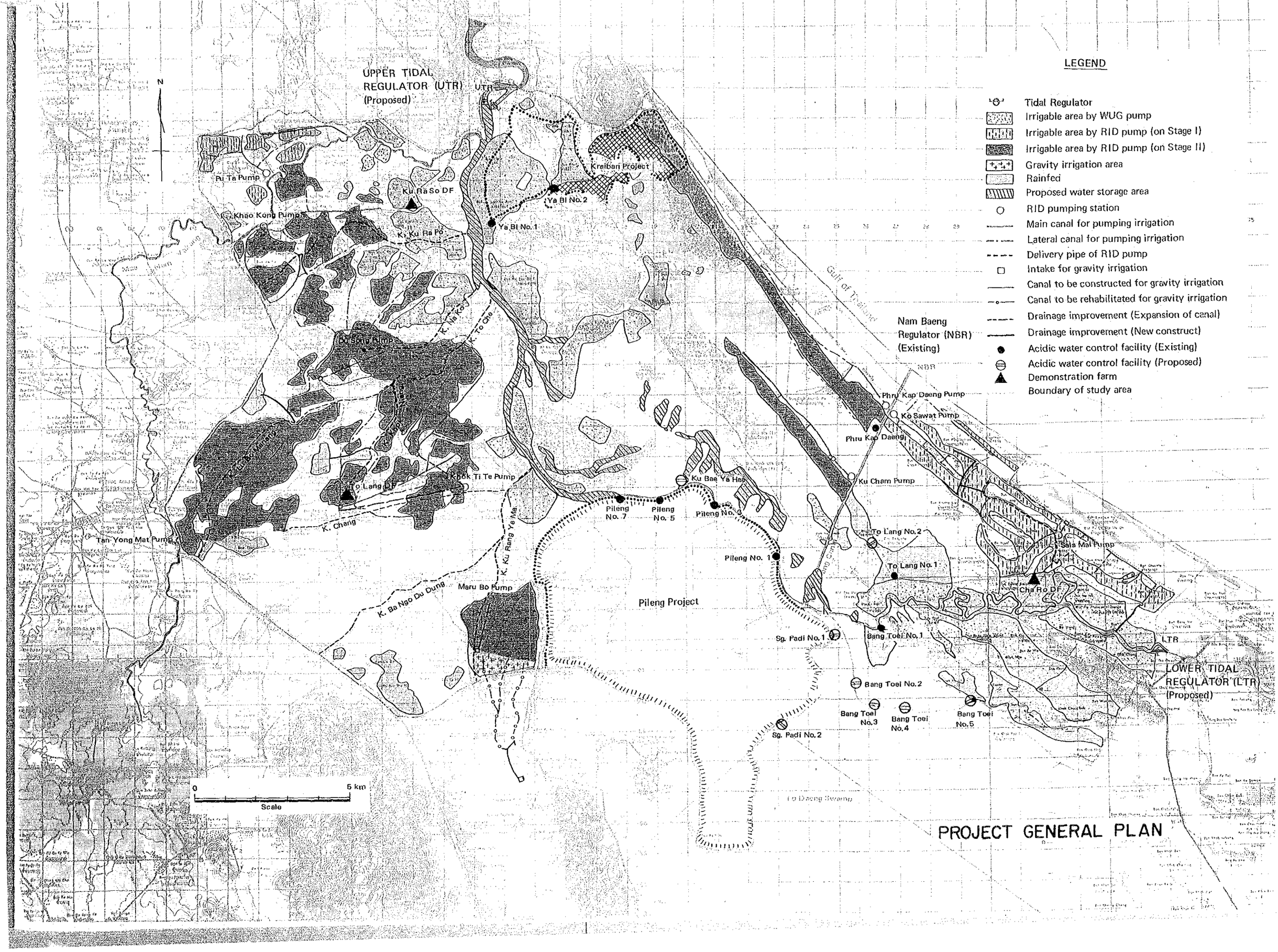


PROJECT GENERAL PLAN

CONTENTS

Page

Preface

Project Location Map

Project General Plan

1. INTRODUCTION 1

2. THE STUDY AREA 2
2.1. Location and Socio-Economic Overview 2
2.2. Population and Farm Households 3
2.3. Land Use 4
2.4. Agriculture 5
2.5. Mae Nam Bang Nara 7
2.6. Existing Constraints and Development Approach 9

3. PLAN FORMULATION 10
3.1. Objectives 10
3.2. Agricultural Development Plan 11
3.2.1. Land Use Plan 11
(1) Land Use 11
(2) Project Service Area 12
(3) Irrigation Development 13
(4) Drainage Improvement 15
(5) Irrigated Cropping Patterns 15
3.2.2. Agricultural Production 18
3.2.3. Water Storage Fisheries Development 19
3.3. Project Facilities 19
3.3.1. Tidal Regulators 19
(1) Location and Size 19
(2) Water Storage Effect 22
(3) Inundation Alleviation Effect 23
3.3.2. Irrigation and Drainage Facilities 24
(1) WUG Pumping Irrigation Scheme 24
(2) RID Irrigation and Drainage Scheme 24
3.3.3. Acidic Water Inflow Control Scheme 26
3.4. Rural Infrastructure 28

4. PROJECT IMPLEMENTATION PROGRAMME 28
4.1. Organization and Management 28
4.1.1. Project Implementing Agencies 28
4.1.2. Project Management and Implementation 29
(1) Project Lead Agency 29
(2) Project Policy and Steering Structure 29
(3) Special Task Force Unit 30

Page

4.2. Construction and O&M of Major Work 31
4.2.1. Mode and Procurement of Construction Work 31
4.2.2. Construction of Two Tidal Regulators..... 32
4.2.3. Construction of RID Irrigation and Drainage Scheme 32
4.3. On-Farm Work Development..... 34
4.3.1. Size of Tertiary Irrigation Service Units..... 34
4.3.2. Demonstration Farms 34
4.3.3. Construction of On-Farm Work 35
4.4. Consulting Services and Staff Training..... 35
4.4.1. Consulting Services 35
4.4.2. Staff Training 37
4.5. Project Implementation Schedule 37
4.6. Staging of the Project Development 38
4.6.1. Concept for Staged Development 38
4.6.2. Stage I Development 39
4.6.3. Stage II Development 40
4.7. Cost Estimate 40
4.7.1. Project Cost 40
4.7.2. O&M Cost 41

5. PROJECT EVALUATION 47
5.1. Economic Analysis 47
5.1.1. Project Benefit 47
5.1.2. Economic Internal Rate of Return 47
5.2. Farm Incomes 49
5.3. Indirect Effects of the Project 50

6. RECOMMENDATION ..... 52 to 53

DRAWINGS

Page

LIST OF TABLES

Table S-1. Land Use Plan 12
Table S-2. Project Service Area 12
Table S-3. Cropping Patterns with the Project 17
Table S-4. Agricultural Production without and with the Project 18
Table S-5. RID Tidal Regulators 21
Table S-6. RID Pumping Irrigation Scheme 25
Table S-7. RID Drainage Improvement Scheme 25
Table S-8. RID Acidic Water Inflow Control Scheme 27
Table S-9. Project Cost Summary 42
Table S-10. Project Cost Summary by Fiscal Year 45
Table S-11. Project Cost Summary by Fiscal Year for Stage I Development 46
Table S-12. Net Production Value without and with the Project.. 48
Table S-13. Farm Budgets..... 49

LIST OF FIGURES

Figure S-1. Construction Schedule: Two Tidal Regulators 33
Figure S-2. Project Implementation Schedule 36

LIST OF DRAWINGS

No. RI Upper Tidal Regulator: General Plan
No. R2 Upper Tidal Regulator: Regulator Body (1/2)
No. R3 Upper Tidal Regulator: Regulator Body (2/2)
No. R4 Upper Tidal Regulator: Gate Arrangement
No. R5 Upper Tidal Regulator: Bang Nara Closure Dam
No. R6 Lower Tidal Regulator: General Plan
No. R7 Lower Tidal Regulator: Regulator Body
No. R8 Lower Tidal Regulator: Gate Arrangement
No. R9 Lower Tidal Regulator: Bang Nara Closure Dam
No. ID9 Irrigation Facilities: Inclined Pumps
No. ID4 Irrigation Facilities: Pump Discharge Tanks and Irrigation Canals
No. ID10 Drainage Facilities : River Channel Improvement

1. INTRODUCTION

1.1. The Study area is located in Changwat Narathiwat of the Lower Southern region of Thailand being adjacent to the Thai-Malaysian border and has been identified to be socially and economically depressed as compared to the rest of the Southern region and the Kingdom as a whole. Particular attention has been, therefore, paid to the planning and formulation of an agricultural development in the Study area. At present, Mae Nam Bang Nara which lies in the center of the Study area is tidal and saline throughout its course being directly affected by the tidal oscillations of the Gulf of Thailand and also is frequently inundated along the river during the heavy rains, so that the agricultural development in the Study area is strongly handicapped.

1.2. In response to the request made by the Government of the Kingdom of Thailand (hereinafter referred to as "the Government") on 13 February 1985, the Government of Japan decided to implement the feasibility study on the Bang Nara Irrigation and Drainage Project (hereinafter referred to as "the Study") within the general framework of technical cooperation between Japan and Thailand as signed on 5 November 1981. The Japan International Cooperation Agency (hereinafter referred to as "JICA"), the official agency responsible for the implementation of technical cooperation programmes of the Government of Japan, commenced the Study in close cooperation with the Royal Irrigation Department (hereinafter referred to as "RID") and other authorities concerned.

The Phase I (pre-feasibility) Study was carried out during the period of June to November 1985 to conduct a preliminary study on the agricultural development plan in the Study area. This draft Final Report for the feasibility study has been prepared based upon the results of the Phase II (feasibility) Study consisting of the field work from December 1985 to March 1986 and the home office work from June to August 1986.

2. THE STUDY AREA

2.1. Location and Socio-Economic Overview

The Study area with the land area of 46,700 ha is situated in the northeastern part of Changwat Narathiwat and in the basin of Mae Nam Bang Nara with a total drainage area of 1,401 sq.km being penetrated through the low-lying coastal plain along the east coast of the Thai peninsula. It is located some 1,200 km far away from Bangkok.

The Study area covers portions of 4 Amphoe, viz. Muang Narathiwat, Yingo, Rangae and Tak Bai, occupying about 11 percent of the Changwat area and 18 percent of the Changwat population. The population of Narathiwat at the end of 1984 totals about 484,000, the majority of which are Thai Muslim and prefer to communicate in Jawi. The gross domestic product (GDP) of Changwat Narathiwat is compared to that for the rest of the country.

	Changwat Narathiwat	Southern Region	Kingdom
1983 per capita GDP (฿)	12,900	16,200	18,800
Per capita GDP growth rate	(1978 to 1983)		
	0.6%	0.7%	3.4%

Agriculture is the main productive sector in Changwat Narathiwat accounting for 46 percent of total output, whereas the industrial sector has an output value of only 9 percent. This means that the Changwat economic structure has an obviously narrow base. Within the agricultural sector, the crop product occupies 90 percent of its total output value that is extremely high as compared with others and has the annual growth rate of 0.3 percent that is quite low. The livestock and fishery sectors have 7.3 percent and 1.4 percent of the total agricultural output respectively, but the annual growth rate has been recorded at 5.7 percent and 18.3 percent respectively.

2.2. Population and Farm Households

The demographic information in the Study area in the mid-1985 explains the population of 63,810, the households of 11,665 and the average family size of 5.5, in which the farm population constitutes 83 percent or 52,760 in 9,660 families. The average family size of 5.5 is considerably higher than the Narathiwat average of 4.8 and the Southern region of 5.2. Population growth rate slightly increased from 2.0 percent in the latter half of the 1970s to 2.1 percent.

There are several pattern farms which would be largely classified into sole paddy group (approximately 40 percent) and mixed paddy/rubber group (approximately 60 percent. Average farm size would be 1.9 ha and 2.5 ha, respectively. Such small farm size and the low productivity are combined to maintain the agricultural income low. The low farm income and relatively large family size to support account in part for the high proportion of the farmers with off-farm income which would be derived from the rubber tapper, unskilled construction labor and the seasonal employment in Malaysia.

It has been estimated that annual average per capita income in the Study area's farm households would be slightly above ฿4,000 which is compared to the Thai average rural per capita income of ฿5,580 in 1985 price. The 1985 poverty line in the Thai rural area of ฿3,870 per capita explains that some of the small and medium farmers (say, 20 to 30 percent) would be on the poverty line.

2.3. Land Use

The present land use survey outlines that the farm land would be composed of the paddy field of 12,430 ha (27 percent), the rubber planted area of 8,320 ha (18 percent), the coconut planted area of 4,380 ha (9 percent) and other miscellaneous. In addition, three Forest Reserves such as (1) Laem Nam Bang Nara I, (2) Kok Mai Rua, and (3) part of Laem Nam Bang Nara II have been designated with a total area of 12,400 ha (27 percent). The majority of such forests are located as swamp forests in the low-lying land around Mae Nam Bang Nara. (refer to Table S-1 in para. 3.2.1.)

Comparison of the aerial photographs taken in March 1984 with those in 1975 indicates very little change. This means that the land use in the Study area has been stabilized to a high degree with the exception of intrusions into residual upland forest and swamp forest for pasture and paddy field development both by the Government agencies and by individual illegal settlers.

Changwat Narathiwat Office explains that in the Study area, (1) any wildlife propagation site and archaelogical and historical and cultural treasure have not been recognized to date, and (2) at present, there is no wildlife conservation site, but a study area (50 ha) for the wildlife inside the Forest Reserve "Kok Mai Rua", while the non-hunting area is in the Forest Reserves "Laem Nam Bang Nara I and II".

2.4. Agriculture

The climate of the Study area which is typical of an equatorial location with a full-time maritime exposure is featured by uniform temperatures throughout the year (annual mean: 27.2°C), high humidity (annual mean: 80.7%) and heavy rainfall.

The greatest single influence on the rainfall pattern is caused by the northeast monsoon during the period of November to January which accounts for about 50 percent of annual rainfall. Annual rainfall varies from about 2,500 mm at Narathiwat and 2,200 mm at Tak Bai along the coast to less towards the inland with the record of 1,600 mm at Rangae. The rainfall is of highly seasonal nature with the period of February to April for low rainfall. The months of May to August during the southwest monsoon have moderate rainfall averaging about 200 mm per month, and during this period, the off-season paddy and field crops cannot grow without having irrigation.

For the present paddy field, the main-season paddy which is rainfed and photo-sensitive is cultivated with the transplanting in September and October and the harvesting in February and March. Salient features of paddy production in the Study area are presented below:

- Some of the paddy field is flooded directly from Mae Nam Bang Nara, Mae Nam Yakang and their small tributaries, and also inundated by the impeded poor drainage.

- Due to the variability in the onset of monsoon rains, most of the area is subject to suboptimal time of the preparation of nursery bed and land and subsequent transplanting.

- Early finish of the monsoon rains is quite common resulting in dry fields and moisture stress during the grain development and maturation after flowering in January when the risk of heavy rain and flood passes.

- The soils have a rather low level of fertility with the nitrogen and phosphate required to get the satisfactory yields. Some areas are underlain by an acid sulfate material and also rendered unproductive by the water deficit problems when the soils are over-drained.

- These factors, being coupled with lower input, low yield and return and more attractive return to the off-farm work, have indicated the reason why 30 to 40 percent of the paddy field is not planted. This tendency could be expected to be further aggravated unless the appropriate measures are taken to reduce the risk factors and to make the paddy production more attractive.

- Paddy production data by Amphoe concerned with the Study area explain that average rates of planted/total field and harvested/planted would be 68 percent and 87 percent, respectively. With an average yield for the planted area that is estimated at 1.4 ton per ha, a total annual production of the main-season paddy accounts for some 12,100 ton which would be insufficient to meet the local demand in the Study area.

Rubber is the dominant perennial crop. The area planted is 8,320 ha accounting for some 30 percent of the total agricultural land in the Study area, with the following factors:

- While some of the rubber grow in the better soils with fair drainage, the rubber planted in the flood-prone area is water-logged for part of the year with consequent reductions in yield.

- The rubber production practices are featured by a low input-low output approach. Most of the current rubbers are either unselected seedling material of low yield potential or over-aged, and have not been fertilized.

- Most of the farmers tap daily but suspend during the period of rainfall and inundation. Standards of tapping are generally low, especially among hired tappers, resulting in excessive bark consumption and damaged and infected panels. Standards of on-farm processing to unsmoked sheet are also low with the use of sulphuric acid.

- Out of the total rubber planted area, about 74 percent or 6,190 ha would be suffering from the decrease of tapping days due to annual flooding and inundation as well as less response to the replanting with improved higher yielding clones, resulting in low production.

2.5. Mae Nam Bang Nara

Mae Nam Bang Nara is running through the low-lying coastal plain being parallel to the east coast, with a total length of about 60 km and two outlets at Narathiwat to the ocean and Mae Nam Kolok connection, about 2 km upstream of its river mouth at Taba. It has a total catchment area of 1,401 sq.km dividing into 677 sq.km for Mae Nam Bang Nara and 724 sq.km for its major tributary, Mae Nam Yakang. It has been estimated that its average annual runoff would account for 1,834 million cu.m, of which 700 million cu.m are from Mae Namg Bang Nara and 1,134 million cu.m from Mae Nam Yakang, and about 60 percent of which is being concentrated during the rainy season from November to next January.

In connection with this Project, RID constructed the Nam Baeng tidal regulator in the Tak Bai area in 1983 with the excavation of the Nam Baeng drainage channel which is connected to the middle course of Mae Nam Bang Nara. Although this scheme would have given an effect of reduction of the annual inundation during heavy rains, there would be a tendency to promote the drainage over the low-lying swamp areas in its vicinity during the dry season.

The following three major problems with respect to the current conditions involved in Mae Nam Bang Nara have been pointed out:

(1) Salinity Intrusion

Mae Nam Bang Nara which has less slope is tidal and brackish throughout its entire course being directly affected by the tidal oscillations with the salinity intrusion into the river during the high tides. A wide seasonal fluctuation of the salinity is observed throughout its course, especially higher during the dry season; hence, this has refused an effective utilization of this water for agriculture.

(2) Annual Inundation and Flooding

Heavy rainfalls in spells of 3 to 5 days occur during the northeast monsoon particularly in December resulting in frequent flooding and inundation over the low-lying areas along Mae Nam Bang Nara with its peak water level at about EL +2 m. On the other hand, attenuation of the flood water in Mae Nam Yakang from Rangae to its mouth occurs due to the overtopping at river bank and the subsequent flooding takes place over the high-lying land towards Mae Namg Bang

Nara. Additionally, there are deep and prolonged inundation and impeded drainage in the eastern part of the Study area with the flood originating from the Bang Nara tributaries.

(3) Inflow of the Acidic Water

In the vicinity of the bifurcation of the Nam Baeng drainage channel from Mae Namg Bang Nara and other small drainage channels recently excavated, as well as in the area of the Pileng land settlement project, the sulfate ions are being dissolved from the leachate of actual acid sulfate soils in connection with the dehydration of pyrite. The field observation shows that there would be sites with the Bang Nara water of pH value close to 4 during the less rainfall period.

2.6. Existing Constraints and Development Approach

The farm households numbered at 9,660 in the Study area have relatively small farm size as compared to other regions partly in connection with the traditional southern land inheritance system and additionally suffer from the unstable and low productivity of main-season paddy with many risk factors. On the other hand, the rubber production would have less incentive for its improvement due to the inundation and impeded drainage problems. Although the off-farm employment is popular to support their low farm income and large family size, the present income level is low being close to the Thai rural poverty line.

Particular attention has been paid to the average wage rate of ฿150 per day earned in the neighbouring Malaysia which is more than two times higher than the Study area wage of ฿60 per day. This would have been related to the severe problem in terms of the *socio-economic underdevelopment and further generated the*

social-psychological and security problems in this border Changwat; therefore, it has been recognized that the economic development in the Study area is an urgent matter.

It would not be easy to enlarge the above mentioned small sized farm households taking into consideration less impact from the new land development and settlement scheme currently promoted by the Government because of its small scale as well as the less feasibility for the reclamation of swamp forests in terms of the problem soils. Under this circumstance, the top priority should be given to development of the Bang Nara water resources which have not been utilized to date. In line with this, it would be an approach to promote, on maximum scale, an in-situ agricultural development through the construction of tidal regulators at two outlets with the control of acidic water inflow and the subsequent provision of irrigation and drainage facilities.

3. PLAN FORMULATION

3.1. Objectives

The planning and formulation of the agricultural development in quick yielding manner should be made in line with the prime objective related to the social welfare and poverty alleviation as well as the national rural development policy.

The proposed Project has been formulated in line with a strategy that the water resources in the Mae Nam Bang Nara basin should be made available for irrigation development while the annual inundation during the heavy rains should be alleviated to a possible extent. In order to attain this strategy, it would be essential to build, in addition to existing Nam Bang tidal regulator, a tidal regulator (or a salinity barrier) at each

side of Narathiwat and Tak Bai along Mae Nam Bang Nara for the purpose of the exclusion of salinity intrusion and the provision of water storage for irrigation development, and concurrently to reduce the annual inundation over the low-lying area along Mae Nam Bang Nara through proper operation of the relevant tidal gates.

The next step would be (1) to provide the irrigation and drainage facilities for the possible service area with an aim to enhance the agricultural productivity in existing farm land, and (2) to stabilize this area from the socio-economic-political viewpoint in such manner that the irrigation distribution system would be planned to be capable of actual delivery of water to the maximum number of farmers within a scope that the national socio-economic policy would permit. And, at the same time, a full support from the Government agencies concerned would be extended to the Muban families who could get the maximum benefits at the earliest practicable date.

3.2. Agricultural Development Plan

3.2.1. Land Use Plan

(1) Land Use

The land use plan in the Study area as formulated under the Project is given in Table S-1.

The perspective for new land development is limited to minor extent involving the rehabilitation of land on the fringes of swamp forests and ridge depression. The proposed Project would not incorporate any component to reclaim the swamp forests for paddy field because of poor soil conditions and related high development cost.

Table S-1. Land Use Plan

(Unit : ha)

Land Type	Present Total in the Study Area	The Project							Outside the Project
		Irrigation Development and Drainage Improvement 1/			Drainage Improvement			Conversion to Fruit	
		Paddy Field	Right-of-Way	Total	High-lying	Low-lying	Total		
Paddy Field	12,430	9,980	340	10,320	520	-	520	-	1,590
Rubber Area	8,320	-	-	-	6,190	60 2/	6,250	-	2,070
Coconut Area	4,380	-	-	-	-	-	-	-	4,380
Orchard	1,180	-	-	-	-	-	-	-	1,180
Forest Reserve	12,400	-	-	-	-	-	-	-	12,400
Communal Copse	600	-	-	-	-	-	-	60	540
Others	7,390	-	-	-	-	-	-	-	7,390
Total	46,700	9,980	340	10,320	6,710	60	6,770	60	29,550

1/ ..... Including those for irrigation development only.

2/ ..... With operation of the tidal gates.

(2) The Project Service Area

The area to be served by the irrigation development and drainage improvement under the proposed Project would be enumerated by development component as shown below:

Table S-2. Project Service Area

(Unit: ha)

	Drainage Improvement	Irrigation Development				Total
		WUG Pumping	RID Pumping	Gravity	Total	
(1) Irrigation Development Only						
Paddy Field	-	3,520	1,990	140	5,650	5,650
(2) Irrigation Development + Drainage Improvement						
Paddy Field	-	350	3,940	40	4,330	4,330
(3) Drainage Improvement Only						
Paddy Field	520	-	-	-	-	520
Rubber Area	6,250	-	-	-	-	6,250
Sub-total	6,770	-	-	-	-	6,770
Total	6,770	3,870	5,930	180	9,980	16,750
Paddy Field	520	3,870	5,930	180	9,980	10,500
Rubber Area	6,250	-	-	-	-	6,250

(3) Irrigation Development

- It would be a basic principle to make supplemental irrigation for the main-season paddy and full irrigation for the off-season field crops and vegetables in existing rainfed paddy field.

- With the target to maximize the irrigable area on the basis of the available water resources in line with the objective as mentioned in para. 3.1. existing rainfed paddy field of 9,800 ha would be converted into the irrigated one by pumped up water from the proposed Bang Nara storage and its upstream Mae Nam Yakang. In the water storage balance simulations, the minimum river maintenance flow of 5 cu.m per sec for the lower reaches of Mae Nam Bang Nara in terms of water environment and river entrance sand bar at Narathiwat estuary and the future demand of 1 cu.m per sec including the domestic water supply for Narathiwat Municipality have been taken into consideration.

- With a view to diverting the available streamflow in the Bang Nara tributaries, existing rainfed paddy field of 180 ha in the upstream of Khlong Maru Bo would be irrigated in the gravity manner with an aim to improve the rainfed field as much as possible.

- Taking into account the impounding water level of the Bang Nara water storage, the proposed irrigation schemes would depend upon the pumping method as a whole. Under this circumstance, two modes of the pumping irrigation have been delineated:

Portable pumping scheme:

° Existing paddy field below EL +2 m on an average which is distributed on the fringe of the Bang Nara water

storage would be irrigated by portable lift pumps utilizing existing small tributaries and drains reversely from the water storage. It could be mentioned that this type of the small pumps have been procured and operated by many farmers or their groups in the Mae Nam Chao Phraya Basin and Northeast Region. This is hereinafter referred to as "WUG pumping irrigation scheme".

Fixed pumping scheme:

° Existing paddy field with EL +2 to 13 m would be irrigated by fixed type pumps with some improvement of existing small tributaries and drains from the Bang Nara water storage. Following this, the main and lateral canals would be provided upto the outlets into each terminal service unit. This is referred to as "RID pumping irrigation scheme".

- The service area proposed under the irrigation development as mentioned above is summarized below:

(Unit: ha)

*	Pumping irrigation from the Bang Nara Water Storage and Mae Nam Yakang		
	Paddy field, below EL +2m on an average by portable pump	3,870	(40) (39)
	Paddy field, EL+2 to 13 m by fixed pump	5,930	(60) (59)
	Sub-total	9,800	(100) (98)
*	Gravity irrigation from the Bang Nara tributary	180	(2)
	Total	9,980	(100)

(4) Drainage Improvement

Apart from the effect of flood mitigation over the low-lying land along Mae Nam Bang Nara by two proposed tidal regulators, appropriate drainage improvement scheme would be provided for 7 sub-areas over the high-lying land covering the western part of the Project area where the overtopping of Mae Nam Yakang occurs and the eastern part with the flood originating from the Bang Nara tributaries. This scheme which intends not to prevent the flooding but to alleviate deep and prolonged inundation and impeded drainage would serve existing paddy field of 4,850 ha and rubber planted area of 6,190 ha with the improvement of existing river tributaries and drains by widening and deepening.

(5) Irrigated Cropping Patterns

The irrigated cropping patterns composed of 98 percent of the main-season paddy, 2 percent of the perennial forage crops and 25 percent of the off-season field crops and vegetables would be introduced under the Project.

Increased production of the main-season paddy would contribute to overcome the present rice deficit in the Study area. In view of the current Government policy not to increase the rice production due to the depression of its export and the unfavorable farm gate price, the production of off-season paddy has not been incorporated into a plan.

Extent of the off-season field crops and vegetables which would take a form of the collective cultivation on the basis of a Muban cooperative has been worked out at the realizable level taking into account the availability of farming labor and the possible marketing of such products to the neighboring Malaysia in connection with completion of the on-going Taba New Town Development Scheme as well as the increasing local demand including that of Hadyai/Songkhla region.

It is also intended that with a view to promoting the livestock development, the perennial green mowed forage crops such as Torpedo and Para Grass have been incorporated into the irrigation plan in the area above EL +1.8 m which would not be so suitable for the paddy cultivation mainly due to soil property and would be cultivated on the basis of Muban cooperative operations. In addition, the promising fruit such as Long Kong which would not be directly irrigated could be introduced with the conversion of the present communal copse-wood land where a higher groundwater table would be kept in the vicinity of the paddy fields under irrigation throughout the year.

The proposed cropping patterns under the Project are shown in Table S-3.

Table S-3. Cropping Pattern with the Project

(Unit : ha)

	Total Area	%	By Irrigation Type: WUG Pumping Below EL1.8m	WUG Pumping EL1.8 to 4m	WUG Pumping Total	By Irrigation Type: RID Pumping & Gravity EL 2 to 13 m	By Stage: Stage I WUG Pumping	Stage I RID Pumping	Stage I Total	Stage II RID Pumping & Gravity
(1) Paddy Field										
Service Area	9,980	100	3,370	500	3,870	6,110	3,870	1,240	5,110	4,870
Main-Season Paddy										
Local Improved	3,370		3,370	-	3,370	-	3,370	-	3,370	-
HYV (RD13)	4,810		-	364	364	4,446	364	903	1,267	3,543
HYV (RD 7)	1,600		-	121	121	1,479	121	300	421	1,179
Sub-toal	9,780	98	3,370	485	3,855	5,925	3,855	1,203	5,058	4,722
Off-Season Field Crops and Vegetables										
Sweet Corn	620		210	31	241	379	241	77	318	302
Mung Bean	620		210	31	241	379	241	77	318	302
Groundnuts	620		210	31	241	379	241	77	318	302
Vegetables	620		210	32	242	378	242	77	319	301
(Tomato)	(310)		(105)	(16)	(121)	(189)	(121)	(38)	(159)	(151)
(Chilli)	(310)		(105)	(16)	(121)	(189)	(121)	(39)	(160)	(150)
Sub-total	2,480	25	840	125	965	1,515	965	308	1,273	1,207
Perennial Forage										
Torpedo/Para Grass	200	2	-	15	15	185	15	37	52	148
Total	12,460	125	4,210	625	4,835	7,625	4,835	1,548	6,383	6,077
(2) Conversion from Communal Copse-Wood Land (not irrigated)	60		20	3	23	37	23	8	31	29
Tree Fruit										
Long Kong										

3.2.2. Agricultural Production

The agricultural production without and with the condition of the Project in its service area is compared in terms of planted area, yield and production.

Table S-4. Agricultural Production Without and With the Project

	Planted Area		Yield		Production		
		*/		*/		*/	
	Without	With	Without	With	Without	With	Incremental
	....(ha)...		..(ton/ha)..		.....(ton).....		
				*/	.... At full development		
Main-Season Paddy							
(1) Irrigation and Drainage Improvement							
	7,018	9,780			9,766	31,710	21,944
(Local Improved)	(2,366)	(3,370)	(1.3)	(2.8)	(3,076)	(9,436)	(6,360)
(HYV-RD 13)	(3,489)	(4,810)	(1.4)	(3.4)	(5,018)	(16,354)	(11,336)
(HYV-RD 7	(1,163)	(1,600)	(1.4)	(3.7)	(1,672)	(5,920)	(4,248)
(2) Drainage Improvement Only							
	354	354	1.3	1.7	460	602	142
Total	7,372	10,134			10,226	32,312	22,086
Off-Season Field Crops and Vegetables (Irrigation)							
Sweet Corn	-	620	-	3.0	-	1,860	1,860
Mungbean	-	620	-	1.2	-	744	744
Groundnut	-	620	-	1.8	-	1,116	1,116
Vegetables	-	620					
(Tomato)	(-)	(310)	(-)	(15.0)	(-)	(4,650)	(4,650)
(Chili)	(-)	(310)	(-)	(12.0)	(-)	(3,720)	(3,720)
Total		2,480					
Perennial Forage Crop (Irrigation)							
Torpedo/Para Grass	-	200	-	40.0	-	8,000	8,000
Rubber (Drainage Improvement)							
	6,250	6,250	0.71	0.96	4,438	6,000	1,562
Tree Fruit							
Long Kong	-	60	-	4.0	-	240	240
Bang Nara Water Storage Fisheries							
		(Water Surface Area)					
	-	1,390	-	0.15	-	209	209

3.2.3. Water Storage Fisheries Development

With the construction of two tidal regulators and acidic water flow check facilities for the strategic basins, the Bang Nara water storage would have a potential to promote the freshwater capture fisheries under extensive low-input farming with the review of storage morphometry, water quality still being slightly acidic and nutrient increases. Management of this fisheries would be developed with the stocking and restocking with appropriate fish species at adequate levels if the fisheries are sufficiently productive and economic. (Refer to Table S-4 in para. 3.2.2.)

3.3. Project Facilities

3.3.1. Tidal Regulators

(1) Location and Size

In addition to existing Nam Baeng channel and its outlet tidal regulator with a total gate opening width of 24 m, the most appropriate plan has been proposed to establish the Upper Tidal Regulator with a total gate opening width of 120 m to be located some 6 km upstream of the Narathiwat river mouth and about 1 km downstream of Mae Nam Yakang's confluence and of the Lower Tidal Regulator with a total gate opening width of 24 m some 7 km upstream of the Mae Nam Kolok connection. These two sites have been identified by RID with a top priority for the urgent construction, and RID has already completed the topographical survey and geological and soil mechanics investigations required even for the detailed design work.

During the course of regulators' site selection, some of the possible alternative sites have been thoroughly examined from the viewpoints of development potential of the available water

resources, probable influence to the regulators' downstream reaches and river mouths, proper operation of the relevant facilities and required cost. As far as the structural alternatives of tidal regulators are concerned, a type of the vertical lift gated concrete structure and non-overflow typed embankment closure has been employed taking an advantageous structural stability in comparison with another type composed of the ungated overflow typed embankment closure and water level drawdown control structure by vertical lift gates. Then, a total gate opening width of each tidal regulator has been given on the basis of existing river width in the vicinity of each site taking into account a relationship between the construction cost and the extent to alleviate the annual inundation, with additional investigation of such supplemental ways as river channel excavation, removal of the sand bar at Narathiwat river mouth and so on.

It has been experienced that the ocean outlet of the Nam Baeng channel with the regulator about 400 m upstream from its channel end has been open sometimes during the high flood season and soon been blocked from the ocean side by sand bar generated with approximately 2.5 million cu.m per annum of the longshore sediment moves along the coast. The current procedures to open the sand bar by digging a narrow ditch across the bar and then adding the Bang Nara flood flow for flushing sand would be continued taking into account the technical difficulty to maintain the entrance even with the provision of a breakwater or training wall system; therefore, no structural improvement of the existing Nam Baeng Tidal Regulator and its ocean outlet has been incorporated in the Project.

The preliminary design of two tidal regulators is shown in nine Drawings as attached at the end of this Report, and major design dimensions of such regulators are explained in Table S-5.

Table S-5. RID Tidal Regulators

Item	Upper Tidal Regulator	Lower Tidal Regulator
Regulator Body		
- Total gate opening width	120 m	24 m
- Elevation of sill	EL -4.0 m	EL -5.0 m
- Elevation of gate crest	EL +1.1 m	EL +1.6 m
- Impounding water level		
High	EL +0.4 m	EL +0.4 m
Low	EL -0.2 m	-0.2 m
- Flood conditions		
° At 5-yr return period:		
Upstream level	EL +2.23 m	EL +1.47 m
Downstream level	EL +1.63 m	EL +1.44 m
Max. outflow	1,229 cu.m/sec	185 cu.m/sec
-do- velocity	1.65 m/sec	1.25 m/sec
° At 50-yr return period:		
Upstream level	EL +3.25 m	EL +1.92 m
Downstream level	EL +2.32 m	EL +2.20 m
Max. outflow	1,911 cu.m/sec	326 cu.m/sec
-do- velocity	2.20 m/sec	2.04 m/sec
- Gate		
° Clear span	20.0 m	12.0 m
° Gate height	5.1 m	6.6 m
° Type		
One-leaf roller, shell	5 spans	-
Two-leaf roller, shell	1 span	-
One-leaf roller, girder	-	1 span
Two-leaf roller, shell & girder	-	1 span
° Seal	3-side rubber	3-side rubber
° Operating speed	0.3 m/min.	0.3 m/min.
Connection Channel		
- Length	700 m	340 m
- Bed width	150 m	30 m
- Elevation of bed	EL -4.0 m	EL -5.0 m
Bang Nara Closure Dam (Earth Fill with Riprap Protection)		
- Length	220 m	75 m
- Max. height	8.5 m	8.5 m
- Elevation of crest	EL +3.5m	EL +2.5 m
- Crest width	9.0 m	9.0 m

(2) Water Storage Effect

With the proper operation of the regulators' tidal gates, a fixed impounding water level of Mae Nam Bang Nara as compared to its present tidal variation would be maintained, and this results in the establishment of a water storage necessary for irrigation.

It would be possible to raise a full water level of the water storage upto EL +1.1 m of the gate top at the Upper Tidal Regulator that is the lowest among the three; however, this requires the right-of-way for the submerged area including 2,700 ha of the paddy field and 60 ha of the rubber area. When a long dike along both sides of Mae Nam Bang Nara with 25 check gates at its tributaries is provided to eliminate the above-mentioned land loss, this arrangement would invite such disadvantages as high cost for the initial construction, difficulty in the operation of such many gates and poor drainage in the farm land adjacent to the dikes.

Taking into consideration the environmental constraints of existing swamp forests in the Laem Nam Bang Nara II Forest Reserve as well as the wildlife and riverside regimes, a normal impounding water level of the non-bunded water storage would be given at EL +0.4 m that any farm land is not submerged. In view of a perspective that excessive drawdown of the impounding water level for long period in the critical dry years would cause irreversible environmental damage to the ecology of swamp forests as well as the unfavorable dehydration of potential acid sulfate soils in the tributaries, the lower limit of the impounding water level would be taken at EL -0.2 m.

Dimensions of the Bang Nara water storage to be established immediately after the completion of two tidal regulators are summarized below:

Impounding Water Level and Water Storage

	Water Level	Water Storage
Full Water Level	EL +0.4 m	15.8×10^6 cu.m
Low Water Level	EL -0.2 m	11.3×10^6 cu.m

Difference: Effective Water Depth = 0.6 m

Effective Water Storage = 4.5×10^6 cu.m

Water Storage Surface Area: 1,390 ha

of which : river course, 510 ha

swamp forest, 880 ha

Catchment Area: 1,401 sq.km

of which: Mae Nam Bang Nara, 677 sq.km

Mae Nam Yakang, 724 sq.km

Annual Average Inflow: $1,834.3 \times 10^6$ cu.m (1956 to 1985)

of which: 700.6×10^6 cu.m from Mae Nam Bang Nara

$1,133.7 \times 10^6$ cu.m from Mae Nam Yakang

Annual Average Irrigation Diversion: 38.6×10^6 cu.m (1955 to 1985)

(3) Inundation Alleviation Effect

The hydraulic flood simulations study indicates that approximately 160 ha of the paddy field and 60 ha of the rubber area which are low-lying along Mae Nam Bang Nara would be protected from the current inundation when the target heavy rainfall with a five-year return period is applied. More particularly, a significant effect has been given to a conclusion that the Lower Tidal Regulator would function to eliminate the current flood invasion into Mae Nam Bang Nara due to the flooding of Mae Nam Kolok. This flood invasion amounts to 10 million cu.m which would be equivalent to the channel storage volume of Mae Nam Bang Nara.

3.3.2. Irrigation and Drainage Facilities

(1) WUG Pumping Irrigation Scheme

As soon as the Bang Nara water storage is established, the above-mentioned irrigable area would be in a possible situation to be serviced by a series of portable pumps (self-priming centrifugal pump directly coupled with gasoline engine on common base), when the water users' groups are properly organized and the on-farm work including the pump procurement is provided under the Government technical and financial assistance. This arrangement would correspond to the planning and formulation of a quick yielding project as are emphasized in para. 3.1.

(2) RID Irrigation and Drainage Scheme

In connection with the completion of two tidal regulators which are the key facilities in the Project, the associated RID irrigation and drainage facilities would be in the stage of full scale construction. RID would be responsible for the construction and O & M of fixed type pumping stations and subsequent canal systems for 10 schemes to irrigate 5,930 ha of existing paddy field, while the water users' groups would be responsible for the terminal irrigation on-farm work and related services. RID would also be responsible for the construction and subsequent O & M of 7 drainage improvement subprojects. The preliminary design of the proposed RID irrigation and drainage facilities is presented in three Drawings at the end of this Report.

Table S-6. RID Pumping Irrigation Scheme

No. Subproject	Service Area (ha)	Diversion Channel 1/ (km)	Pump 2/ Max.Q (cu.m/sec)	Pump 2/ No. of Units	Main and Lateral Canals (km)
STAGE I					
1. Pu Ta	230	-	0.32	2	5.1
2. Sala Mai	490	1.3	0.68	2	11.8
3. Ko Sawat	520	-	0.72	2	15.0
Sub-total	1,240	1.3	1.72	6	31.9
STAGE II					
(First Package)	1,130	-	1.55	6	39.0
4. Khao Kong	560	-	0.77	2	16.9
5. Phru Kap Daeng	380	-	0.52	2	14.3
6. Ku Cham	190	-	0.26	2	7.8
(Second Package)	2,000	6.6	2.76	6	52.7
7. Du Song	880	3.1	1.22	2	20.0
8. Khok Ti Te	1,120	3.5	1.54	4	32.7
(Third Package)	1,560	4.6	2.15	5	28.3
9. Tan Yong Mat	1,090	-	1.50	3	18.9
10. Maru Bo	470	4.6	0.65	2	9.4
Sub-total	4,690	11.2	6.46	17	120.0
Total	5,930	12.5	8.18	23	151.9

1/ ..... Deepening of the Bang Nara tributaries from the Bang Nara water storage to the pumping plants.
2/ ..... Inclined mixed or axial flow type.

Table S-7. RID Drainage Improvement Scheme

No. Subproject	Catchment Area (ha)	Drainage Channel 1/ Improvement (km)	Drainage Channel 1/ Construction (km)	Drainage Channel 1/ Total (km)	Service Area Paddy Field (ha)	Service Area Rubber Area (ha)
STAGE I						
1. Ban Lo Mo	1.2	-	2.5	2.5	70	50
2. Ban Sala Pradu	1.8	-	1.1	1.1	130	-
3. Khlong Sala Mai	10.0	5.0	1.7	6.7	500	-
Sub-total	13.0	5.0	5.3	10.3	700	50
STAGE II 2/						
4. Khlong Ku Ra Po	26.4	9.0	0.8	9.8	590	240
5. Khlong Na Ko	9.8	4.9	-	4.9	520	280
6. Khlong To Che	39.8	21.1	2.5	23.6	2,290	1,740
7. Khlong Chang	90.3	25.0	0.8	25.8	750	3,880
Sub-total	166.3	60.0	4.1	64.1	4,150	6,140
Total	179.3	65.0	9.4	74.4	4,850	6,190

1/ .... Widening and deepening of the Bang Nara tributaries.
2/ .... (1) First package : Khlong Ku Ra Po
(2) Second package : Khlong Na Ko + Khlong To Che (To Che + Khok Niang) + Khlong Chang (Chang)
(3) Third Package : Khlong To Che (Lu Bo Manang) + Khlong Chang (Ba Ngo Du Dung + Ku Rong Ya Ma)

3.3.3. Acidic Water Inflow Control Scheme

In relation to the present inflow of acidic water into Mae Nam Bang Nara as explained in para. 2.5, attention has been paid to the target basins including that of the Pileng land settlement scheme and those of its vicinity including six small rivers and drains called "Khlong Sg. Padi", "Khlong Bang Toei, "Ku Bae Ya Hae drain", "Khlong To Lang", "Pru Kap Daeng drain" and "Khlong Ya Bi".

The following countermeasures to protect the Bang Nara water storage from acidification have been established:

- During the rainy season, the sulfate ions which are formed during the previous dry season are dissolved by heavy rainfalls and then flushed away in a form of floods to the ocean.

- During the dry season, it is essential to keep the groundwater level at about 0.4 m below the ground surface with the provision of well-designed water level control facilities so-called "Acidic Water Flow Check Facilities".

At present, RID has completed the sluice gates at 4 sites of the Pileng area, one at Khlong Bang Toei, one at Khlong To Lang, one at Khlong Ya Bi and one at Pru Kap Daeng drain and is presently constructing one sluice gate at Khlong Ya Bi. Following this, RID has a plan to provide additional check structures for the remaining four rivers such as Ku Bae Ya Hae drain, Khlong Bang Toei, Khlong To Lang, and Khlong Sg. Padi and to complete a series of the acidic water flow check facilities at 17 sites covering the above-mentioned seven target basins. When proper control mode and operation rule are observed by the RID operators in connection with

the effort to neutralize the acidity in the Bang Nara storage by mobilizing a large amount of the Yakang freshwater inflow through operation of the tidal regulators, there would be fundamentally no problem with respect to the effect on the water storage quality for irrigation.

The agricultural development covering the area where the sulfate ions are currently dissolved would be left over for future consideration, taking into account the less benefit to be derived from the development and also the relative difficulty in water conveyance from the Bang Nara storage when the acidic water flow check facilities are operated.

Table S-8. RID Acidic Water Inflow Control Scheme (STAGE I)

No.	Sub-basin	Acidic Water Flow Check		Catchment Area (sq.km)	Paddy Field to be Controlled (ha)
		Already Constructed	To be Constructed		
1.	Khlong Ya Bi	Ya Bi No.1 Ya Bi No.2	-	21.0	345
2.	Ku Bae Ya Hae Drain	-	Ku Bae Ya Hae /1	14.3	-
3.	Pileng Drains	Pileng No.7 Pileng No.5 Pileng No.3 Pileng No.1	-	51.2	-
4.	Sg. Padi	-	Padi No.1 /1 Padi No.2 /1	78.2	-
5.	Khlong Ban	Bang Toei No.1	Bang Toei No.2 /2 Bang Toei No.3 /2 Bang Toei No.4 /2 Bang Toei No.5 /2	13.0	24
6.	Khlong To Lang	To Lang No.1	To Lang No.2 /1	12.8	410
7.	Pru Kap Daeng Drain	Pru Kap Daeng	-	8.9	10
	Total	9 sites	8 sites	199.4	1,005

/1 ... Gate type.
/2 ... Fixed weir type.

3.4. Rural Infrastructure

It is understood that the provision of rural infrastructure in the Project area has received some strengthening in recent years due to its location adjacent to the Malaysian border and to a fact that this is recognized as a security sensitive area. While the Changwat Narathiwat is progressively developing towards the Thai national average for rural areas, the measures to overcome deficiencies in the social and physical infrastructure in the Project area are already being incorporated into the departmental plans and proposals. Under this circumstance, any component of the rural infrastructure sector related to the Project has not been included in the Project.

4. PROJECT IMPLEMENTATION PROGRAMME

4.1. Organization and Management

4.1.1. Project Implementing Agencies

There would be a wide range of the Government agencies to provide the services for water resources and related agricultural development in the Bang Nara Irrigation and Drainage Project. Such agencies would include the following:

1) Royal Irrigation Department (RID)
2) Department of Agriculture (DOA)
3) Department of Agricultural Extension (DOAE)
4) Department of Land Development (DLD)
5) Livestock Development Department (LDD)
6) Department of Fisheries (DOF)
7) Cooperative Promotion Department (CPD)
8) Department of Local Administration (DOLA)

9) Community Development Department (CDD)
10) Office of Rubber Replanting Aid Fund (ORRAF)
11) Marketing Organization for Farmers (MOF)
12) Bank for Agriculture and Agricultural Cooperatives (BAAC)
13) Southern Regional Agricultural Office (SRAO)

4.1.2. Project Management and Implementation

(1) Project Lead Agency

The key issue for successful implementation of the subject Project would focus upon realization of the proposed irrigated agricultural development programme through the operation of demonstration farms, the organization of active water users' groups with subsequent development of on-farm facilities, and the implementation of various extension services to the Project farmers.

It is recommended that an appropriate agency to serve as a coordinating lead agency would be the Office of the Permanent Secretary of the Ministry of Agriculture and Cooperatives (MOAC) which has both the mandate and authority needed to take a broad overview of the rural area development.

(2) Project Policy and Steering Structure

It has been mentioned by RID that a special board to be chaired by the Minister of Agriculture and Cooperatives would be organized as a Central Steering Committee for the Project, both for overall planning and decision-making functions at the national level. The Board would have its members comprising the Permanent Secretary of MOAC and the heads of all line departments concerned

including RID, DOA, DOAE, DLD, DOF, LDD and CPD; the Changwat Narathiwat Governor; Directors of ORRAF and MOF; General Manager of BAAC; and the representatives of DOLA and CDD, Ministry of Interior as well as the Budget Bureau and the National Economic and Social Development Board.

An existing Changwat Development Committee which advises the Governor and serves as a coordinating body at Changwat level would be fully mobilized with the Project policy structure and function at area development level. The Committee under the chairmanship of the Narathiwat Governor would have the members including the Director of SRAO; the Chief of Changwat Planning Unit; Changwat heads of all involved departments inclusive of RID, DOAE, DLD, DOF, LDD, CPD, CDD, ORRAF, MOF, and BAAC; and Amphoe heads of Muang Narathiwat, Tak Bai, Range and Yingo.

(3) Special Task Force Unit

It is needless to say that the development and successful achievement of irrigated agriculture under the Project requires a multi-disciplinary approach. Taking into account the information of communities and target groups as well as the current problems from a combination of agronomic, economic, and social causes, it would be imperative, among others, to organize a Special Task Force Unit in the Project to commence the favorable operation of three demonstration farms during the initial period of detailed design work for two tidal regulators and to facilitate the formation of viable water users' groups during the pre-construction stage of RID major irrigation work.

The Special Task Force Unit would be composed of the community development workers in CDD, agricultural extension specialists in DOAE, irrigation engineers in RID, cooperative promotion specialists in CPD and administrative personnel in Changwat Narathiwat and, when necessary, anthropologists or rural sociologists from the Center for the Southern Thailand Studies at Pattani campus of the Prince of Songkhla University.

4.2. Construction and O & M of Major Work

4.2.1. Mode and Procurement of Construction Work

RID would be solely responsible for initial construction and subsequent O & M of such major work as (1) two tidal regulators, (2) 8 acidic water flow check facilities, (3) 7 drainage improvement schemes and 10 RID pumping irrigation systems down to tertiary outlets.

It is suggested that all the major work construction would be awarded on the basis of international competitive bidding in accordance with the premise that the Project would be financed by an international lending agency. Aside from the large contract for a simultaneous construction work of the two tidal regulators, the size and phasing of contracts for other major work would be dictated by the rate at which detailed design and contract documents could be prepared; therefore, the contracts for such work would probably be too small to be of little interest to international contractors, and such work would be packaged for execution by the local contractors. The manufacture and installation of tidal gates and RID pumping equipment at 10 stations would be procured from the overseas manufacturers.

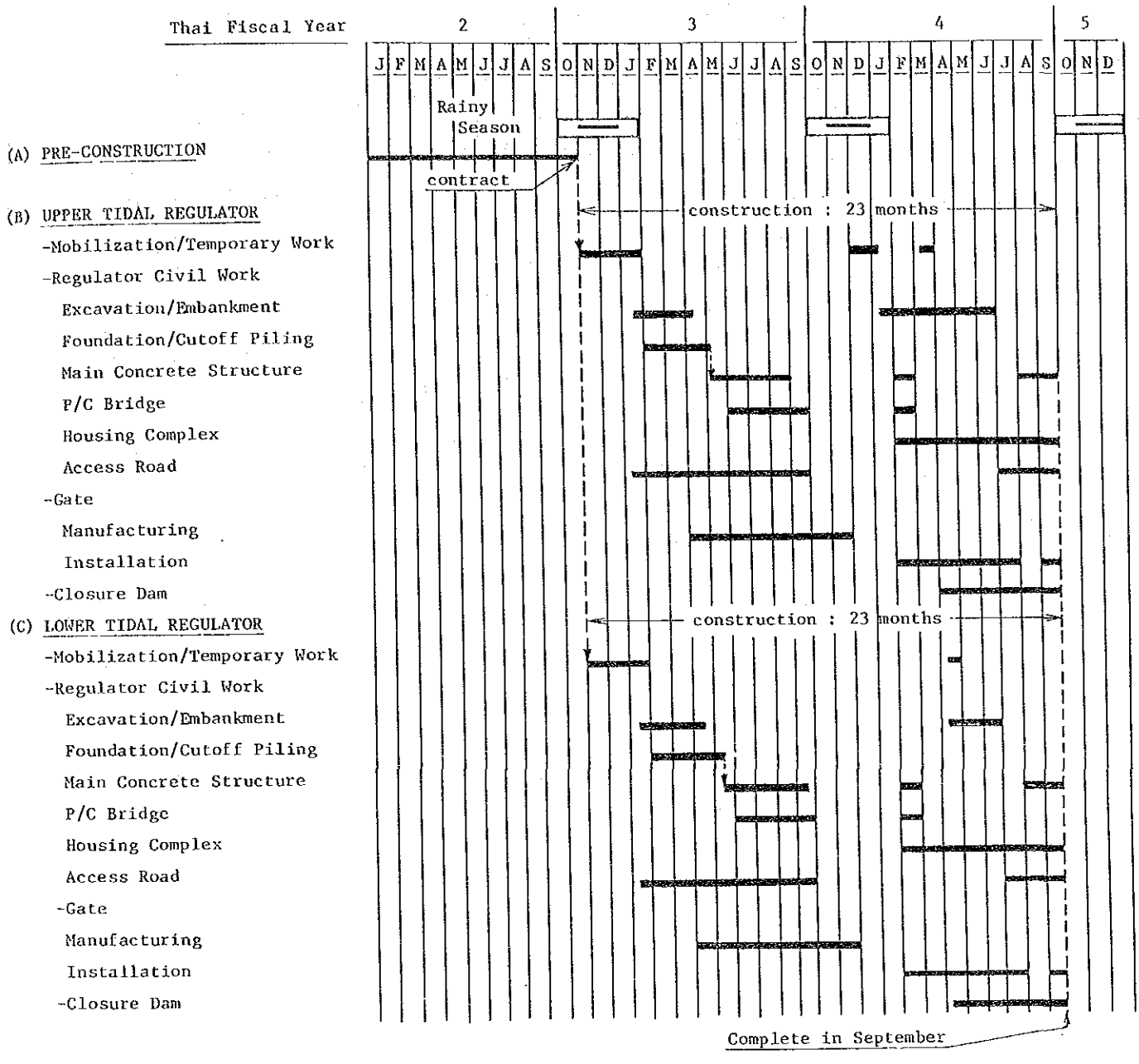
4.2.2. Construction of Two Tidal Regulators

Taking into account the scale and conditions of construction work, the construction period of two tidal regulators would require at least 23 months (1.9 years) on the basis of a package contract under the simultaneously proceeding programme from the start to completion in view of an effective mobilization of the construction machinery. Before this, at least one year would be taken for the pre-construction activities including the detailed design, access road, power line, contracting and so forth. It has been learned that RID has completed the land acquisition for the Lower Tidal Regulator, while the official procedure to acquire the land for the Upper Tidal Regulator has been in progress without any difficulties. The proposed construction schedule for two tidal regulators is outlined in Figure S-1, indicating the suspension of work by machinery during the rainy season from October to January.

4.2.3. Construction of RID Irrigation and Drainage Scheme

It is suggested that construction of part of the RID irrigation and drainage systems which are located in the relatively low-lying areas would be commenced in the Project Year 4 taking into account more quick accrual of the anticipated benefits to be derived from the two tidal regulators' construction, the Government's financial load on the Project as well as the assumed rate of water users' group's formation and subsequent on-farm development as is compiled in Figure S-2. Construction of all the RID facilities would take 6 years with four packages, each of which would need 2 years for completion including the procurement of incline pumps to be imported. This construction schedule has been conceived on the basis of (1) sound yearly distribution of the construction cost, and (2) combination of the drainage and irrigation subprojects on the premise that the drainage improvement proceeds prior to irrigation development. Composition of four packages as envisaged is explained in Tables S-6 and S-7.

Figure S-1. Construction Schedule: Two Tidal Regulators



4.3. On-Farm Work Development

4.3.1. Size of Tertiary Irrigation Service Units

Taking into account the Project farm size and piece-meal distribution of the irrigation service areas as are specifically featured in the Project, it is suggested that an appropriate size of a tertiary unit would range from 20 to 30 ha in comparison with the present RID standard size of 50 ha. As is designed on three sample areas, an appropriate average size of the tertiary unit would be about 20 ha. With the reduction of this size, the section of tertiary canals from the RID turnouts would be smaller resulting in considerable decrease of the current troubles such as right-of-way and canal maintenance, and there would be the increasing possibility to construct by the water users' groups.

4.3.2. Demonstration Farms

The first task to be carried out by the Special Task Force Unit would be the final location and planning of three demonstration farms, the formation of water users' groups concerned, and the construction of water source work and on-farm facilities. It has been tentatively proposed to locate three demonstration farms as given below:

(1) Ban Ku Ra So (13.8 ha) in WUG pumping scheme (Stage I)
Tambol Lamphu, Amphoe Muang Narathiwat

(2) Ban To Lang (23.5 ha) in RID Khok Ti Te pumping scheme (Stage II)
Tambol Tanyongmilo, Amphoe Rangae

(3) Ban Cha Ro (26.1 ha) in WUG pumping scheme (Stage I)
Tambol Phraiwan, Amphoe Tak Bai

As is scheduled in Figure S-2, the Special Task Force Unit would complete three demonstration farms after the formation of respective water users' group at the end of the Project Year 2 and would commence the actual operation of irrigated agriculture by using deep wells as temporary water source until the switch over to the Project irrigation water sources. It is anticipated that the demonstration activities at three sites would be terminated in the Project Year 9 in connection with the field training of agricultural extension workers, and then all the activities at these demonstration areas would be transformed to the normal operations by respective water users' groups.

4.3.3. Construction of On-Farm Work

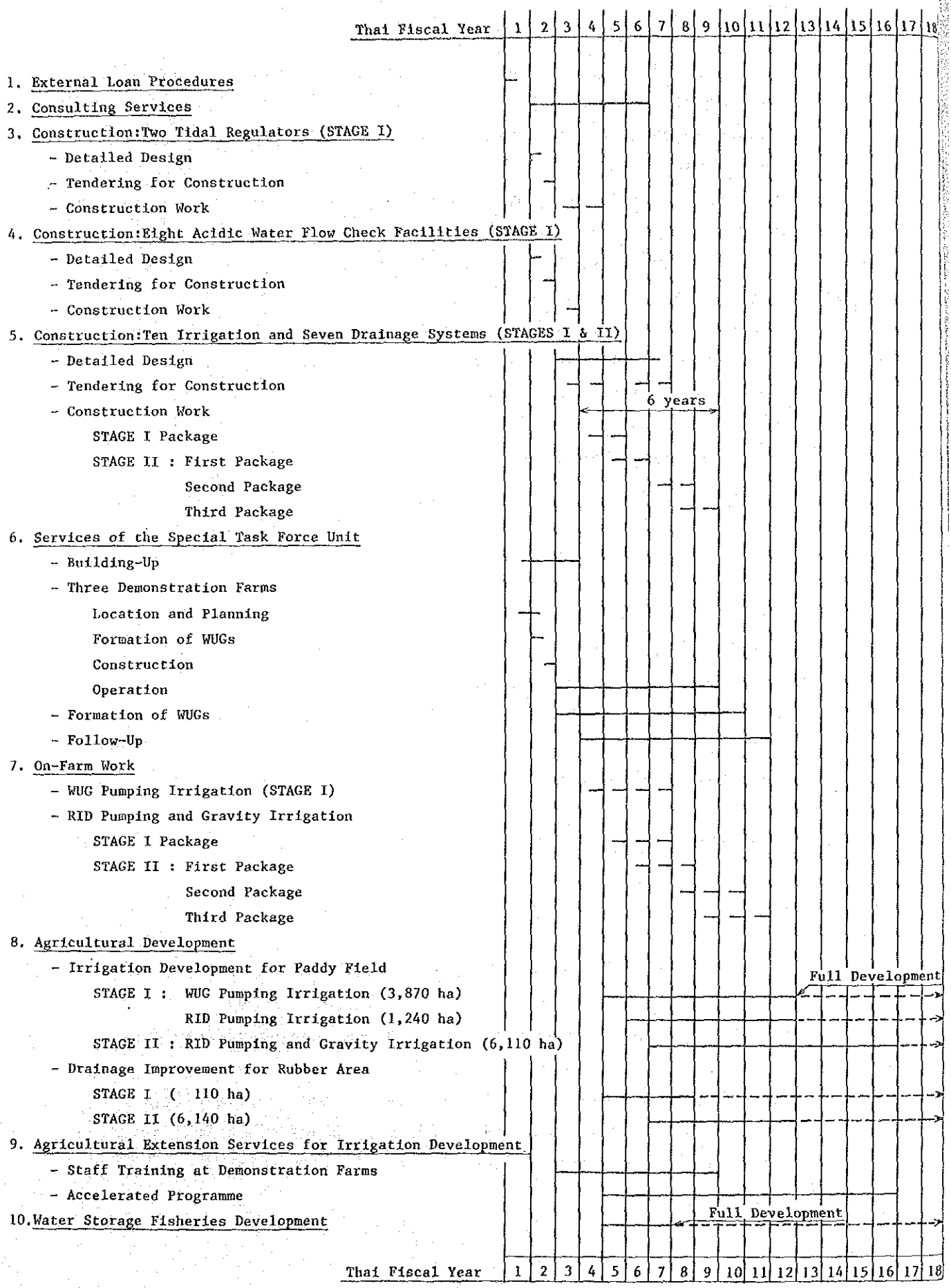
After the formation of water users' group for each tertiary unit, the relevant on-farm work would be in construction stage and it is suggested that the executing agency for this would be the water users' group. It is stressed that the farmers in each tertiary unit would be organized to contribute, free of charge, all the unskilled labor and land for construction, while such water facilities as made of concrete and other materials would be constructed on local contractor basis or force account basis under the guidance of RID.

4.4. Consulting Services and Staff Training

4.4.1. Consulting Services

To ensure the rapid and sound execution of the Project, the services of a consultant team which would be composed of the foreign and Thai local firms in a joint-venture manner would be provided under the Project during the five-year service period to assist RID in detailed design and construction for two tidal regulators and irrigation and drainage facilities, as well as to carry out the advisory services for the Project-related

Figure S-2. Project Implementation Schedule



agricultural development inclusive of strengthening the Special Task Force Unit and assisting DLD in programming and monitoring a soil improvement scheme. It is estimated that about 300 man-months of consultant effort would be required.

4.4.2. Staff Training

Under the Project, emphasis would be placed upon local on-the-job and in-service practical training in specific technical skills including the field of tidal regulator operation, irrigated agricultural extension services, on-farm irrigation development practices, problem soil improvement and organization of water users' groups which would be particularly directed towards the needs of staff of the Project implementing agencies. The Project would also provide the overseas training in a total amount equivalent to about 30 man-months with the objective which is the mind broadening exposure to relevant activities in other countries and the rapid application of the expertise acquired to concentrate the maximum benefits on the Project. Visits would be arranged to the on-going similar-natured projects with a proven record of success in the neighbouring countries.

4.5. Project Implementation Schedule

The proposed construction/implementation programme and related scheduling for various Project components have been established on the basis of the Project Year (Thai Fiscal) as is specified in Figure S-2. The Project implementation schedule explains that the construction of major work by RID would take 7 years from the Project Years 3 to 9, and relevant on-farm work construction would be carried out during 8 years from the Project Years 4 to 11. The last water users' groups in the Project, Stage II which would be organized to construct their on-farm work in the Project Year 11 and to start irrigation in the Project Year 12, would reach a full production in the Project Year 16.

4.6. Staging of the Project Development

4.6.1. Concept for Staged Development

It has been worked out to implement the proposed Project in two stages within the RID's responsibility taking into account the elevation of irrigable areas for existing rainfed paddy field by pumping, scope of the initial construction cost required for major work of the associated irrigation and drainage schemes, and the quick accrual of the anticipated benefits to be derived from the investment for two tidal regulators.

- Stage I Development:

  (1) Construction of the Upper and Lower Tidal Regulators to be supplemented with that of the acidic water flow check facilities at 8 sites.

  (2) Construction of the major work relevant to the RID pumping irrigation and associated drainage improvement schemes in the relatively low-lying areas.

- Stage II Development:

  Construction of the major work related to the RID drainage improvement and pumping and gravity irrigation schemes in the high-lying areas.

4.6.2. Stage I Development

° As soon as the two tidal regulators are completed by RID, the Bang Nara water storage with control of the acidic water inflow would be established after the first rainy season and be ready to bring irrigation. It has been envisaged that 3,870 ha of existing paddy field largely below EL +2 m on average which is distributed on the fringes of the water storage would be commenced to irrigate with portable pumps under the water users' groups for agricultural development.

° In addition, it has been contemplated that a proper arrangement for early construction of the major work for some of the RID pumping irrigation schemes in the relatively low-lying areas which are located in the vicinity of the proposed demonstration farms and are qualified with the completion of detailed design for short period as well as with the comparatively procurable budget for the construction would be made by the Government in view of the quick yielding of the Project. These schemes would involve 3 subprojects of the RID pumping irrigation at Pu Ta, Sala Mai and Ko Sawat covering the irrigable area of 1,240 ha in total and associated drainage improvement subprojects at 3 locations such as Ban Lo Mo, Ban Sala Pradu and Khlong Sala Mai covering the service area of 700 ha for paddy field and 50 ha for rubber area in total.

° Construction period of the RID facilities in the Stage I would take 3 years, which would develop the irrigated agriculture covering existing rainfed paddy field of 5,110 ha that is equivalent to 51 percent of the total Project service area.

4.6.3. Stage II Development

° It has been considered that RID would commence the construction of major work for the irrigation and drainage facilities in high-lying areas at adequate period being subject to the Government financial arrangement after the completion of two tidal regulators which is the key facilities in the Project. It would be desirable that the commencement date of major work construction for the Stage II development by RID be given immediately after completion of the tidal regulators because of quick accrual of the full benefits to be realized from the tidal regulators as well as in due consideration of the progress on the formation of the water users' groups concerned and the subsequent development of on-farm work.

° RID would be responsible for construction of 7 pumping irrigation schemes and one gravity irrigation scheme in the higher-lying areas above the WUG pumping scheme. These irrigation schemes would be constructed in closer connection with the drainage improvement schemes concerned over 4,850 ha of existing paddy field and 6,190 ha of rubber planted area.

° Construction of the RID facilities in the Stage II which would serve the irrigated agriculture over 4,870 ha of existing paddy field would need a period of 5 years, while the water users' groups would be responsible for the terminal irrigation on-farm work and related services.

4.7. Cost Estimate

4.7.1. Project Cost

The base cost for the Project which includes the construction cost and its associated cost has been estimated on the basis of price level at 1986-February term dividing into local cost, indirect foreign cost and direct foreign cost at Baht currency rate. The base cost contains various taxes and duties related to construction work and equipment procurement to be incurred in the Project. The physical contingency has been taken at 10 percent of the base cost. The price contingency has been given by the escalation factor of 3 percent per annum for both the local and foreign currencies. Breakdown of the Project cost thus estimated is compiled in Table S-9.

The Project cost by Thai fiscal year for the Project as a whole and for the Stage I development is also summarized in Tables S-10 and 11.

4.7.2. O & M Cost

The RID annual O & M cost at full development would be ฿3.27 x 10^6 for the Stage I development and ฿9.86 x 10^6 for the Project as a whole including (1) salaries and wages, (2) fuel and repair for O & M equipment, (4) RID pump electricity, and (5) general expenditures, while the annual cost for O & M of the water users' group pumps including the cost for gasoline and repair would be ฿657 x 10^3 at full development.

Table S-9. Project Cost Summary

Currency Equivalents at 1986-February Term

Baht 1.00 = US $ 0.038 = Yen 6.84

Baht 26.3 = US $ 1.00 = Yen 180

L.C. = Local Cost I.F.C. = Indirect Foreign Cost

F.C. = Foreign Cost D.F.C. = Direct Foreign Cost

(Unit : ฿ x 10^6)

	Project as a whole					Stage I Development				
	L.C.	F.C.			Total	L.C.	F.C.			Total
		I.F.C.	D.F.C.	Total			I.F.C.	D.F.C.	Total	
A. Major Work										
A.1. Tidal Regulators	117.92	78.31	162.10	240.41	358.33	117.92	78.31	162.10	240.41	358.33
A.1.1. Upper Tidal Regulator	86.78	54.77	125.31	180.08	266.86	86.78	54.77	125.31	180.08	266.86
1. Civil Work	56.72	50.79	21.14	71.93	128.65	56.72	50.79	21.14	71.93	128.65
1.1 Temporary Work	2.85	1.64	2.75	4.39	7.24					
1.2 Regulator Body and Connection Channel	40.66	39.28	18.39	57.67	98.33					
1.3 Sapi Yo Closure Dam	1.57	0.93	-	0.93	2.50					
1.4 Bang Nara Closure Dam	10.04	5.50	-	5.50	15.54					
1.5 Road	0.63	2.48	-	2.48	0.11					
1.6 O&M Facilities	0.97	0.96	-	0.96	1.93					
2. Gate Work	30.06	3.98	104.17	108.15	138.21	30.06	3.98	104.17	108.15	138.21
2.1 Manufacturing	-	-	93.72	93.72	93.72					
2.2 Transportation	0.34	0.80	4.49	5.29	5.63					
2.3 Installation	29.72	8.18	4.04	7.22	36.94					
2.4 O&M Equipment	-	-	1.92	1.92	1.92					
A.1.2. Lower Tidal Regulator	31.14	23.54	36.79	60.33	91.47	31.14	23.54	36.79	60.33	91.47
1. Civil Work	21.77	21.95	5.41	27.36	49.13	21.77	21.95	5.41	27.36	49.13
1.1 Temporary Work	1.49	0.77	0.91	1.68	3.17					
1.2 Regulator Body and Connection Channel	16.16	16.69	4.50	21.19	37.35					
1.3 Bang Nara Closure Dam	2.13	1.22	-	1.22	3.35					
1.4 Road	0.96	2.57	-	2.57	3.53					
1.5 O&M Facilities	1.03	0.70	-	0.70	1.73					
2. Gate Work	9.37	1.59	31.38	32.97	42.84	9.37	1.59	31.38	32.97	42.84
2.1 Manufacturing	-	-	27.17	27.17	27.17					
2.2 Transportation	0.12	0.29	1.59	1.88	2.00					
2.3 Installation	9.25	1.30	1.45	2.75	12.00					
2.4 O&M Equipment	-	-	1.17	1.17	1.17					
A.2. Acidic Water Flow Check Facilities	8.41	7.42	-	7.42	15.83	8.41	7.42	-	7.42	15.83
A.2.1 Ku Bae Ya Hae	0.74	0.64	-	0.64	1.38					
A.2.2 Sg. Padi No.1	3.24	3.06	-	3.06	6.30					
A.2.3 Sg. Padi No.2	3.24	3.06	-	3.06	6.30					
A.2.4 Bang Toei No.2	0.19	0.08	-	0.08	0.27					
A.2.5 Bang Toei No.3	0.19	0.08	-	0.08	0.27					
A.2.6 Bang Toei No.4	0.19	0.08	-	0.08	0.27					
A.2.7 Bang Toei No.5	0.19	0.08	-	0.08	0.27					
A.2.8 To Lang No.2	0.43	0.34	-	0.34	0.77					

Currency Equivalents at 1986-February Terr

Baht 1.00 = US $ 0.038 = Yen 6.84

Baht 26.3 = US $ 1.00 = Yen 180

L.C. = Local Cost I.F.C. = Indirect Foreign Cost

F.C. = Foreign Cost D.F.C. = Direct Foreign Cost

(Unit : ¥ x 10^6)

	Project as a whole					Stage I Development				
	L.C.	F.C.			Total	L.C.	F.C.			Total
		I.F.C.	D.F.C.	Total			I.F.C.	D.F.C.	Total	
A.3 Irrigation and Drainage System	117.63	170.78	34.06	204.84	322.47	16.50	24.49	6.52	29.51	47.51
A.3.1 Drainage Improvement	41.16	53.08	-	53.08	94.24	2.45	3.49	-	2.49	5.94
1. Ban Lo Mo	0.09	0.36	-	0.36	0.45	0.09	0.36	-	0.36	0.45
2. Khlong Ku Ra Po	4.78	5.78	-	5.78	10.56	-	-	-	-	-
3. Khlong Na Ko	3.21	4.42	-	4.42	7.63	-	-	-	-	-
4. Khlong To Che	12.23	15.03	-	15.03	27.26	-	-	-	-	-
5. Khlong Chang	18.49	24.36	-	24.36	42.85	-	-	-	-	-
6. Ban Sala Pradu	0.10	0.27	-	0.27	0.37	0.10	0.27	-	0.27	0.37
7. Khlong Sala Mai	2.26	2.86	-	2.86	5.12	2.26	2.86	-	2.86	5.12
A.3.2 RID Pumping Irrigation	75.93	117.14	34.06	151.20	227.13	14.05	21.00	6.52	27.52	41.57
1. Pu Ta	3.18	2.77	2.08	4.85	8.03	3.18	2.77	2.08	4.85	8.03
2. Khao Kong	6.78	11.97	3.12	15.09	21.87	-	-	-	-	-
3. Du Song	12.03	18.11	4.86	22.97	35.00	-	-	-	-	-
4. Tan Yong Mat	8.12	9.43	4.31	13.74	21.86	-	-	-	-	-
5. Khok Ti Te	19.99	30.86	7.63	38.49	58.48	-	-	-	-	-
6. Maru Bo	5.78	8.27	2.95	11.22	17.00	-	-	-	-	-
7. Sala Mai	5.13	7.27	2.67	9.94	15.07	5.13	7.27	2.67	9.94	15.07
8. Ko Sawat	5.74	10.96	1.77	12.73	18.47	5.74	10.96	1.77	12.73	18.47
9. Phru Kap Daeng	4.88	7.98	2.68	10.66	15.54	-	-	-	-	-
10. Ku Cham	4.30	9.52	1.99	11.51	15.81	-	-	-	-	-
A.3.3 RID Gravity Irrigation	0.54	0.56	-	0.56	1.10	-	-	-	-	-
Sub-total (A)	243.96	256.51	196.16	452.67	696.63	142.83	110.22	168.62	278.84	421.67
B. Demonstration Farms	0.80	1.00	-	1.00	1.80	0.80	1.00	-	1.00	1.80
B.1 Ban Ku Ra So (13.8 ha)	0.23	0.32	-	0.32	0.55					
B.2 Ban To Lang (23.5 ha)	0.17	0.25	-	0.25	0.42					
B.3 Ban Cha Ro (26.1 ha)	0.40	0.43	-	0.43	0.83					
C. WUG Pumps and On-Farm Work	39.10	24.31	-	24.31	63.41	20.73	12.91	-	12.91	33.64
C.1 WUG Pumping Irrigation	16.03	10.00	-	10.00	26.03	16.03	10.00	-	10.00	26.03
C.2 On-Farm Work for RID Pumping and Gravity Irrigation	23.07	14.31	-	14.31	37.38	4.70	2.91	-	2.91	7.61
D. O & M Equipment	1.03	0.32	7.65	7.97	9.00	0.61	0.18	4.59	4.77	5.38
E. Land Acquisition	20.99	-	-	-	20.99	6.60	-	-	-	6.60
F. Consultants and Training	23.76	-	52.34	52.34	76.10	14.25	-	31.40	31.40	45.65

Currency Equivalents at 1986-February Term

Baht 1.00 = US $ 0.038 = Yen 6.84

Baht 26.3 = US $ 1.00 = Yen 180

L.C. = Local Cost I.F.C. = Indirect Foreign Cost

F.C. = Foreign Cost D.F.C. = Direct Foreign Cost

(Unit : ฿ x 10^6)

	Project as a whole					Stage I Development				
	L.C.	F.C.			Total	L.C.	F.C.			Total
		I.F.C.	D.F.C.	Total			I.F.C.	D.F.C.	Total	
G. Engineering and Adminstration	64.54	2.65	5.91	8.56	73.10	37.93	1.56	3.55	5.11	43.04
Base Cost (A. to G.)	394.17	284.80	262.06	546.86	941.03	223.74	125.88	208.16	334.04	557.78
H. Physical Contingencies (10%)	39.43	28.49	26.20	54.69	94.12	22.38	12.58	20.82	33.40	55.78
I. Price Contingencies (3% p.a.)	76.35	59.11	35.75	94.86	171.21	32.40	16.18	25.17	41.35	73.75
Project Cost (A. to I.)	509.95	372.40	324.01	696.41	1,206.36	278.52	154.64	254.15	408.79	687.31
(Stage I/Total Project)						(0.55)	(0.42)	(0.78)	(0.59)	(0.57)
(Currency Percent)	(42)	(31)	(27)	(58)	(100)	(40)	(23)	(37)	(60)	(100)

Table S-10. Project Cost Summary by Fiscal Year

(Unit: ฿x10^6)

Thai Fiscal Year / Cost Item	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Total
A. Major Work	-	-	224.96	165.83	58.47	36.09	62.61	105.54	43.03	-	-	-	-	-	-	-	696.63
A.1. Tidal Regulators	-	-	209.13	149.20	-	-	-	-	-	-	-	-	-	-	-	-	358.33
A.2. Acidic Water Flow Checks	-	-	15.83	-	-	-	-	-	-	-	-	-	-	-	-	-	15.83
A.3. Irrigation and Drainage	-	-	-	16.63	58.47	36.09	62.61	105.54	43.03	-	-	-	-	-	-	-	322.47
B. Demonstration Farms	-	1.80	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.80
C. WUG Pumps and On-Farm Work	-	-	-	5.18	13.52	13.59	6.94	6.12	9.19	6.73	2.14	-	-	-	-	-	63.41
C.1. WUG Pumps	-	-	-	5.18	10.49	7.77	2.59	-	-	-	-	-	-	-	-	-	26.03
C.2. RID Pumps and Gravity	-	-	-	-	3.03	5.82	4.35	6.12	9.19	6.73	2.14	-	-	-	-	-	37.38
Sub-total (A+B+C)	-	1.80	224.96	171.01	71.99	49.68	69.55	111.66	52.22	6.73	2.14	-	-	-	-	-	761.84
D. O&M Equipment	-	-	-	-	3.49	-	4.52	0.61	0.38	-	-	-	-	-	-	-	9.00
E. Land Acquisition	-	3.50	3.10	2.97	-	6.63	4.79	-	-	-	-	-	-	-	-	-	20.99
F. Consultants and Training	-	23.52	19.32	19.15	7.54	6.57	-	-	-	-	-	-	-	-	-	-	76.10
G. Engineering and Administration	5.52	9.08	7.74	6.20	7.20	6.73	7.34	7.46	6.19	4.16	3.24	0.91	0.63	0.35	0.21	0.14	73.10
Base cost (X)	5.52	37.90	255.12	199.33	90.32	69.61	86.20	119.73	58.79	10.89	5.38	0.91	0.63	0.35	0.21	0.14	941.03
H. Physical contingencies (10%)	0.55	3.79	25.51	19.93	9.04	6.96	8.63	11.98	5.88	1.09	0.54	0.09	0.06	0.04	0.02	0.01	94.12
Total Cost (X+H=Y)	6.07	41.69	280.63	219.26	99.36	76.57	94.83	131.71	64.67	11.98	5.92	1.00	0.69	0.39	0.23	0.15	1,035.15
I. Price Contingencies (3%, p.a.)	0.18	2.54	26.09	27.51	15.82	14.85	21.80	35.14	19.72	4.12	2.27	0.43	0.32	0.20	0.13	0.09	171.21
Total Project Cost (Y+I)	6.25	44.23	306.72	246.77	115.18	91.42	116.63	166.85	84.39	16.10	8.19	1.43	1.01	0.59	0.36	0.24	1,206.36

Table S-11. Project Cost Summary by Fiscal Year for Stage I Development

(Unit : ฿x10^6)

Thai Fiscal Year / Cost Item	1	2	3	4	5	6	7	8	9	10	11	12	Total
A. Major Work	-	-	224.96	165.83	30.88	-	-	-	-	-	-	-	421.67
A.1. Tidal Regulators	-	-	209.13	149.20	-	-	-	-	-	-	-	-	358.33
A.2. Acidic Water Flow Checks	-	-	15.83	-	-	-	-	-	-	-	-	-	15.83
A.3. Irrigation and Drainage	-	-	-	16.63	30.88	-	-	-	-	-	-	-	47.51
B. Demonstration Farms	-	1.80	-	-	-	-	-	-	-	-	-	-	1.80
C. WUG Pumps and On-Farm Work	-	-	-	5.18	13.52	10.80	4.14	-	-	-	-	-	33.64
C.1. WUG Pumps	-	-	-	5.18	10.49	7.77	2.59	-	-	-	-	-	26.03
C.2. RID Pumps and Gravity	-	-	-	-	3.03	3.03	1.55	-	-	-	-	-	7.61
Sub-total (A+B+C)	-	1.80	224.96	171.01	44.40	10.80	4.14	-	-	-	-	-	457.11
D. O & M Equipment	-	-	-	-	2.09	-	2.71	0.36	0.22	-	-	-	5.38
E. Land Acquisition	-	3.50	3.10	-	-	-	-	-	-	-	-	-	6.60
F. Consultants and Training	-	14.11	11.59	11.49	4.52	3.94	-	-	-	-	-	-	45.65
G. Engineering and Administration	3.31	5.46	4.64	3.72	4.32	4.03	4.40	4.47	3.71	2.49	1.94	0.55	43.04
Base Cost (X)	3.31	24.87	244.29	186.22	55.33	18.77	11.25	4.83	3.93	2.49	1.94	0.55	557.78
H. Physical Contingencies (10%)	0.33	2.48	24.43	18.62	5.53	1.88	1.13	0.49	0.39	0.25	0.19	0.06	55.78
Total Cost (X+H=Y)	3.64	27.35	268.72	204.84	60.86	20.65	12.38	5.32	4.32	2.74	2.13	0.61	613.56
I. Price Contingencies (3% p.a.)	0.11	1.66	24.99	25.70	9.68	4.00	2.85	1.42	1.32	0.94	0.82	0.26	73.75
Total Project Cost (Y+I)	3.75	29.01	293.71	230.54	70.54	24.65	15.23	6.74	5.64	3.68	2.95	0.87	687.31

5. PROJECT EVALUATION

5.1. Economic Analysis

The proposed Project would result in producing immediate and tangible benefits to about 4,100 farm households for the Stage I development and to about 8,700 farm households after full development of the Project.

5.1.1. Project Benefit

Comparison of the net production value without and with the Project is made in Table S-12.

5.1.2. Economic Internal Rate of Return

Using the discounting costs and benefits over a 50-year evaluation period, the economic internal rate of return for the Project has been calculated as given below:

Discount Rate	6%	8%	10%	12%
(1) Project as a Whole				
Present Worth Value (฿ x 10^6)				
Benefit	-	931.6	660.8	484.3
Cost	-	716.9	641.7	580.2
Benefit-Cost	-	+214.7	+19.1	-95.9
Benefit/Cost	-	1.30	1.03	0.83
Economic Internal Rate of Return: 10.3%				
(2) Stage I Development				
Present Worth Value (฿ x 10^6)				
Benefit	654.4	457.0	332.5	-
Cost	480.5	437.1	401.5	-
Benefit-Cost	+173.9	+19.9	-69.0	-
Benefit/Cost	1.36	1.05	0.83	-
Economic Internal Rate of Return: 8.4%				

Table S-12. Net Production Value Without and with the Project

(Unit : ฿ x 10^6)

	Project as a Whole */				Stage I Development */			
	Without	With	Incremental	%	Without	With	Incremental	%
*/ .... at full development.								
Main-Season Paddy								
(1) Irrigation and Drainage Improvement								
	13.44	82.73	69.29		6.45	37.74	31.29	
(Local Improved)		(21.66)				(21.66)		
(HYV - RD13)		(44.80)				(11.80)		
(HYV - RD 7)		(16.27)				(4.28)		
(2) Drainage Improvement Only								
	0.59	0.97	0.38		-	-	-	
Total	14.03	83.70	69.67	49	6.45	37.74	31.29	51
Off-Season Fields Crops and Vegetables (Irrigation)								
Sweet Corn	-	1.64	1.64		-	0.84	0.84	
Mung Bean	-	2.45	2.45		-	1.26	1.26	
Groundnuts	-	3.14	3.14		-	1.61	1.61	
Vegetables	-	37.38	37.38		-	19.19	19.19	
(Tomato)	(-)	(29.72)	(29.72)		(-)	(15.24)	(15.24)	
(Chilli)	(-)	(7.66)	(7.66)		(-)	(3.95)	(3.95)	
Total	-	44.61	44.61	31	-	22.90	22.90	37
Perennial Forage Crop (Irrigation)								
Torpedo/Para Grass								
	-	1.06	1.06	1	-	0.28	0.28	1
Rubber (Drainage Improvement)								
	43.21	59.68	16.47	11	0.75	1.05	0.30	1
Tree Fruit								
Long Kong	-	9.27	9.27	6	-	4.79	4.79	7
Bang Nara Water Storage Fisheries								
	-	2.38	2.38	2	-	2.38	2.38	3
Total	57.24	200.70	143.46	100	7.20	69.14	61.94	100

Sensitivity of the economic internal rate of return for the entire Project has been tested:

	Alternative	Economic Internal Rate of Return
Case 1.	a 10% increase in cost	9.5%
Case 2.	a 10% reduction in net production value with the Project	9.0%
Case 3.	a two-year delay of benefit	9.4%
Case 4.	a two-year delay of Stage II development	10.0%
Case 5.	a combination of Case 1 and Case 2	8.2%
Case 6.	a combination of Case 1, Case 2 and Case 3	7.6%
Case 7.	a combination of Case 1, Case 2, Case 3 and Case 4	7.4%
Case 8.	a 36% decline in world market price of paddy	7.5%
Case 9.	an extension of Stage I building-up period by five years and Stage II by three years	9.5%

5.2. Farm Incomes

The farm budgets have been prepared for two model farms, viz. (1) *sole paddy farm and (2) mixed paddy/rubber farm* with such different farm sizes as small, medium and large.

Table S-11. Farm Budgets

(Unit: ฿ x 10^3)

Sole Paddy Farm

Size	Small		Medium		Large	
	Without	With	Without	With	Without	With
Paddy Field (ha)	1.2		1.8		2.8	
Family Size	4.8		5.0		6.3	
Farm Income	7.9	22.5	10.4	32.8	16.2	52.7
Off-Farm Income	10.0	10.0	10.0	10.0	8.0	8.0
Total	17.9	32.5	20.4	42.8	24.2	60.7
(Per Capita)	(3.7)	(6.8)	(4.1)	(8.6)	(3.8)	(9.6)

Mixed Paddy/Rubber Farm

Size	Small		Medium		Large	
	Without	With	Without	With	Without	With
Paddy Field (ha)	0.8		1.2		1.3	
Rubber Area (ha)	0.6		1.0		2.0	
Family Size	5.0		5.2		6.1	
Farm Income	11.8	23.0	15.4	32.3	22.1	46.8
Off-Farm Income	8.0	8.0	8.0	8.0	10.0	10.0
Total	19.8	31.0	23.4	40.3	32.1	56.8
(Per Capita)	(4.0)	(6.2)	(4.5)	(7.8)	(5.3)	(9.3)

It is expected that the annual farm incomes after a full development of the Project would exceed, as a whole, ฿5,580 of the Thai average rural per capita income as stated in para. 2.2, and this would greatly contribute towards the improvement of their living standard.

5.3. Indirect Effects of the Project

Aside from the direct economic benefit, the Project would generate both the indirect and associated socio-economic benefit/impact and exert various influences on the Muban societies:

- In connection with the increased agricultural production as envisaged, it is anticipated that the agro-industries such as post-harvest treatment processing, marketing and distribution would be developed and the related employment opportunities would be increased.

- With the positive technical backup and agricultural extension services under the Government agencies concerned, the water users' groups would be brisk in their movement, and a collective cultivation of the off-season field crops and vegetables, perennial forage crops and fruit tree on the basis of Muban cooperative service unit taking into account special land-lease arrangement within such Muban would lead towards a viable promotion of the cooperative movement as well as a unique creation of the mutual aid system in the lowest level of the administration system. This would promote the development of Muban concerned in every way with the additional Government effort in terms of the family planning and social welfare programmes.

- The increased farm incomes would leave the Project farmers more surplus to be invested for education opportunities of their children, and the socio-economic disparity between the neighboring Malaysia would be alleviated on the basis of the improvement of their living standard. This would be surely connected to easing of the present social-psychological problems in the area to a large extent.

It may be noted that strict attention has been paid to the environment at the Narathiwat estuary during the Study as follows:

- The present estuary flow at Narathiwat during the non-flood period would be mainly dominated by such tidal flow as flood and ebb tide discharges with some freshwater contribution to the ebb discharge from the upstream basins of Mae Nam Yakang and Mae Nam Bang Nara. In the case that incorporates all of the Yakang river flow into the water storage during the non-flood period, there would be only the tidal flow along the lower reaches of Mae Nam Bang Nara when no release of the freshwater takes place from the Upper Tidal Regulator. This would invite some of the adverse effect to the Narathiwat estuary in terms of water environment and river entrance sand bar. The Project plan has incorporated a countermeasure that the minimum river maintenance flow of 5 cu.m per sec as mentioned in (3) of para. 3.2.1 would be always released to alleviate salt water intrusion and carry away waste after construction of the Upper Tidal Regulator in order to conserve the water-related environmental conditions as are currently seen. On the other hand, the irrigation water abstraction from Mae Nam Bang Nara would account for only 2.7 percent of its average annual runoff. With these considerations, there would be fundamentally no problem with respect to the environments in the Narathiwat estuary.

6. RECOMMENDATION

6.1. The proposed Project which intends to increase the production of main-season paddy and off-season field crops and vegetables on existing paddy fields and of existing rubbers and to result in higher income and increased employment for the area's small farmers, would be technically sound and socio-economically viable taking into appropriate account various environmental issues related. With adequate overall management and coordination among the Governmental agencies, well-coordinated institutional set-up for the Project farmers and proper operation and maintenance of the Project facilities, it should be a great and valuable asset to the Bang Nara river basin where the development has been made to lesser extent.

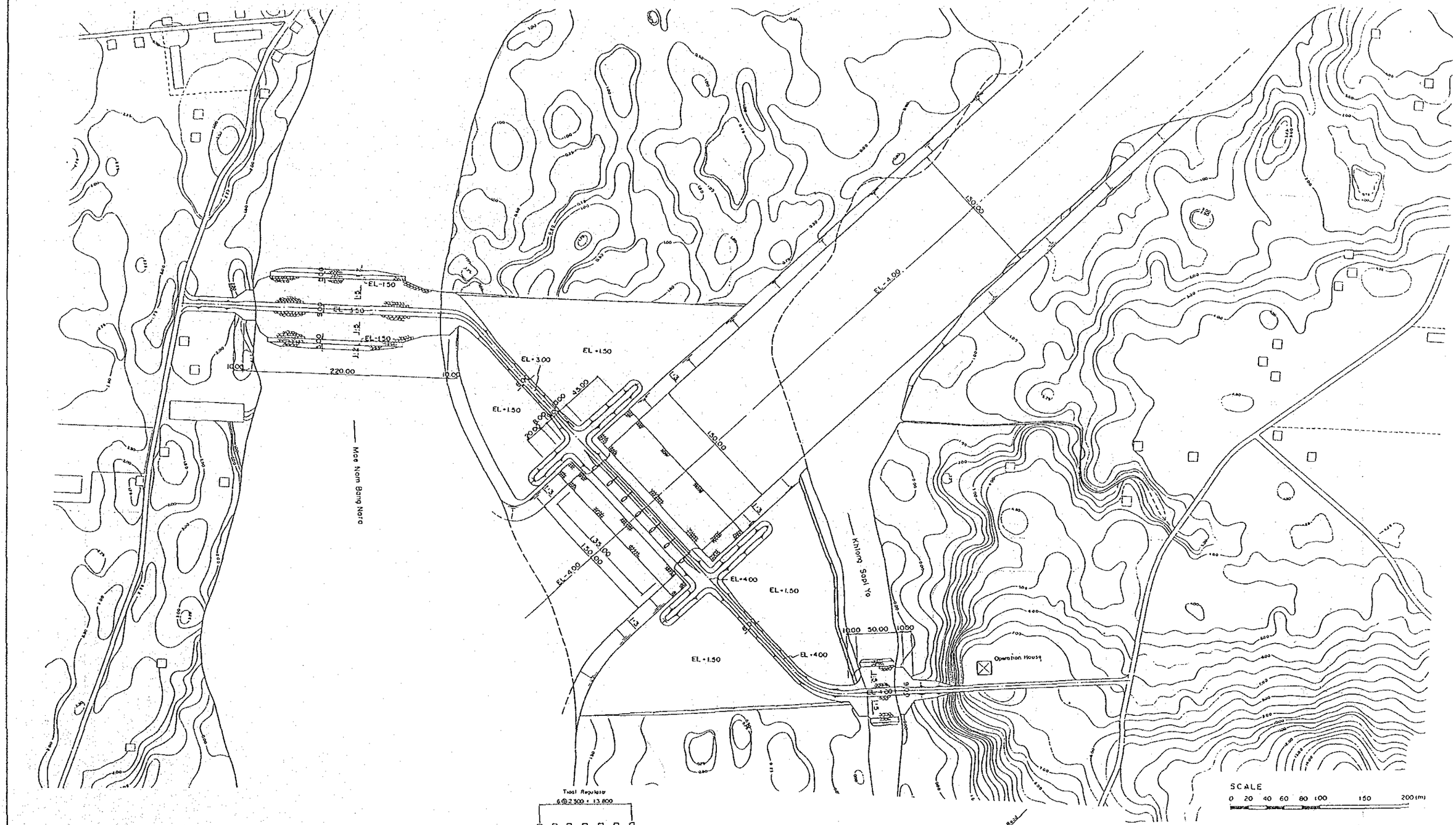
The Government should, therefore, take the next procedures and necessary arrangements for immediate implementation of the Project covering an irrigable area of 9,980 ha (or 62,400 rai) which has been given a high priority by the Government.

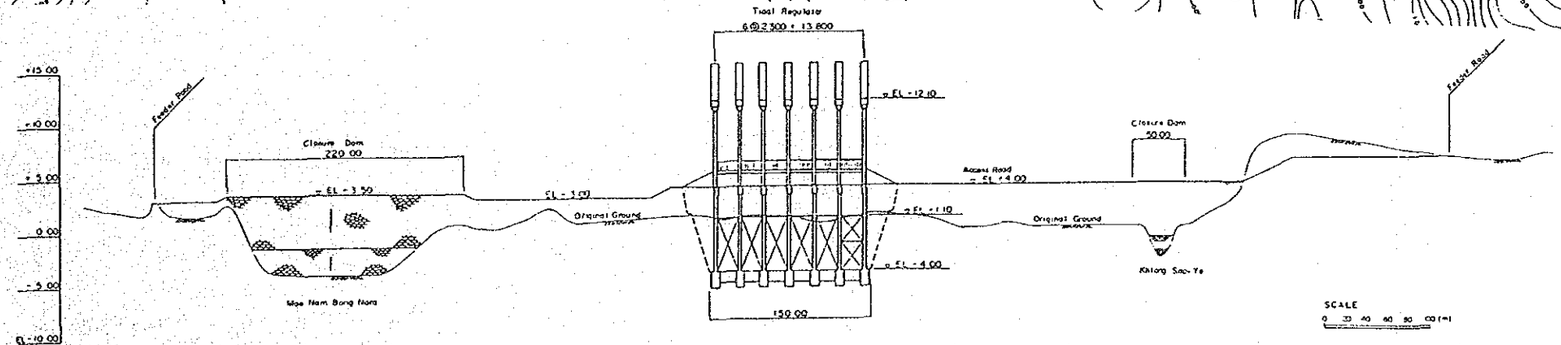
6.2. The formation of water users' groups at the pre-construction stage is the key recommendation to ensure the quick-yielding implementation of the Project in connection with their timely development of the tertiary irrigation service units including the WUG pumping irrigation scheme.

To realize this, it is suggested to organize the Special Task Force Unit on multi-disciplinary basis in the Project during its beginning stage to commence the favorable operation of demonstration farms and to facilitate the prompt formation of active water users' groups. This Unit which streamlines the

specific forms of cooperation between the line agencies concerned would be composed of the community development organizers, agricultural extension workers, irrigation engineers, cooperative promotion experts, rural sociologists and Changwat administrative personnel.

6.3 The impounding water level of the proposed Bang Nara water storage has been given in due consideration of a countermeasure not to cause irreversible environmental damage to the ecology of the Laem Bang Nara II Forest Reserve as well as the status of potential acid sulfate soils over the storage-related basins. It is recommended that the Government would carry out the regular monitoring and evaluation on the above related matters during and after the Project implementation.





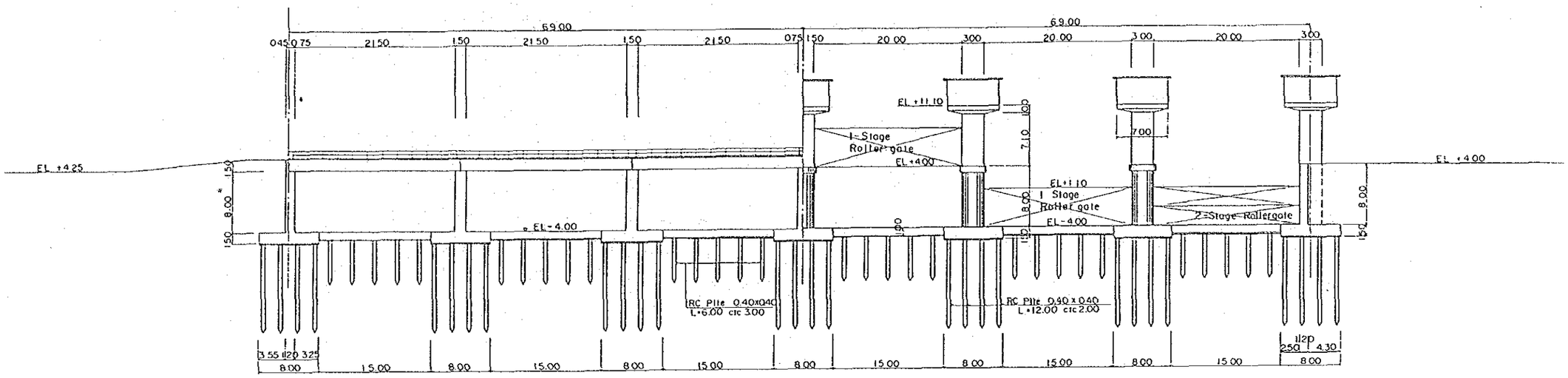
FEASIBILITY STUDY
ON BANG NARA IRRIGATION AND
DRAINAGE PROJECT

UPPER TIDAL REGULATOR
GENERAL PLAN

DRAWING NO. R1 | DATE

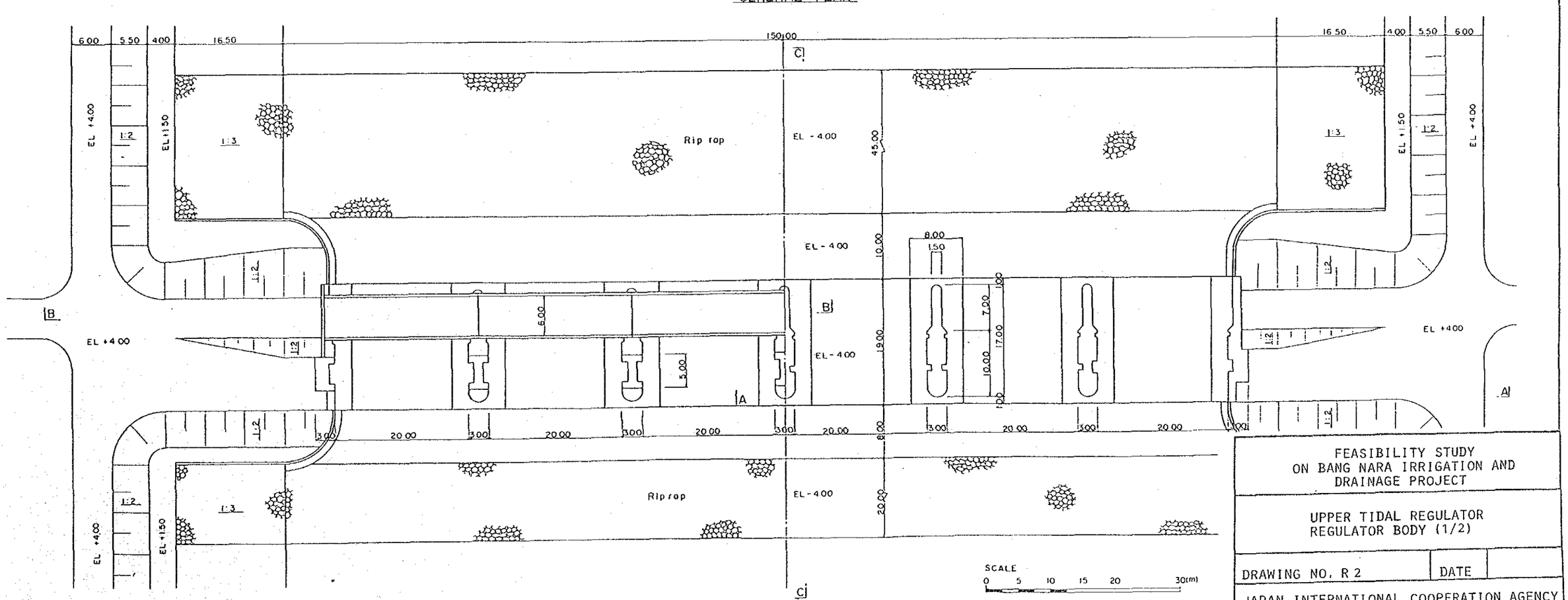
JAPAN INTERNATIONAL COOPERATION AGENCY

SECTION B-B



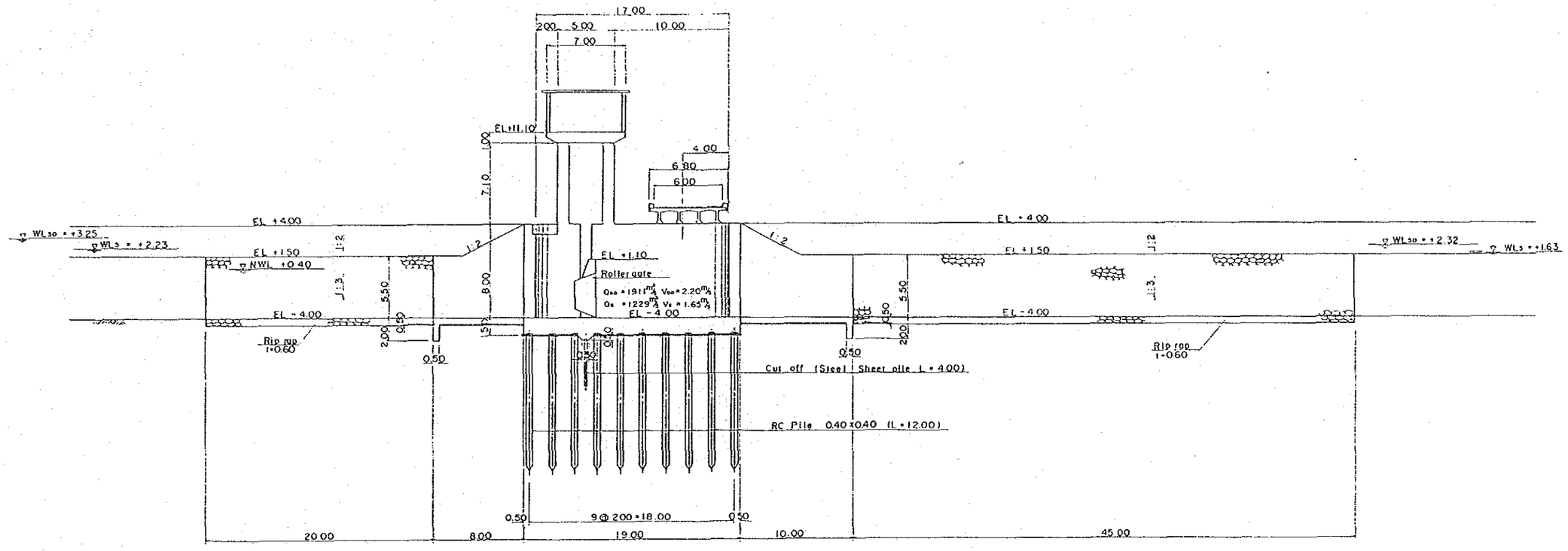
SECTION A-A

GENERAL PLAN

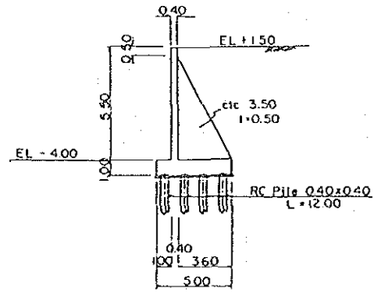


FEASIBILITY STUDY ON BANG NARA IRRIGATION AND DRAINAGE PROJECT	
UPPER TIDAL REGULATOR REGULATOR BODY (1/2)	
DRAWING NO. R 2	DATE
JAPAN INTERNATIONAL COOPERATION AGENCY	

SECTION C - C



WING WALL



SCALE
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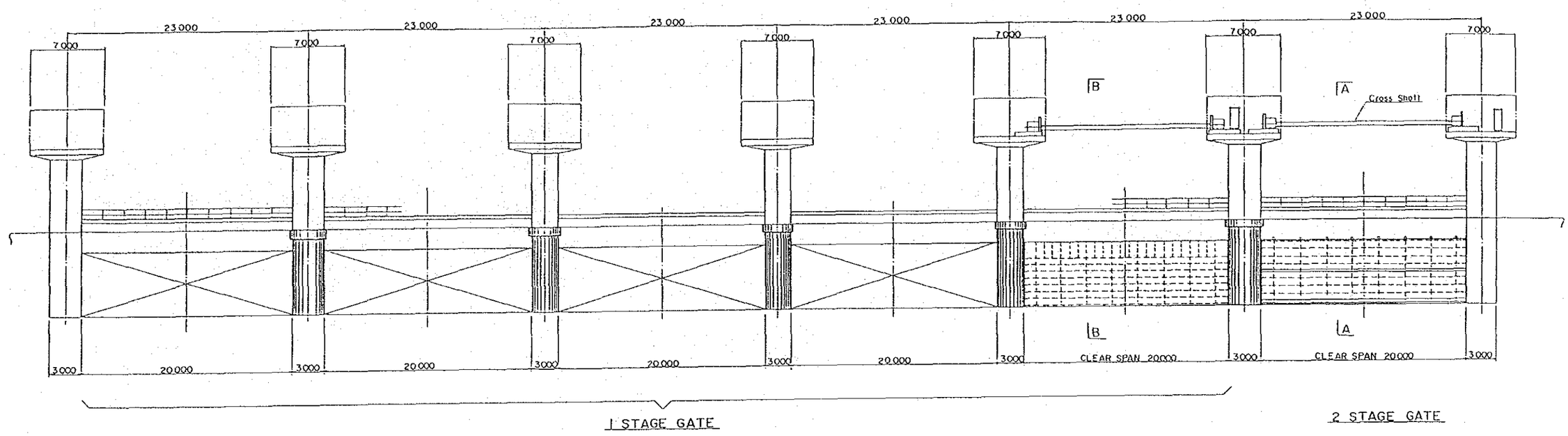
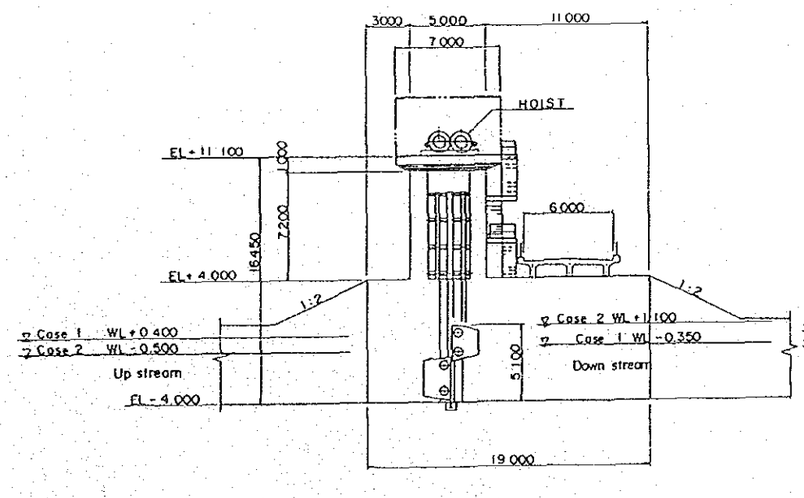
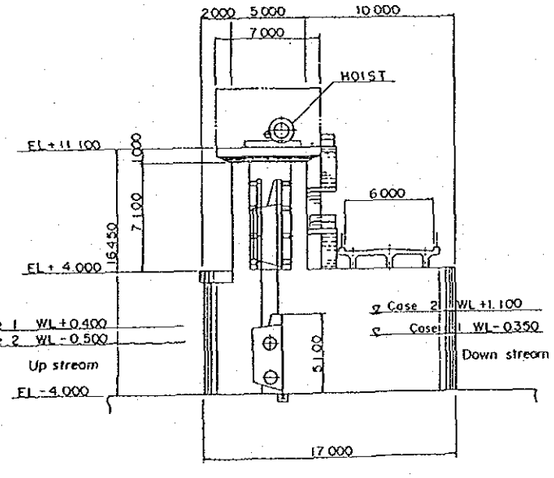
FEASIBILITY STUDY ON BANG NARA IRRIGATION AND DRAINAGE PROJECT	
UPPER TIDAL REGULATOR REGULATOR BODY (2/2)	
DRAWING NO. R 3	DATE
JAPAN INTERNATIONAL COOPERATION AGENCY	

ELEVATON (UPSTREAM VIEW)





SECTION A - A
2-STAGE GATE



SECTION B - B
1-STAGE GATE

SCALE
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UPPER TIDAL REGULATOR
GATE DESIGN CONDITION

	1 - STAGE GATE	2-STAGE GATE
TYPE	Shell Type Roller Gate	Shell Type Roller Gate
QUANTITY	5	1
CLEAR SPAN	20,000	20,000
GATE HEIGHT	5,100	5,100
DESIGN WATER LEVEL	Up stream	Down stream
Case - 1	WL + 0.400	WL - 0.350
Case - 2	WL - 0.500	WL + 1.100
ELEVATION Operating Floor	EL + 11.100	
Sill	EL - 4.000	
HOIST	Wire Rope Winch	
Operating Speed	0.3 m/min	

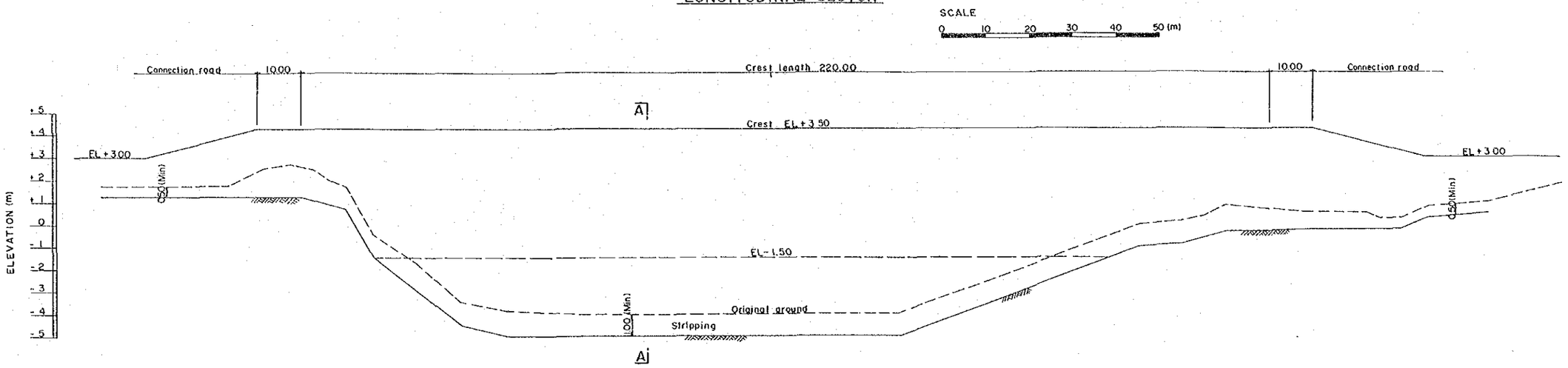
FEASIBILITY STUDY
ON BANG NARA IRRIGATION AND DRAINAGE PROJECT

UPPER TIDAL REGULATOR
GATE ARRANGEMENT

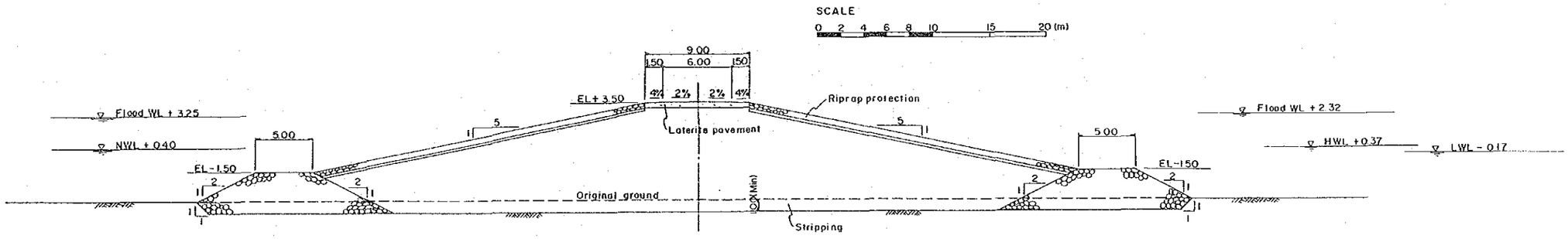
DRAWING NO. R 4 | DATE

JAPAN INTERNATIONAL COOPERATION AGENCY

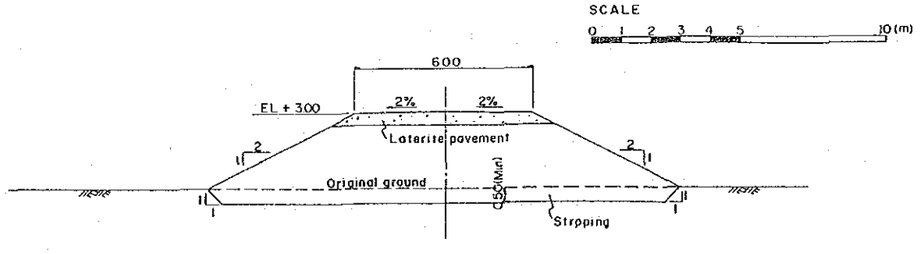
LONGITUDINAL SECTON



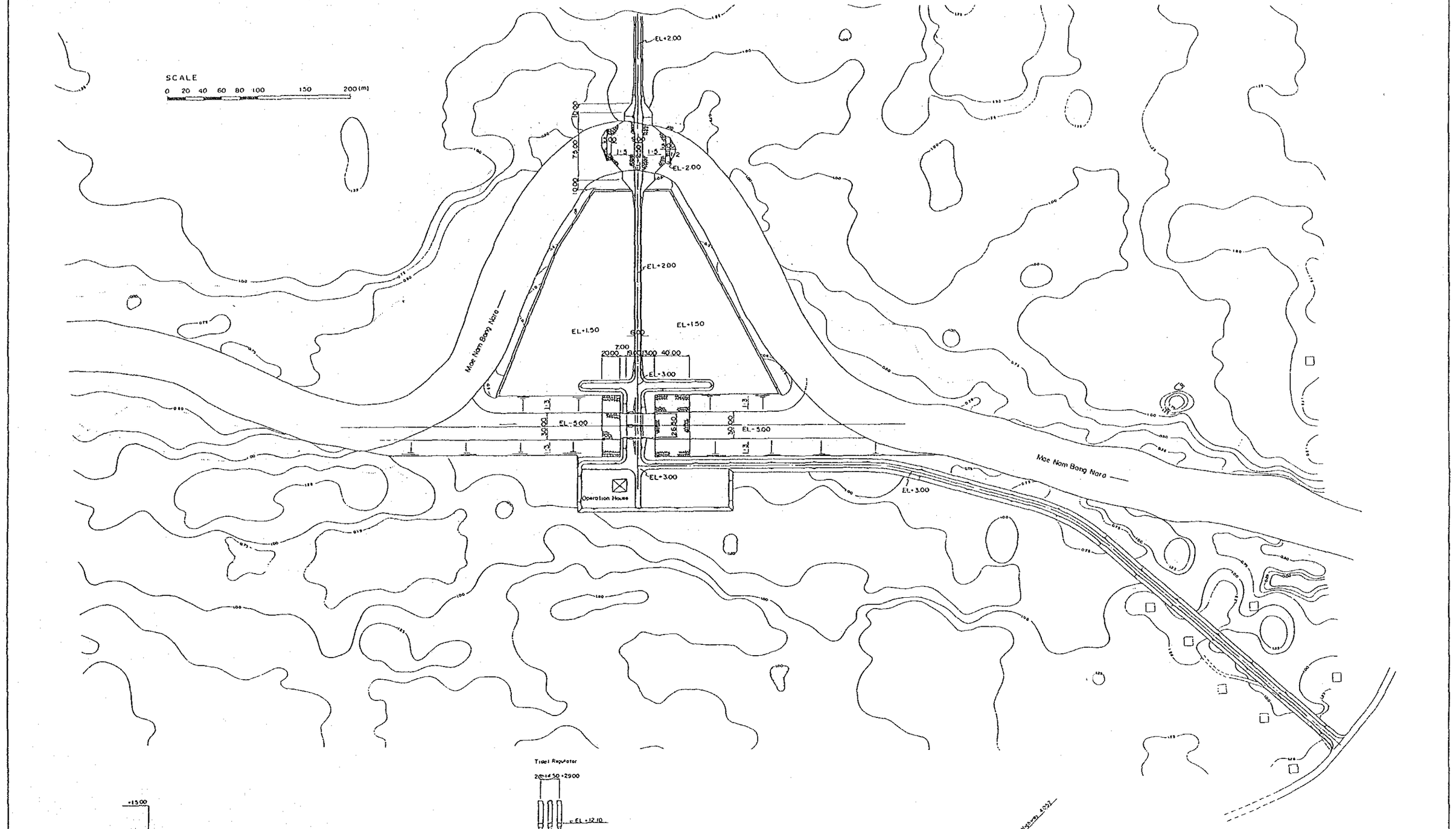
SECTION A - A

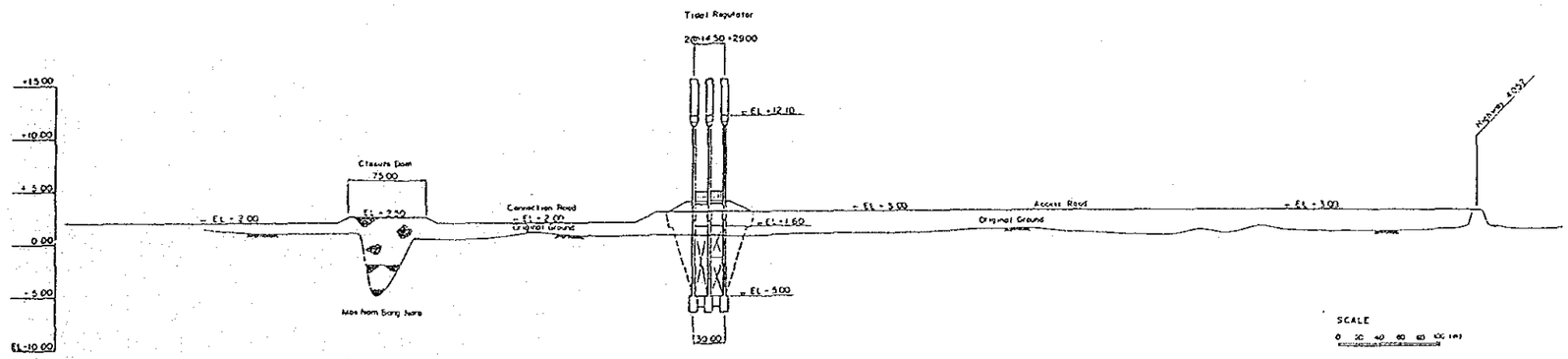


CONNECTION ROAD



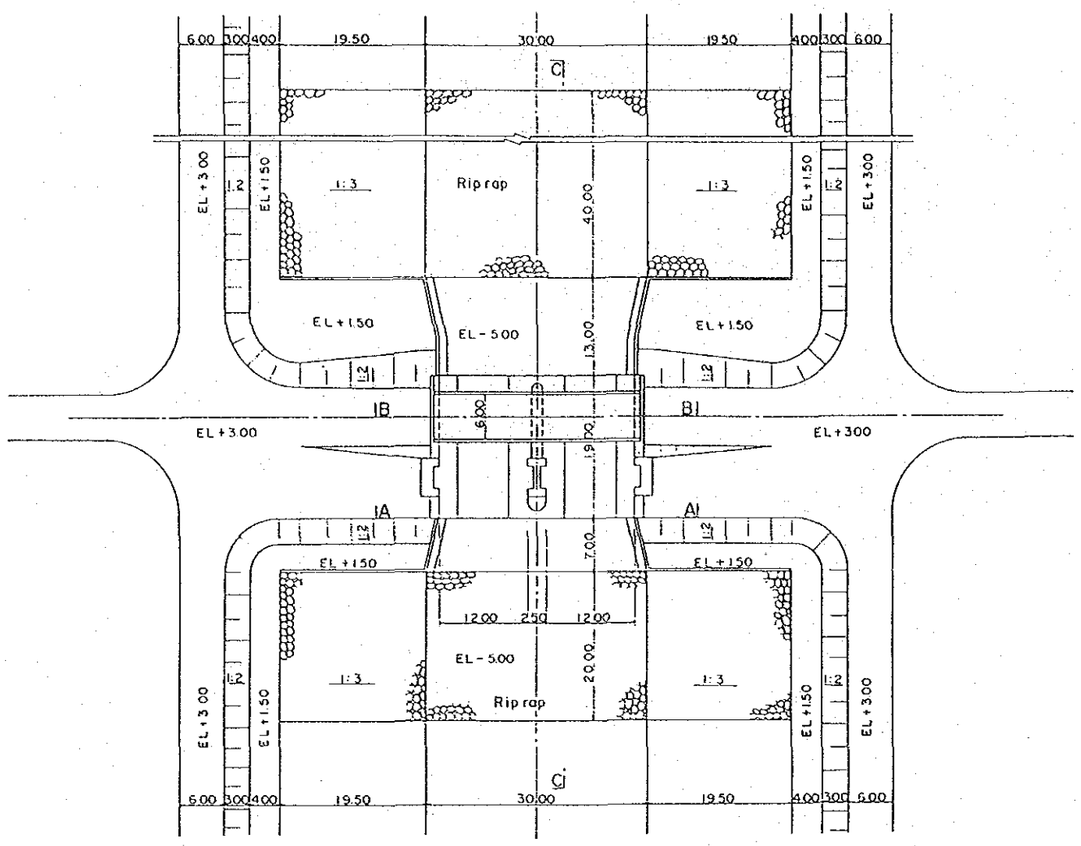
FEASIBILITY STUDY ON BANG NARA IRRIGATION AND DRAINAGE PROJECT	
UPPER TIDAL REGULATOR CLOSURE DAM	
DRAWING NO. R 5	DATE
JAPAN INTERNATIONAL COOPERATION AGENCY	





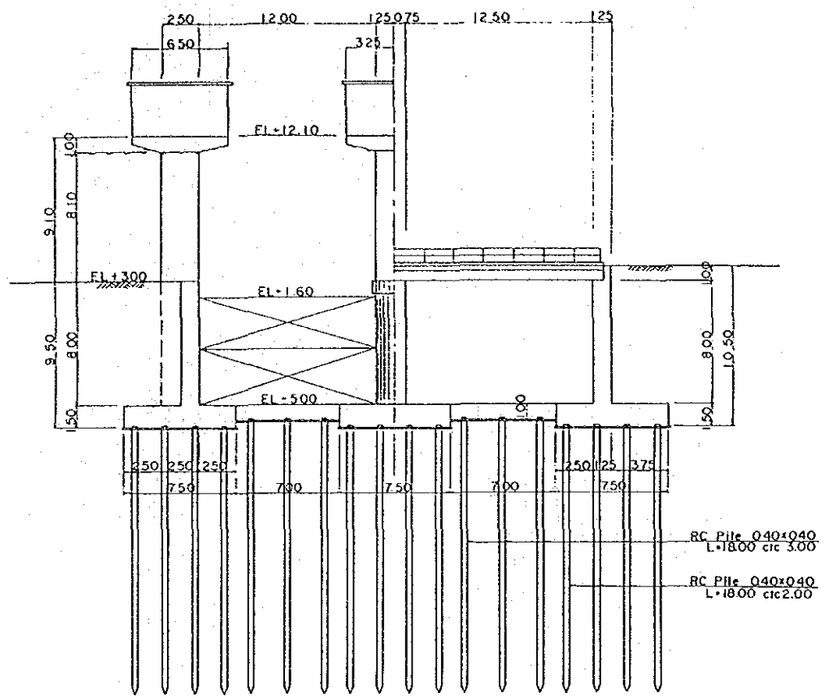
FEASIBILITY STUDY ON BANG NARA IRRIGATION AND DRAINAGE PROJECT	
LOWER TIDAL REGULATOR GENERAL PLAN	
DRAWING NO. R 6	DATE
JAPAN INTERNATIONAL COOPERATION AGENCY	

GENERAL PLAN

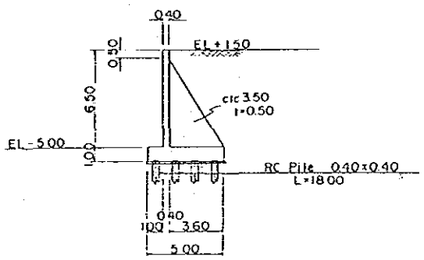


SECTION A - A

SECTION B - B



WING WALL



SECTION C - C

SCALE

PLAN
0 5 10 15 20 30 40(m)

SECTION
0 2 4 6 8 10 15 20(m)

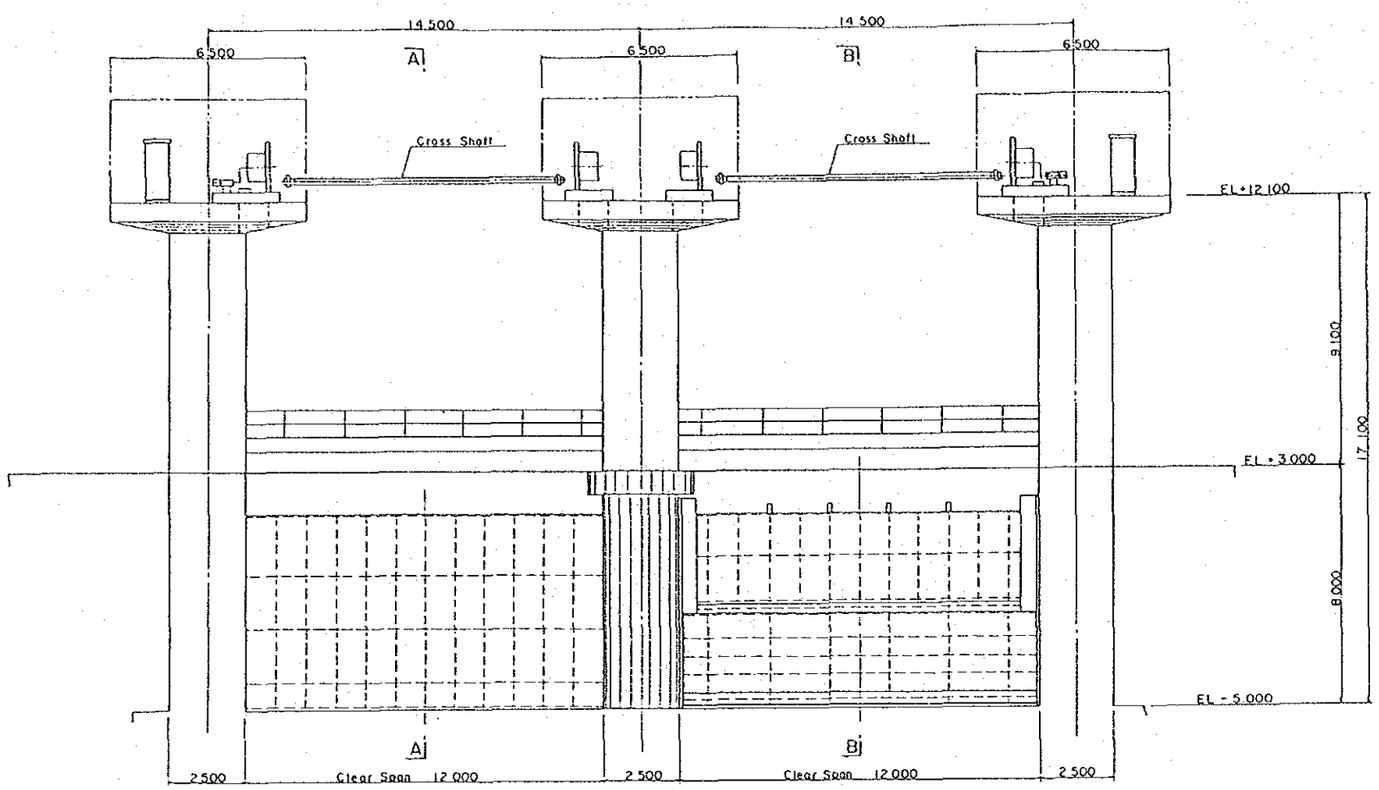
FEASIBILITY STUDY
ON BANG NARA IRRIGATION AND
DRAINAGE PROJECT

LOWER TIDAL REGULATOR
REGULATOR BODY

DRAWING NO. R 7 | DATE

JAPAN INTERNATIONAL COOPERATION AGENCY

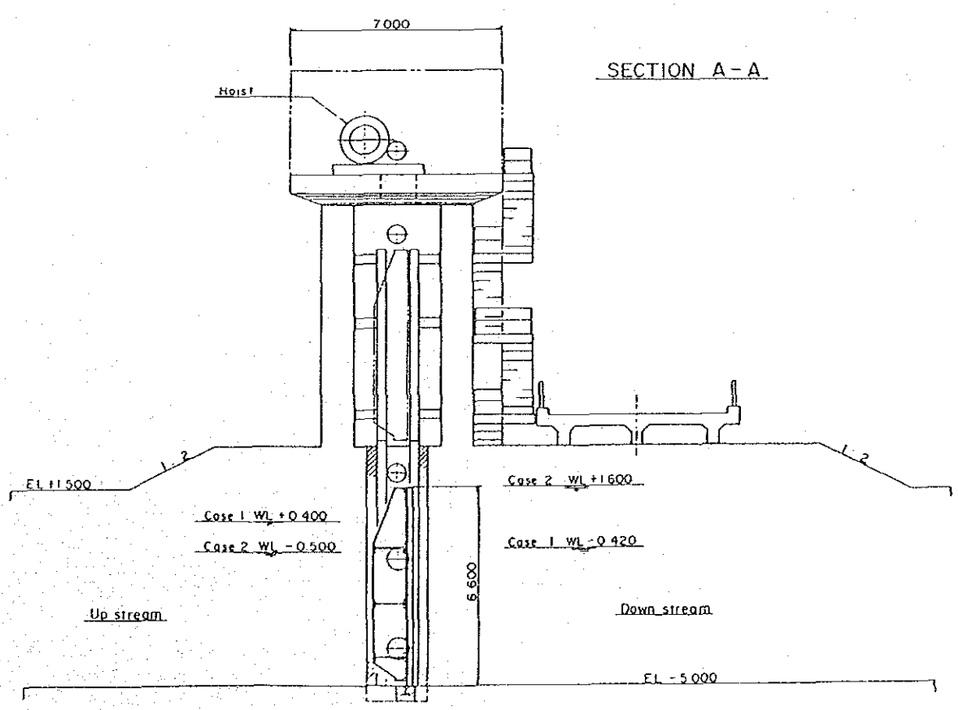
ELEVATION (UPSTREAM VIEW)



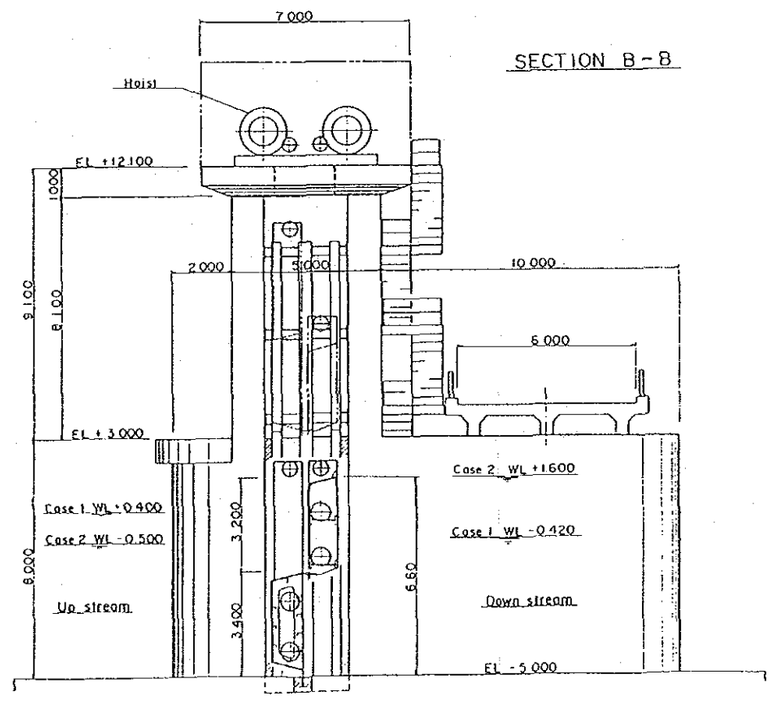
LOWER TIDAL REGULATOR GATE DESIGN CONDITION

	1-STAGE GATE	2 STAGE GATE
TYPE	Girder Type, Roller Gate	Shell and Girder, Type Roller Gate
QUANTITY	1	1
CLEAR SPAN	12.000	12.000
GATE HEIGHT	7.200	7.200
DESIGN WATER LEVEL	Up stream	Down stream
Case 1	WL+0.500	WL -0.420
Case 2	WL-0.500	WL +1.600
ELEVATION		
Operating Floor	EL +12.700	
Sill	EL -5.000	
HOIST	Wire Rope Winch	
OPERATING SPEED	0.3 m/min	

SECTION A-A



SECTION B-B



SCALE
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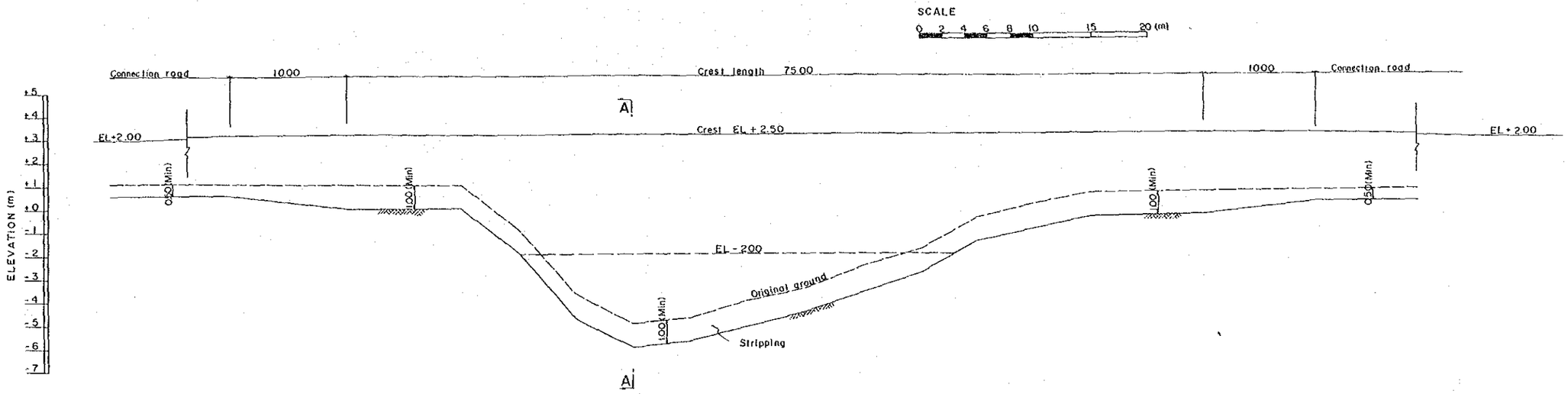
FEASIBILITY STUDY
ON BANG NARA IRRIGATION AND DRAINAGE PROJECT

LOWER TIDAL REGULATOR
GATE ARRANGEMENT

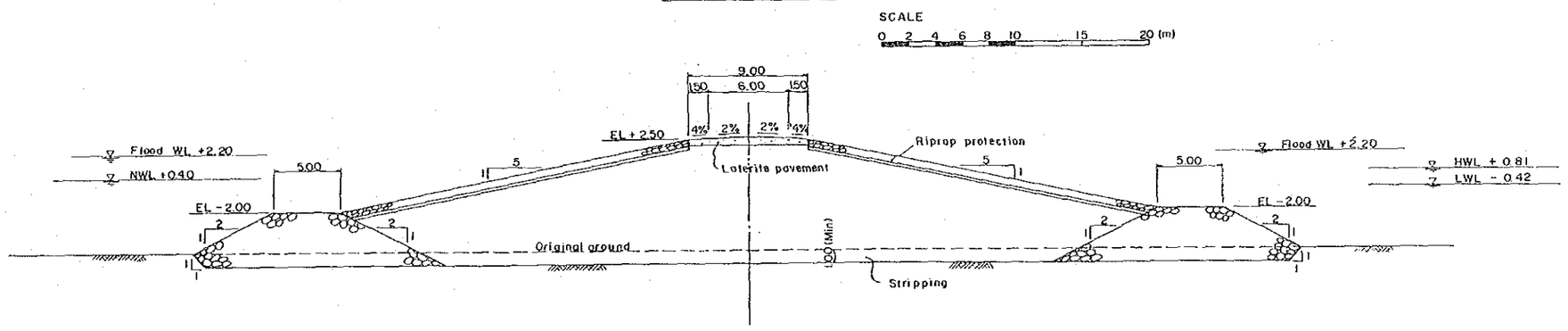
DRAWING NO. R 8 | DATE

JAPAN INTERNATIONAL COOPERATION AGENCY

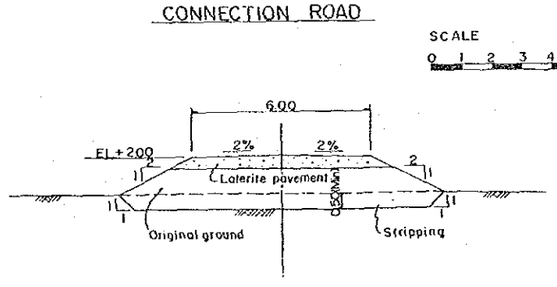
LONGITUDINAL SECTION



SECTION A - A

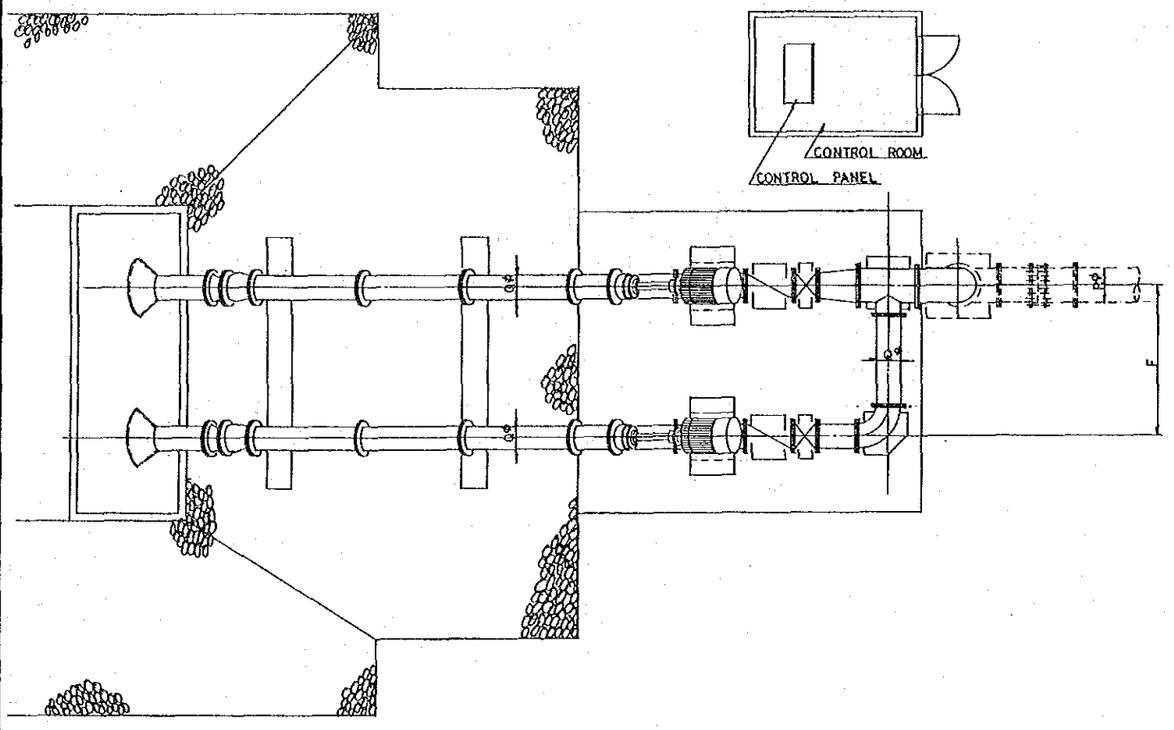


CONNECTION ROAD

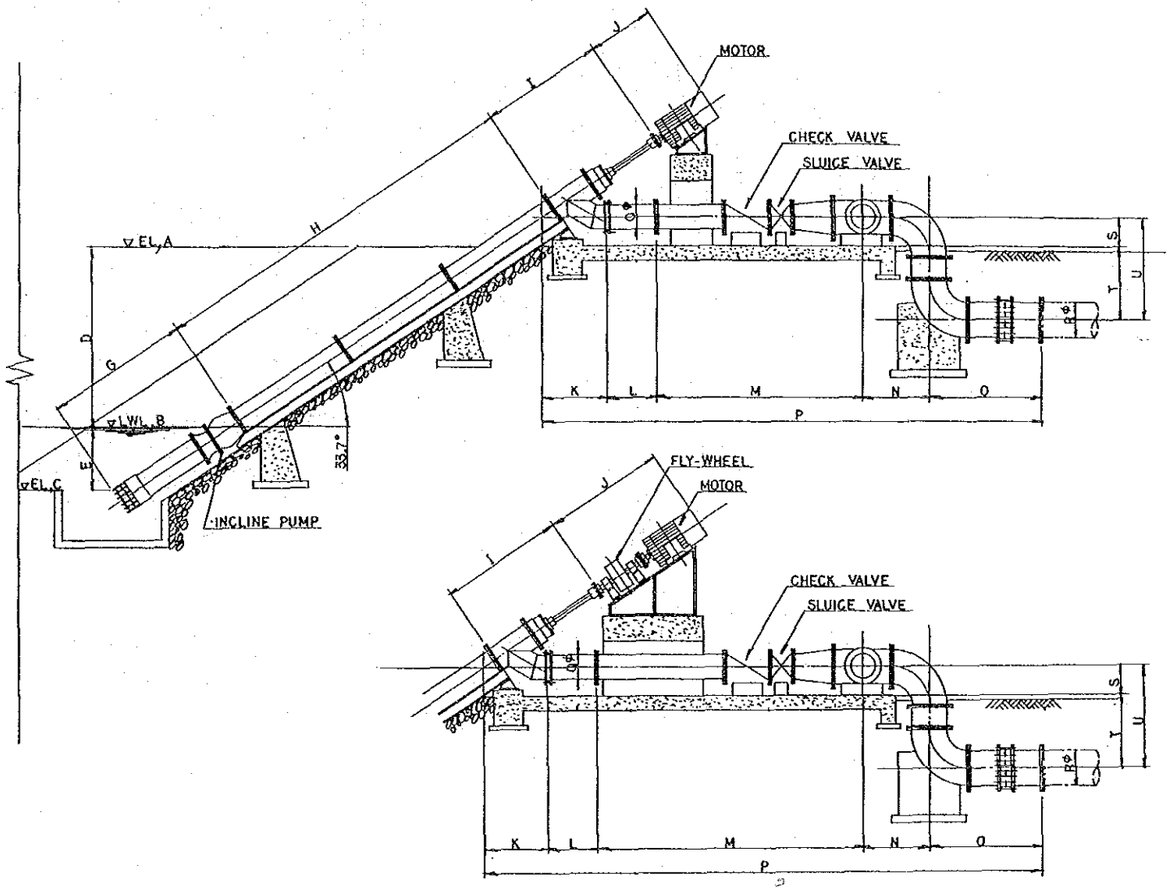


FEASIBILITY STUDY ON BANG NARA IRRIGATION AND DRAINAGE PROJECT	
LOWER TIDAL REGULATOR CLOSURE DAM	
DRAWING NO. R 9	DATE
JAPAN INTERNATIONAL COOPERATION AGENCY	

PLAN



PROFILE



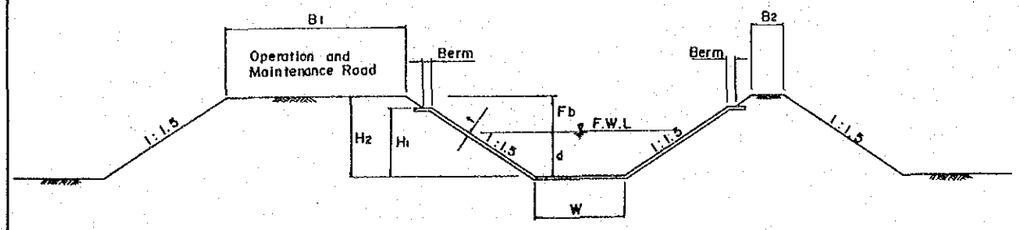
NO	P/S NAME	DIA. OF PUMP (mm)	TYPE OF PUMP	CAPACITY (m³/min)	HEAD (m)	SPEED (rpm)	OUT PUT (kW)	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	REMARKS
1	PU TA	300	MIXED FLOW	9.6	7.0	1450	18.5	+5.84	+0.84	+0.84	5000	750	2000	1780	9870	1740	653	821	750	4529	1400	2500	10000	300	600	600	1900	2500	
2	KHAO KONG	450	MIXED FLOW	23.1	7.9	980	45	+7.53	+1.64	+1.64	5890	1130	2000	2665	11550	2260	845	1140	930	4030	1400	2500	10000	450	600	600	1900	2500	
3	DU SONG	500	MIXED FLOW	36.6	17.9	980	160	+3.40	-0.37	-1.60	3770	1250	2000	2950	7500	2450	2335	1229	1124	4747	1400	2500	11000	500	900	700	1800	2500	FLY-WHEEL
4	TAN YONG MAT	600	AXIAL FLOW	45	5	740	55	+16.80	+10.91	+10.90	5890	1500	2000	3535	11500	2750	880	1432	1200	4468	1500	2500	11000	600	900	700	1800	2500	
5	KHOK TI TE	450	MIXED FLOW	25.2	21.5	980	132	+3.50	-0.42	-1.50	3920	1130	2000	2670	7800	2260	2335	1140	930	5030	1400	2500	11000	450	800	700	1800	2500	FLY-WHEEL
		400	MIXED FLOW	21	11.7	1475	75					1000	2000	2670	7800	2050	880	1016	850	4234	1400	2500	10000	400	800	700	1800	2500	FLY-WHEEL
6	MARU BO	400	MIXED FLOW	19.5	12.9	1475	75	+3.90	-0.29	-1.10	4190	1000	2000	2360	8300	2050	880	1016	850	4234	1400	2500	10000	400	700	700	1800	2500	
7	SALA MAI	400	MIXED FLOW	20.4	9.3	1475	55	+3.00	-0.29	-1.10	3290	1000	2000	2360	6000	2050	845	1016	850	4234	1400	2500	10000	400	700	700	1800	2500	
8	KO SAWAT	400	MIXED FLOW	21.6	6.7	980	37	+4.30	-0.20	-3.70	4500	1000	2000	2360	8000	2050	826	1016	850	4234	1400	2500	10000	400	800	700	1800	2500	
9	PHRU KAP DAENG	400	MIXED FLOW	15.6	7.2	980	30	+4.30	-0.20	-3.70	4500	1000	2000	2360	8000	2050	826	1016	850	4234	1400	2500	10000	400	700	700	1800	2500	
10	KU CHAM	300	MIXED FLOW	7.8	8.4	1475	18.5	+4.60	-0.20	-3.40	4800	750	2000	1780	9200	1740	653	821	750	4529	1400	2500	10000	300	600	600	1900	2500	

FEASIBILITY STUDY
ON BANG NARA IRRIGATION AND
DRAINAGE PROJECT

IRRIGATION FACILITIES
INCLINED PUMP FACILITIES

DRAWING NO. ID 9 | DATE

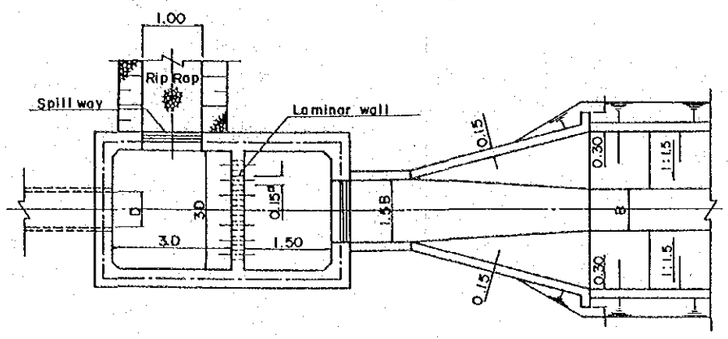
JAPAN INTERNATIONAL COOPERATION AGENCY



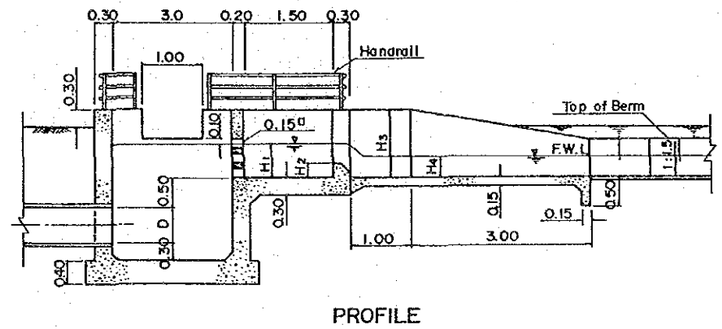
TYPICAL CANAL SECTION

TABLE OF DIMENSIONS FOR IRRIGATION CANAL

TYPE	Q m³/sec	W m	d m	Fb m	H1 m	H2 m	B1 m	B2 m	Berm m	t cm
I	0.01 ~ 0.20	0.50	0.25	0.45	0.50	0.70	3.00	0.50	Min 0.15	5
II	0.20 ~ 0.30	0.70	0.35	0.50	0.65	0.85	3.00	0.50	- do -	5
III	0.30 ~ 0.60	0.90	0.45	0.50	0.75	0.95	3.00	0.50	- do -	5
IV	0.60 ~ 0.80	1.10	0.55	0.55	0.90	1.10	3.00	0.50	- do -	5
V	0.80 ~ 1.10	1.30	0.65	0.60	1.05	1.25	3.00	0.50	- do -	5
VI	1.10 ~ 1.50	1.50	0.75	0.60	1.15	1.35	3.00	0.50	- do -	5



PLAN

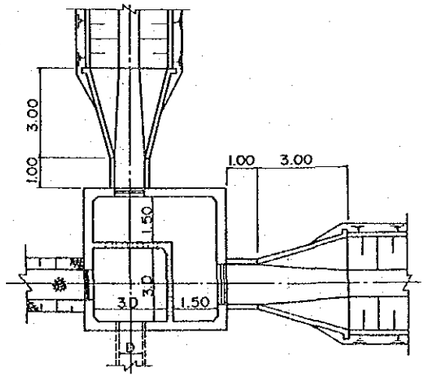


PROFILE

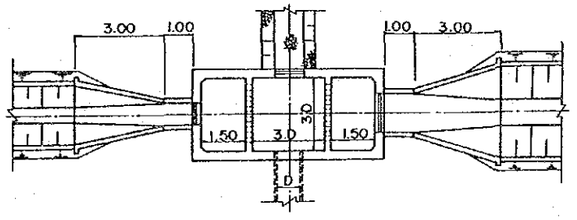
DISCHARGE TANK (TYPE I)
Not to scale

TABLE OF DIMENSIONS FOR DISCHARGE TANK

Q m³/sec	B m	H1 m	H2 m	H3 m	H4 m
1.50 ~ 1.10	1.50	1.15	0.60	1.65	0.75
1.10 ~ 0.80	1.30	1.00	0.50	1.55	0.65
0.80 ~ 0.60	1.10	0.85	0.40	1.40	0.55
0.60 ~ 0.30	0.90	0.70	0.30	1.25	0.45
0.30 ~ 0.20	0.70	0.55	0.25	1.15	0.35
0.20 ~ 0.01	0.50	0.40	0.10	1.00	0.25



PLAN OF DISCHARGE TANK (TYPE 3)



PLAN OF DISCHARGE TANK (TYPE 2)

FEASIBILITY STUDY ON BANG NARA IRRIGATION AND DRAINAGE PROJECT	
IRRIGATION FACILITIES RELATED STRUCTURES (1/5)	
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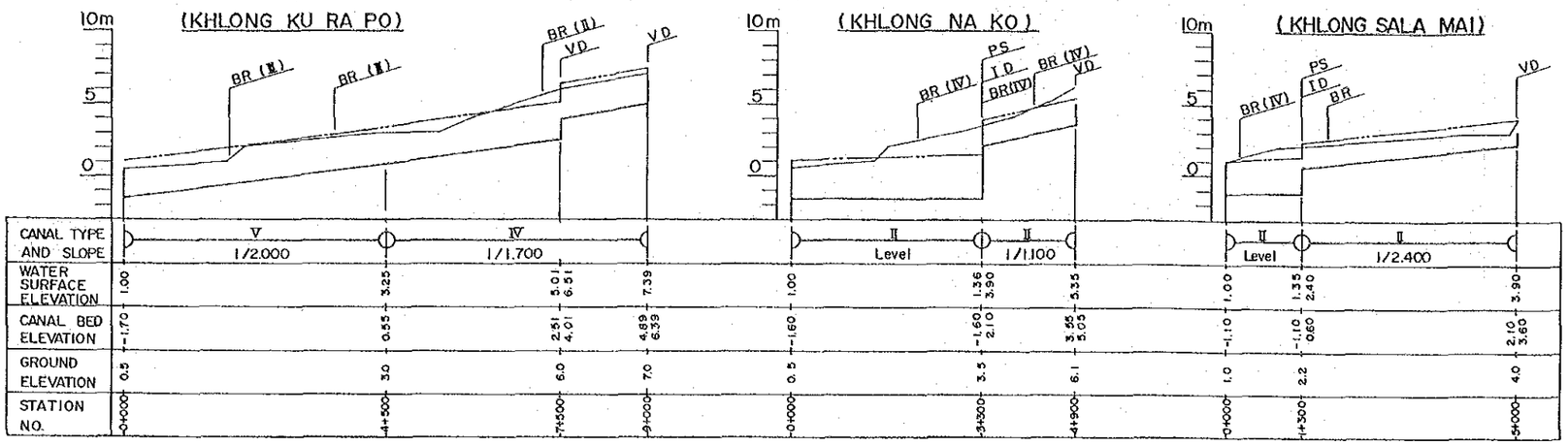
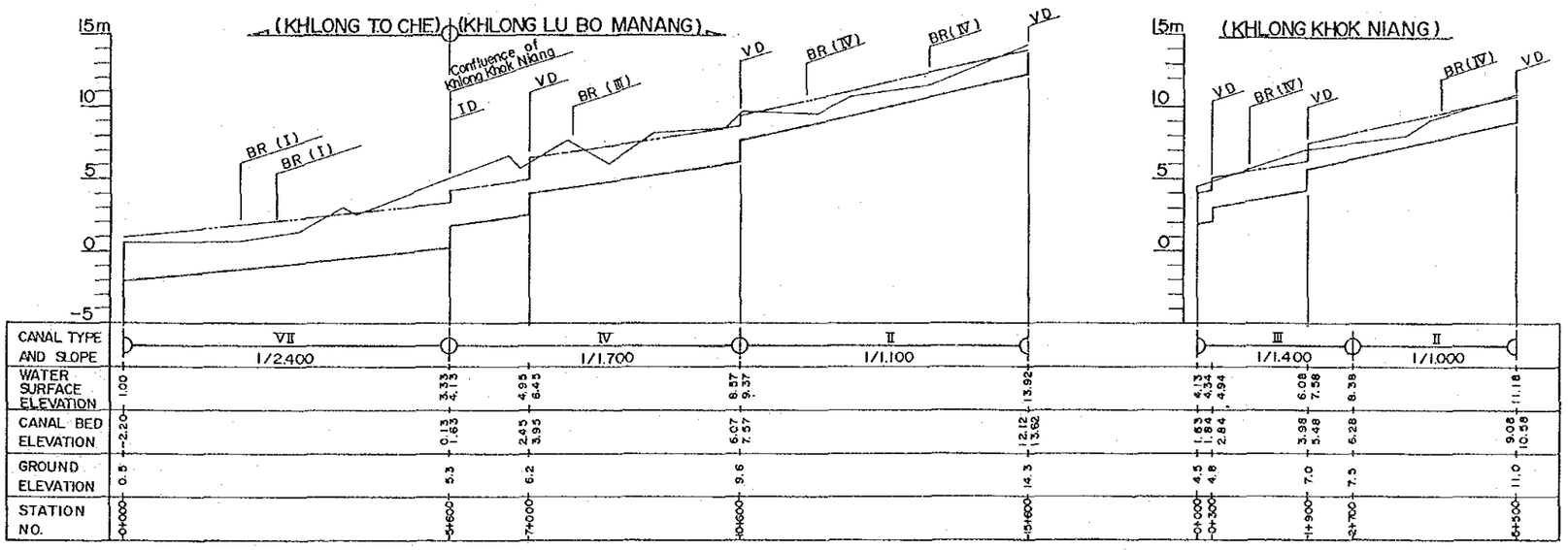
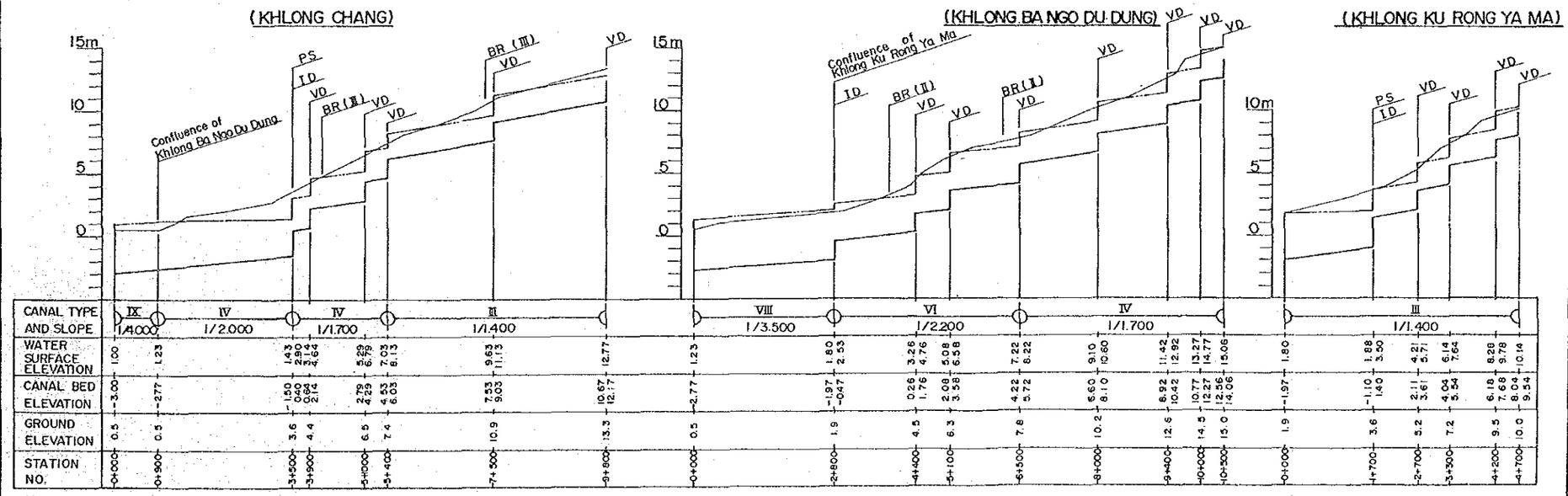
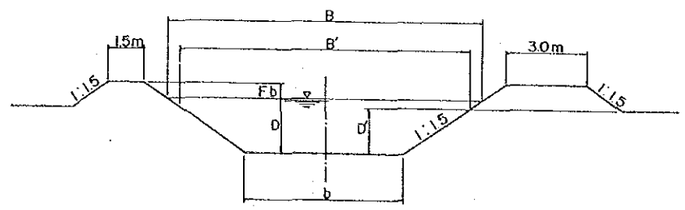






TYPICAL CROSS-SECTION



DIMENSION TABLE

TYPE	Q (m³/sec)	A (m²)	D (m)	D' (m)	b (m)	Fb (m)	B (m)	B' (m)
I	5	4.9	1.3	0.9	2.0	0.3	5.9	4.7
II	10	9.5	1.8	1.4	3.0	0.3	8.4	7.2
III	15	14.3	2.1	1.7	4.0	0.3	10.3	9.1
IV	20	19.0	2.5	2.1	4.0	0.4	11.5	10.3
V	25	23.8	2.7	2.3	5.0	0.4	13.1	11.9
VI	30	28.6	3.0	2.6	5.0	0.4	14.0	12.8
VII	35	33.3	3.2	2.8	6.0	0.4	15.6	14.4
VIII	60	57.1	4.0	3.6	8.5	0.4	20.5	19.3
IX	80	76.2	4.0	3.6	13.5	0.4	25.5	24.3

LEGEND

PS : Pumping Station
VD : Vertical Drop
ID : Inclined Drop
BR : Bridge (Type)

FEASIBILITY STUDY ON BANG NARA IRRIGATION AND DRAINAGE PROJECT

DRAINAGE FACILITIES CANAL PROFILE

DRAWING NO. ID10 | DATE

JAPAN INTERNATIONAL COOPERATION AGENCY