GENERAL DIRECTORATE OF IRRIGATION,
METEOROLOGY AND HYDROLOGY
THE KINGDOM OF CAMBODIA

BASIC DESIGN STUDY REPORT

ON

THE PROJECT FOR THE IMPROVEMENT OF THE FACILITIES OF THE COLMATAGE SYSTEMS IN KANDAL PROVINCE ALONG THE MEKONG RIVER

IN

THE KINGDOM OF CAMBODIA

JULY, 1998

JAPAN INTERNATIONAL COOPERATION AGENCY
SANYU CONSULTANTS INC.

GENERAL DIRECTORATE OF IRRIGATION, METEOROLOGY
BASIC DESIGN STUDY REPORT ON THE PROJECT FOR THE IMPROVEMENT OF THE FACILITIES OF
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PREFACE

In response to a request from the Government of the Kingdom of Cambodia the Government of Japan decided to conduct a basic design study on the Project for the Improvement of the Facilities of the Colmatage Systems in Kandal Province along the Mekong River and entrusted the study to the Japan International Cooperation Agency (JICA).

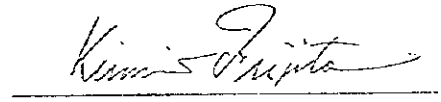
JICA sent to Cambodia a study team from 25th March to 23rd April, 1998.

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

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

I wish to express my sincere appreciation to the officials concerned of the Government of the Kingdom of Cambodia for their close cooperation extended to the teams.

July 1998



Kimio Fujita
President
Japan International Cooperation Agency

July, 1998

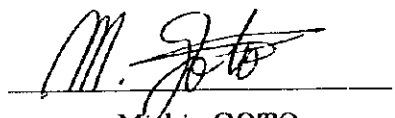
Letter of Transmittal

We are pleased to submit to you the basic design study report on the Project for the Improvement of the Facilities of the Colmatage Systems in Kandal Province along the Mekong River in the Kingdom of Cambodia.

This study was conducted by Sanyu Consultants Inc., under a contract to JICA, during the period from March 18th, 1998 to August 17th, 1998. In conducting the study, we have examined the feasibility and rationale of the project with due consideration to the present situation of Cambodia and formulated the most appropriate basic design for the project under Japan's grant aid scheme.

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

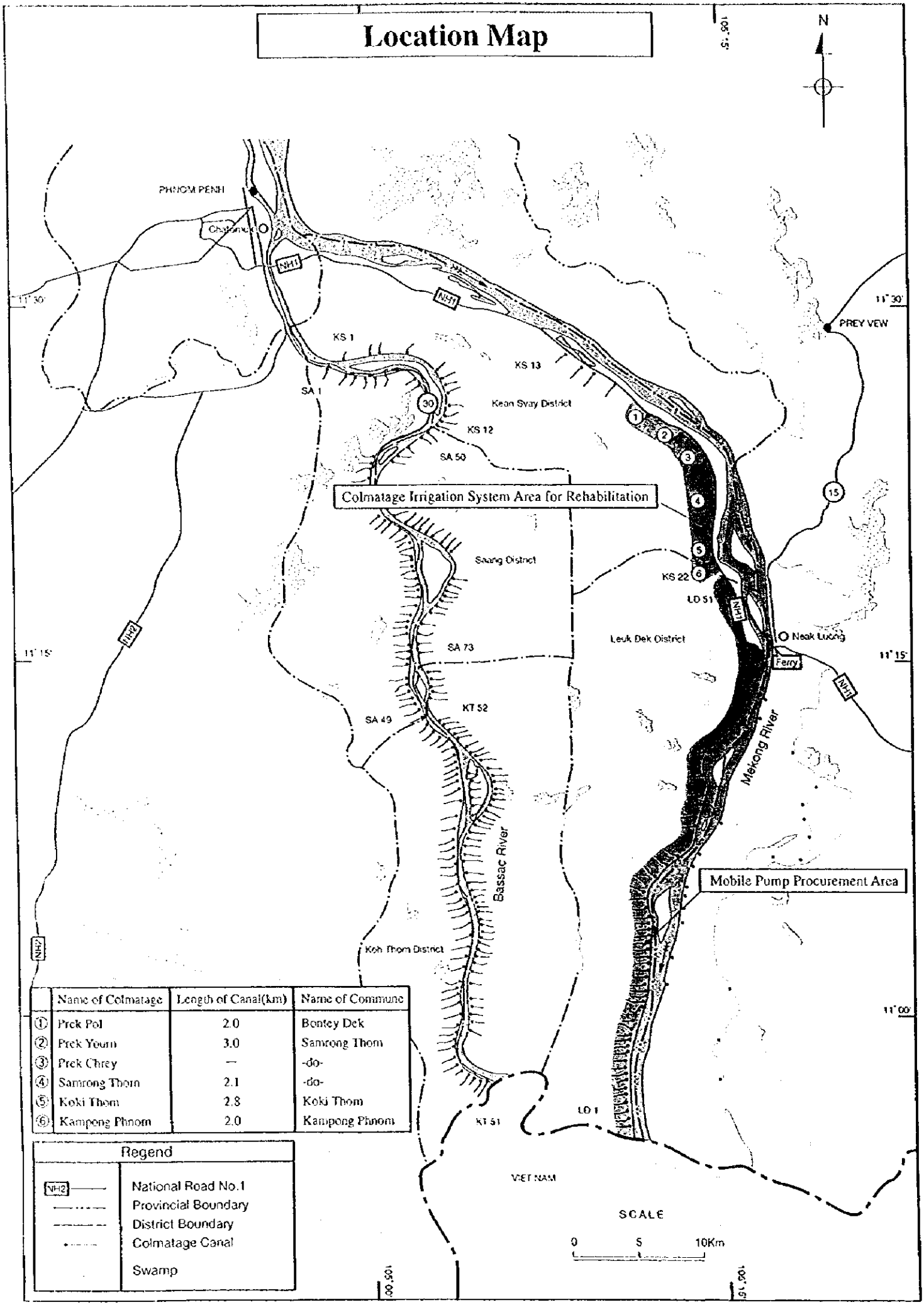
Very truly yours,



Michio GOTO
Project manager,
Basic design study team on the Project for the Improvement of the Facilities of the Colmatage Systems in Kandal Province along the Mekong River.

Sanyu Consultants. Inc.

Location Map

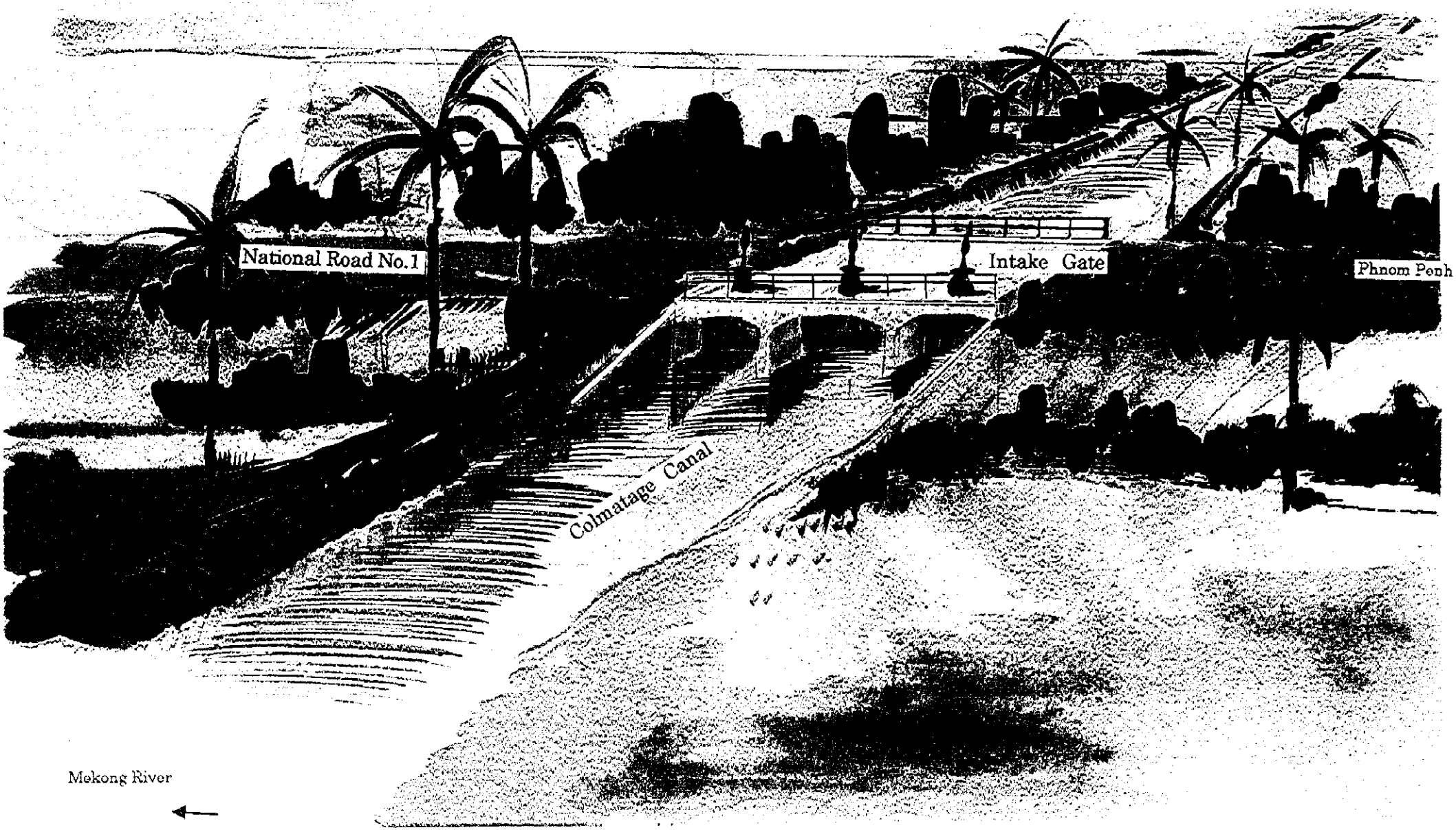


	Name of Colmatage	Length of Canal(km)	Name of Commune
①	Prek Pol	2.0	Bontey Dek
②	Prek Tourn	3.0	Samrong Thom
③	Prek Chrey	—	-do-
④	Samrong Thom	2.1	-do-
⑤	Koki Thom	2.8	Koki Thom
⑥	Kampong Phnom	2.0	Kampong Phnom

Regend	
NH2	National Road No.1
	Provincial Boundary
	District Boundary
	Colmatage Canal
	Swamp

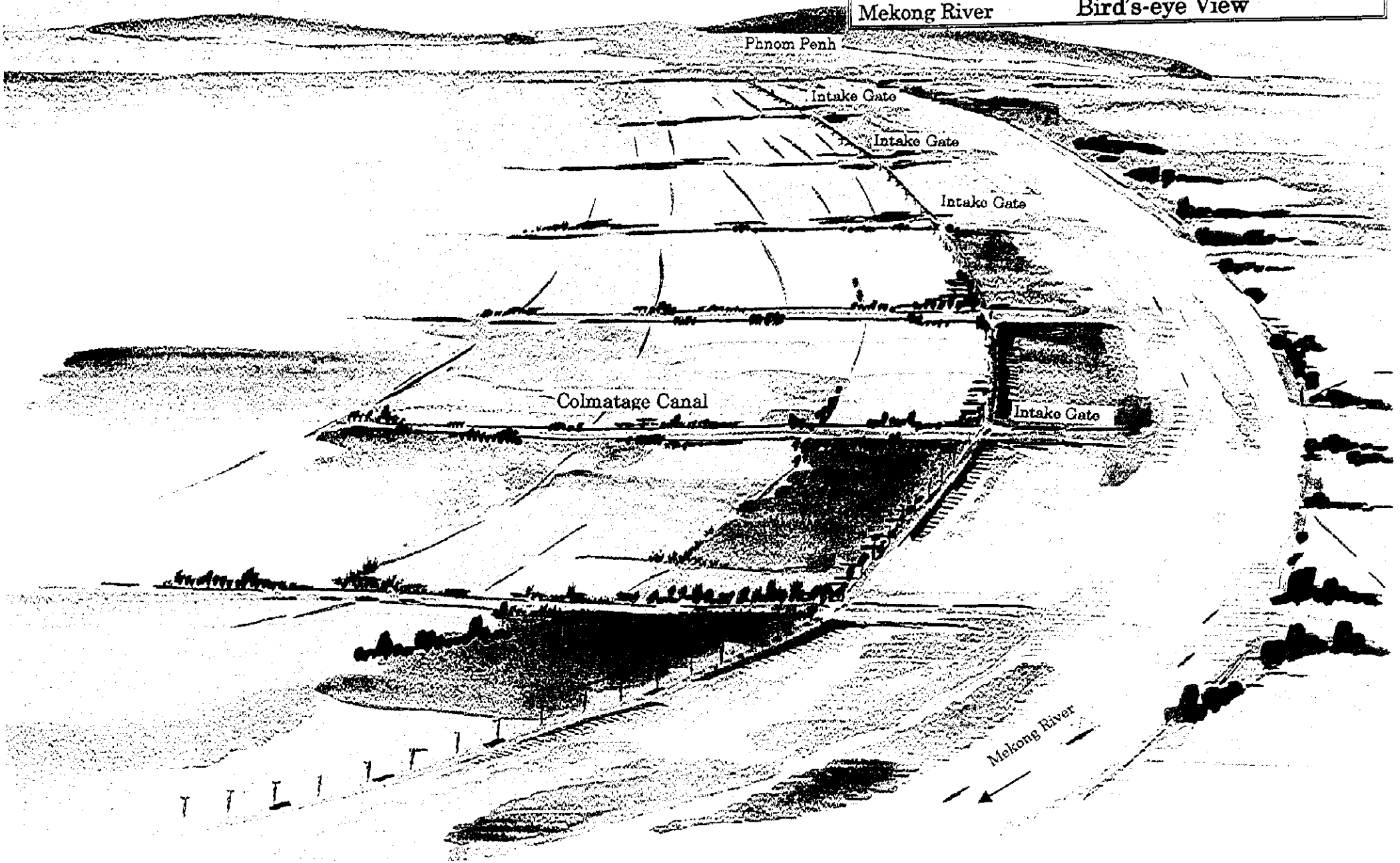
The Project for the Improvement of the Facilities of the Colmatage Systems in Kandal Province along the Mekong River

Conceptional Drawing



The Project for the Improvement of the Facilities of the Colmatage Systems in Kandal Province along the Mekong River

Bird's-eye View



ABBREVIATIONS

ADB	Asian Development Bank
APIP	Agriculture Productivity Improvement Project
CAAEP	Cambodia-Australia Agricultural Extension Project
CSCDI	Contribution for Supporting Community Development Irrigation
CAWS	Church World Service
DE	Department of Engineering, GDIMH
DWM	Department of Water Management, GDIMH
FWUA	Farmer Water Users' Association
GDIMH	General Directorate of Irrigation, Meteorology and Hydrology
GRET	Groupe de recherche et d'echanges technologiques
JICA	Japan International Cooperation Agency
MAFF	Ministry of Agriculture, Forestry and Fisheries
MRC	Mekong River Commission
MPWT	Ministry of Public Works and Transport
NGO	None Government Organization
O&M	Operation and Maintenance
SAL	Structural Adjustment Loan, WB
SECAL	Sectorial Adjustment Loan, WB
WB	World Bank

GLOSSARY

LENGTH

mm : millimeter(s)
cm : centimeter(s)
m : meter(s)
km : kilometer(s)

WEIGHT

g : gram(s)
kg : kilo-gram(s)
ton : ton(s)

DISCHARGE

cu.m/sec : cubic meter per second

ACREAGE

sq.cm : square centimeter(s)
sq.m : square meter(s)
sq.km : square kilometer(s)
ha : hectar(s)

VOLUME

lit, l : liter(s)
cu.m : cubic meter(s)
MCM : million cubic meter(s)

VELOCITY

cm/sec : centimeter per second
m/sec : meter per second

OTHERS

EL : elevation
MSL : mean sea level
FWL : full water level
HWL: high water level
FY : fiscal year
Riel : 1Riel=0.00027US$ (April, 1998)
US$: 1US$=3,650 Riel (April, 1998)

Contents

Preface
Letter of Transmittal
Location Map/Perspective
Abbreviations
Glossary
Contents

Page

Chapter 1 Background of the Project 1

1-1 Outline of the Project 1
1-2 Contents of the Request 2

Chapter 2 Contents of the Project 3

2-1 Objectives of the Project 3
2-2 Basic Concept of the Project 3
2-2-1 Contents of the Request 3
2-2-2 Contents of the Basic Concept 3
2-2-3 Farmer Water Users' Association 9
2-3 Basic Design 13
2-3-1 Design Concept 13
2-3-2 Basic Design 23

Chapter 3 Implementation Plan 36
3-1 Implementation Plan 36
3-1-1 Implementation Concept 36
3-1-2 Implementation Conditions 36
3-1-3 Scope of Works 39
3-1-4 Consultants Supervision 39
3-1-5 Procurement Plan 40
3-1-6 Implementation Schedule 42

3-1-7 Obligation of the Royal Government of Cambodia 42

3-2 Project Cost Estimation 45
3-2-1 Estimated Cost Borne by the Government of Cambodia 45
3-2-2 Operation and Maintenance Cost 45

Chapter 4 Project Evaluation and Recommendation 46

4-1 Project Effect 46
4-2 Recommendation 47

Drawings

Appendices

1. Member List of the Study Team
2. Survey Schedule
3. List of the Attendance of Meeting
4. Minutes of Discussion
5. Cost Estimation Borne by the Government of Cambodia
6. Other Relevant Data
7. Reference

Chapter 1 Background of the Project

1-1 Outline of the Project

Cambodia is bordered by Thailand in the west and by Laos and Thailand in the north, by Viet Nam in the east, by the gulf of Thailand in the south. The total acreage of the county is 181,035 Km^2 , consisting of 19 provinces, two(2) special municipalities and 172 districts. Some 67% (12.1 millions ha) is classified as a forested area. The cultivated area is estimated at 21%(3.78 millions ha), however uncleared mines restrict expansion of cultivated area. The cultivated area with paddy is 2.08 millions ha in 1995, occupying 91.2% of the total planted area with various crops. The current population is estimated at 10.5 millions, which has been growing at annual average of 2.8% with population density of 51 persons per km^2. It is notable that there is sex imbalance, 52.2% are female and 47% male, and high proportion of young generation because of two decades of conflict.

Cambodian economy is still stagnant by the effect of the destruction of social infrastructure, production systems and social services, which occurred during Pol Pot regime. Current per capita GDP of 290US$ is considered as one of the lowest in the world. Agriculture sector in Cambodia has been the top earner of national economy, contributing 75% to employed persons and occupying about 45% of the GDP in 1994. Cambodia was typical rice producing and exporting country with favorable natural condition for paddy cultivation. The internal war, however, brought conspicuous drop of rice production and labor force.

Agricultural sector has been recognized as the top priority for rehabilitation and reconstruction in Cambodia. Agriculture and rural development will contribute directly to boost national and rural economic growth, living standard of rural people and stabilization of rural life.

Under such circumstances, the Government of Cambodia has requested the study of the agricultural development for the Mekong river flooded area including the Project area to the Government of Japan. In compliance with the request of the Government of Cambodia, the Japanese Government conducted "the Agricultural Development Study of the Mekong Flooded Area in Cambodia" between 1996 and 1998. The study area covers an area of about

1.2 million ha, in the five provinces of Kratie, Kampong Cham, Prey Veng, Kandal and Takeo.

After the results of the study, the area between the Mekong and Bassac rivers including the Project area is selected as a first priority project area for the agricultural development of the Colmatage farming improvement and it is recommended to implement urgently. The grant aid for the Colmatage farming improvement in the Project to the Japanese government was requested in 1994 by the government of Cambodia.

1-2 Contents of the Request

Main contents of the request are summarized as below.

(1) Rehabilitation of the 6 colmatage canals in total length of about 16km and 18 gates (6places x 3gates) of intake facilities along the Kean Svay and Luek Dek districts.

(2) Construction of low dikes for protection of flood.

(3) Construction or reconstruction of the 30 mobile pumps in Luek Dek district (Pump diameter 200~300mm, total head 10m)

(4) Construction of 6 motor pools and provision of O&M machinery, small scale agricultural equipment and vehicles, etc.

Chapter 2 Contents of the Project

2-1 Objectives of the Project

The basic goals of the agricultural policies of the First Socioeconomic Development Plan (1996-2000) are to :

- Ensure food security through expansion of paddy production and food availability on the market and through secondary food crops production;
- Contribute to economic growth and foreign currency earning through exports; and
- Improve income opportunities for farm households by diversification of crop production.

In line with the First Socioeconomic Development Plan, the government of Cambodia gives the highest priority to development of colmatage farming in Kandal province. The objectives of the Project are to establish a farmer water users' association (FWUA) of beneficiary farmers, increase agricultural production and improve life standards of farmers through rehabilitation of colmatage irrigation facilities.

2-2 Basic Concept of the Project

2-2-1 Contents of the Request

In respect to the request, the contents of the Project confirmed between the Cambodian side and the Basic Study Team as shown in Table 2-2-1.

2-2-2 Contents of the Basic Concept

(1) Priority of the Project Components

It will be necessary to implement within the budget which will be fluctuated by recently exchange rate between Japanese Yen and US$. Results of the discussion with the GDIMH,

rehabilitation of the colmatage canals should be implemented as planned and not delete parts of planned length of canals or O&M roads. If the budget will be insufficient, it was confirmed to implement the order of the priority of the project components as ①Prek Yourn, ②Koki Thom, ③Prek Pol, ④Prek Chrey,⑤Kampong Phnom improvement/rehabilitation of irrigation facilities and ⑥Provision of O&M equipment.

(2) Rehabilitation of the Colmatage Canals and Their Intake Facilities

The area which includes an intake canal between the Mekong river and National Road No. 1 of Samrong Thom colmatage canal was purchased by a timber company which turned farm lands along the canal into a borrowed pit area for embankment. Thus, it would take long time and require great efforts to get acquisition on the land necessary for construction of the intake canal and leveling of farm lands. Taking into consideration these circumstance, Samrong Thom should be excluded from requested sites of the Project.

Further, culverts crossing the National Road No. 1 were demolished and intake canals between the Mekong river and National Road No. 1 buried in Prek Chrey colmatage canal system during the improvement works of the National Road No. in 1994. Therefore, at present the Prek Chrey colmatage system is not functional

Given the farming practices in the Prek Chrey colmatage canal command area and the eagerness of the farmers to rehabilitate the canal verified by the field surveys' result and discussions with the GDIMH give strong confirmation that the land area necessary for intake canal construction between the Mekong river and National Road No. is acquirable. Therefore this canal should be objective site of the Project.

There are no constraints before the remaining four colmatage canals to be considered as sites of the Project as requested by the Cambodia government.

(3) Provision of low protection dikes (length of 20 km)

In order to protect farm lands and transportation of agricultural products against floods construction of low protection dikes are requested.

It was found out by the field surveys and discussion with the GDIMH and Kean Svay district office that there is no plan dealing with construction of low protection dikes. In the rehabilitation of colmatage canals, maintenance roads are planed as a part of flood

protection for farmlands and transportation for agricultural products. Accordingly, the provision of low protection dikes shall be abandoned.

(4) Provision of Mobile Pump Facilities

In the Leuk Dek district, at 37 out of 51 colmatage canal sites along the Mekong river, mobile pumps have been installed. 24 out of 37 pumping stations are operated and maintained by water users' associations. In order to increase the agricultural production, strengthen the capacity of irrigation and reduce subsidies for O & M work, Cambodian government has promoted a take-over of O & M of irrigation facilities by beneficiary farmers. In accordance with the policy, privatization of pumping stations operated and maintained by water users' associations has been conducted in the Leuk Dek district. Farmers are willing to dredge and rehabilitate the colmatage canals and rebuild old wooden bridges in the area. In fact, provision of pump facilities are not necessary in the Leuk Dek district.

(5) Provision of Motor Pool and Equipment

GDIMH has a plan to dredge and repair the colmatage canals and construct feeder canals after completion of the project. Summary of the rehabilitation/construction of canals are shown below:

Table 2-2-2 Rehabilitation /Construction of the Canals' Dimension (unit: m)

Colmatage	Canal Dimension			O&M Road	Feeder Canal		
Canal Name	length	bottom	height	length	Bottom	height	length
Prek Pol	1,500	8	4.2	2,200	5	2~3	600 x 4
Prek Yourn	2,700	8	4.3	5,200	5	2~3	600 x 5
Prek Chrey	2,000	8	4.1	4,000	5	2~3	600 x 4
Koki Thom	2,800	8	4.1	5,600	5	2~3	600 x 5
Kamp. Phnom	1,900	6	3.8	3,800	5	2~3	600 x 4
Total	10,900			20,800	5	2~3	13,200

While the rehabilitation of main canals covers 10.9 km, the construction of new feeder canals and O & M of roads is 10 and 18 km, respectively. Road surface, in particular, become muddy and difficult to pass by vehicles and carts in the beginning of the dry season. Sedimentation in canals is estimated to be 15 cm/year and slope collapse are often observed. Therefore, maintenance of these facilities is particularly essential.

Out of 86 heavy machines maintained by GDIMH at present, 34 (40%) are operable. Almost all of them are employed for other projects making a supply of bulldozers, excavators, trucks, etc. a necessary provision for the implementation of the present project. Due to lack of budget, O & M of the new construction motor pool is terminated. It is recommended that the Department of Water Management office provide enough space to store the necessary construction machines.

As for the supporting of the establishment and strengthening the farmer water users' associations (FWUA), the GDIMH has a responsibility for O&M of the mobile pumps and intake gates, removal of the mobile pumps, attending the FWUA meeting, leading the water distribution on farm level or maintenance and inspection of gates. In order to carry out these activities, vehicles such as pick-up cars and motorbikes are necessary.

(6) Provision of Mobile Pumps

Incorporation of mobile pumps for rehabilitation of colmatage canals will not only enhance the agricultural production but also assure technology for proper water distribution, O & M of irrigation facilities and farming practices and also strengthen the FWUA.

Mobile pumps are manufactured using engine of motor vehicles. In Cambodia the Department of Water Management has 20 mobile pumps and lend them to the FWUA. Using mobile pumps, about 18,000 m^3 of irrigation water could be supplied for utilization on 240 ha of upland crops during the dry season. Taking into consideration the current practice of mobile pumps usage and the existing farm land area, one mobile pump per colmatage canal is considered sufficient.

(7) Improvement of National Road No. 1

The canal width of the proposed for rehabilitation colmatage canals at the National Road No. 1 is from 20 m to 30 m with an excavation depth of about 6 m. At the road crossing point it is necessary the gate facilities to be renovated. Taking into consideration these conditions, improvement of National Road No. 1 by the Project should be conducted at about 25 m from the center of the existing bridges. Road width and design criteria of asphalt pavement will be adopted by ADB design criteria.

(8) Implementation Agency and O & M System

The GDIMH will be the executing agency for the project. The GDIMH has been implementing several similar projects and possess reliable technology in terms of surveying, design and construction. It has experience of procuring ADB, WB, EU and other organizations' financed projects.

After construction, the O & M of project facilities will be transferred from the GDIMH to the FWUA. Expenses for O & M will be covered by water fee charges and government subsidies.

(9) Support for Farmer Water Users' Association

At present communes and related governmental agencies are responsible for O & M of the proposed rehabilitation of colmatage canals. According to the policy for sustainable irrigation system, the GDIMH will organize the FWUA when the implementation of the project starts. In order to operate and maintain the irrigation facilities smoothly, the organization of the FWUA is one of the most important components of the project . Therefore, it will be necessary to include in the project measures facilitating the organization of the water users' association. Supporting components are shown below. During the implementation of the project, the supervisor of the consultant will control the supporting components in cooperation with the GDIMH. As for the construction of assembly hall for the FWUA will be requested to the grass roots grant aid, if necessary.

Proposed Place :		5 colmatage canals (Prek Pol, Prek Yourn, Prek Chrey, Koki Thom and Kampong Phnom).
Supporting time:		about 2 months during implementation period
Component	:	Supporting of establishment of the farmer water users' associations and workshop for education and training of beneficiary farmers.

Table 2-2-1 Confirmation of the Contents of the Project

Contents of Request			Basic Design Study Results	
Item	Specification	Q'ty	Results	Q'ty
1.Rehabilit. of Colmatage Canal		6 Nos.		4 Nos.
1.1 Kean svay District				
1)Prek Pol	To be implemented	2 km	To be implemented	1.5 km
2)Prek Yourn (Prek Takeo)	To be implemented	3 km	To be implemented	2.7 km
3)Prek Chrouy Chrey	To be implemented	2.5 km	To be implemented	2.0 km
4)Samrong Thom	To be implemented	2.1 km	Excuding	-
5)Koki Thom (Prek Thmei)	Includ. branch canals	2.8 km	To be implemented	2.8 km
1.2 Leuk Dek District				
6)Prek Kampong Phom	To be implemented	2.0 km	Excluding	-
2.Rehabilitation of Intake	Gate Width x Number	6 Nos	Gate Width x Number	4 Nos.
2.1 Kean svay District				
1)Prek Pol	1.8 x 3		2.5 x 3	
2)Prek Yourn (Prek Takeo)	2.36 x 3		2.5 x 3	
3)Prek Chrouy Chrey	None		2.5 x 3	
4)Samrong Thom	2.1 x 3		Excluding	
5)Koki Thom (Prek Thmei)	2.5 x 3		2.5	
2.2 Leuk Dek District				
6)Prek Kompong Phom	2.0 x 3		Excluding	
3. Construction of small Flood	Part of dikes will be connected to		Excluding	
4. Provision of Pump Facilities	Pump Dia. 200~ 300mm、Total Head		Excluding	
5.Provision of Motor Pool				
5.1 Provision of Motor Pool	Construction of Motor Pools	6 Nos.	Excluding	
5.2 Provision of Equipment	Provision of Equipment			
	Equipment	Unit		Unit
	1)Bulldozer(12tons)	2	(9tons)	2
	2)Excavator(0.4 cu.m)	2		2
	3)Dump Truck, 5cu.m	4	Excluding	
	4)Double Cabin Pic up	2		2
	5)Station Wagon	2	Excluding	
	6)Motor Cycle	6		1
	7)Vibration Roller,7ton	2	Excluding	
	8)Crane Truck	1	Excluding	
	9)Plate Compactor, 80kg	2	Excluding	
	10)Tool (LS)	1		1
6. Additional Requests				
6.1 Provision of Mobile Pumps	Dia.300mm,HP75,Q=2,200cu.m/h	10		5
6.2 Supporting for Farmer Water	Assignment of local experts		Assig. of local experts	

2-2-3 Farmer Water Users' Association

In order to increase the agricultural production, to maintain the irrigation system in good condition for long time, to strengthen the capacity of the irrigation and to reduce the regular expenses of government for the O&M work, the Ministry of Agriculture, Forestry and Fisheries (MAFF) has introduced a policy for "Sustainable Irrigation Systems" in 1998. In line with the policy, the GDIMH has a plan to establish the Farmer Water Users' Association (FWUA) at proposed rehabilitation colmatage canals in the Project. To organize and strengthen the FWUA , the Japanese Grant Aid will be essential. Proposal of the procedure of establishment of the FWUA and responsibility of related agencies are shown below:

(1) Role of the Colmatage Rehabilitation Project

After implementation of the Project starts, consultants will prepare the office in the GDIMH head quarter and assist in establishing the FWUA in cooperation with the GDIMH. A main component work by the Project is to support Community Organizer Committee. Figure 2-2-1 shows the organization chart of the supporting system of FWUA.

(2) Establishment of the Community Organizer Committee (COC)

In order to establish the FWUA, GDIMH sets up the COC.

(a) Membership of COC (9 persons)

- President : Representative of GDIMH
- Vice-president : Representative of Department of Agronomy
- Permanent Secretary : Representative of GDIMH Kandal office
- Member : Representative of Kandal provincial Agronomy office
- Member : Representative of district authority
- Member : Chief of Commune (4 chiefs)

(b) Role of COC is shown as below.

- To organize one or many FWUA according to the needs,
- To take account of the number of people and land size in the irrigated area,
- To establish rules of water management,
- To identify the irrigation method,
- To prepare a record on yields for each crop.

(3) Establishment of Steering Committee

After the FWUA is completely established, the COC would become a Steering Committee and it would accept a new member—the chief of the FWUA. The Steering Committee has the following duties:

- To provide a training course on the new techniques of agricultural production, O&M of irrigation system and the budget management.
- To coordinate issues of the interior affair of the FWUA
- To intervene with the FWUA when the natural disaster occurs.

(4) Farmer Water Users' Association (FWUA)

(a) The purpose

- To provide irrigation services for to the members.
- To obtain knowledge on O&M of the irrigation system and the financial management.
- To increase the yield production and seasonal cropping.
- To channel the government subsidies.

(b) Membership of the FWUA committee.

Members of the committee are elected by FWUA members as follows :
of committee are:

- President : in charge of general affairs.
- Vice president A : in charge of planning of O&M
- Vice president B : in charge of water distribution
- Accountant : in charge of financial management
- Members : all chiefs of farmer water users' group

(c) The duties of the FWUA

- To prepare the work plan for FWUA,
- To establish the statute, contract and interior regulations,
- O&M of irrigation facilities,
- To manage and distribute the water for irrigation,
- To strengthen capacity in using and improving the irrigation system,
- To solve all disputes of the FWUA members,
- To collect the irrigation water fee according to the fix price for the FWUA members.

(d) Establishment of the Farmer Water Users' Group (FWUG)

The Farmer Water Users' Group (FWUG) is comprised by farmers who use colmatage canal irrigation water together. Each FWUG could have from 15 to 20 member-families. The FWUG is led by a chief and assistant who are elected by the FWUG members.

(e) Water Fee

Water fee is collected from the FWUA members in accordance with the crop yield/ha. Water fee is to be spent for O&M of irrigation facilities, fuel for pumps, allowance to the FWUA committee member and miscellaneous.

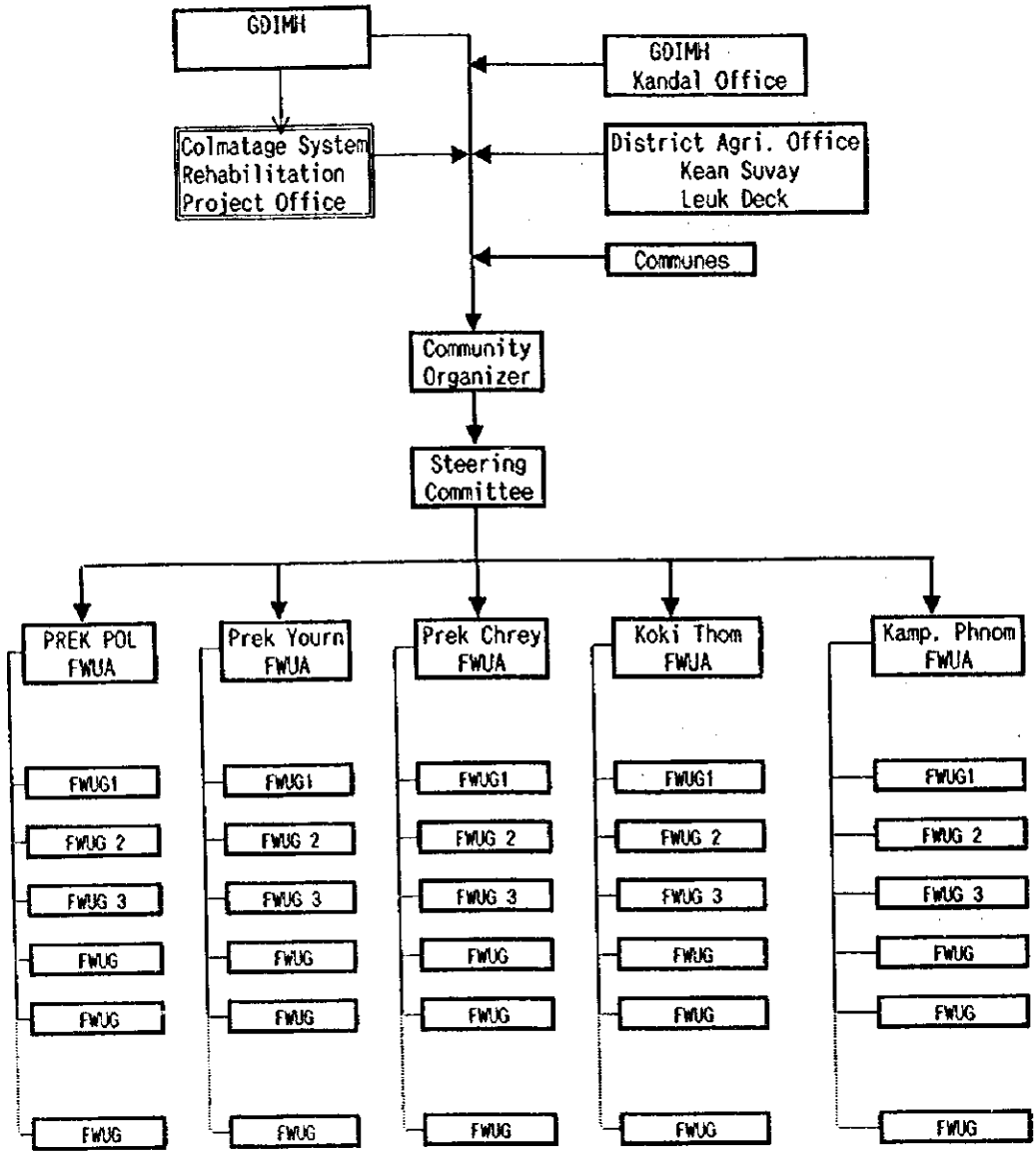


Figure 3-4-4 Supporting System for Farmer Water User Associations(FWUA)

GDIMH : General Directorate of Irrigation Meteorology and Hydrology
FWUA : Farmer Water User's Association
FWUG : Farmer Water Users' Group

2-3 Basic Design

2-3-1 Design Concept

(1) Basic Concept for Canal Rehabilitation

Flow direction of colmatage canal fluctuates seasonally depending on the water levels of Mekong river and back swamp area. Discharge also changes partially due to irregular cross-sections of canal. Water levels of river side and inland side around terminal point of canal are considered as basic flow condition to design canal works. Although the water level of the Mekong river at each intake point of canal can be assumed based on the past observation records of water level at Chrouy Changvar, Chaktomuk and Neak Luong, it will be difficult to grasp the seasonal changes of inundated water level of inland side since the water level is under the influence of other colmatage canals.

Although basic condition for designing canal works is not defined clearly, the following alternatives for canal works based on the degree of flooding of silt-bearing water are considered.

(a) Canal capacity will be expanded and embankment of canal will be constructed.

Bed elevation of canal is planned by considering seasonal fluctuation of the water level of Mekong river, so that canal capacity will be expanded. All cross-sections of canal will be reshaped based on the planned elevation of bed and embankment. In parallel with canal excavation, operation and maintenance road of embankment will be constructed, of which surface elevation will be designed based on the 1/2 or 1/10 flooding water level. Silt-bearing water will be supplied around terminal of canals. Additional area for expanding canal and embankment should be acquired by Royal Government of Cambodia. Agricultural land use along the canal will be changed after completion of rehabilitation works. Regular maintenance works of canal and road is required much more than at present.

(b) Canal capacity will not be expanded largely and present embankment will be reinforced.

Bed and slope of canal will be reshaped at poor sections, although its canal capacity will not be extended largely. Embankment of canal will be reinforced at the present surface level, not be elevated against flooding. Silt-bearing water will be supplied around low farmland in quantities identical to these at present. Expropriation of land is less than the others. Cropping pattern along the canal will not be changed significantly since inundation and silt-bearing water supply condition are almost same as they are at present.

Taking account of background of the project, importance of colmatage agriculture, high development potentiality and possibility of expropriation, the plan (a), expansion of canal capacity and construction of embankment is applicable for the project.

(2) Basic Concept for Canal Works

1) Setting of bed elevation

Inflow into colmatage canal from Mekong river occurs from July until October. Its flow fluctuates according to the conditions of water level between river and inland sides, and farming and fishing activities. Although timing of inflow and its amount depend on the bed elevation of canal and gate opening, the bed elevation should be set so as to take river water from July, taking account of function of canals and cropping system around canals. Average monthly water level of Mekong is assumed based on the past records and tabled as follows.

Table 2-3-1 Average Monthly Water Level of Mekong River (El m)

Colmatage Canal	Jun	Jul	Aug	Sep	Oct	Nov
Prek Pol	2.10	4.05	5.96	7.12	6.87	5.13
Prek Yourn	2.07	3.91	5.87	7.03	6.78	5.03
Prek Chrey	1.97	3.71	5.62	6.74	6.50	4.84
Koki Thom	1.89	3.53	5.41	6.50	6.26	4.66

Note: water level was calculated based on the data of Chrouy Changvar and Neak Luong Stations.

Table 2-3-2 Bed Elevation of Intake Canal (Unit: EL m)

Colmatage Canal	Existing EL of Intake Facility①	Estimated Bed Level②	Water Level in July③	Planned Bed ④
Prek Pol	4.98	5.07	4.05	4.05
Prek Yourn	3.64	3.73	3.91	3.73
Prek Chrey	-	-	3.71	3.71
Koki Thom	3.86	3.82	3.53	3.503

Note: ②=①+ (Distance between①~②) x designed gradient, ④=③, if③≧②, ④=②

Designed canal discharge is set to be more than the present one, considering both water levels of Mekong river and farmland. For planning of design discharge, flood level of Mekong river and elevation of farmland occurring silt-water flooding are assumed based on the hydrological data. In this study, design discharge is set at the 1/2 flood level of Mekong river, considering the functions of canals. Mekong river flood level of 1/2 and 1/10 return periods and silt-water flooding farmland are calculated as follows.

Table 2-3-3 Flood Level of Mekong River and Present Canal Discharge

Colmatage canal	Flood level 1/10 (EL m)	Flood level 1/2 (EL m)	Silt-water flooding farm land (EL m)	Present maximum flow (cu m./s)
Prek Pol	8.87	8.03	6.5~5.2	23
Prek Yourn	8.66	7.82	6.5~5.0	57
Prek Chrey	8.46	7.62	6.5~6.0	-
Koki Thom	8.27	7.43	6.8~5.5	17

Note: 1/10 flood level is quoted from Highway Improvement Project. 1/2 flood level is estimated based on the data of Chrouy Changvar and Neak Luong stations. Silt-water flooding farmland is assumed based on the topo-survey. Present flow is estimated based on the present size of canal and canal slope. Discharge of Prek Chery is not estimated since the canal is enclosed by dike.

2) Canal slope

Flooded water of back swamp area is generally backed into Mekong river from the end of

flooding season. During this period, the canal serves as drainage canal and mitigation route of fish. Catching fish in the canal is also an income activities of farmers. Canal slope should be set so that flooded water can be drained into Mekong river. Considering such conditions and present slope of canal and farmland, canal slope is planned by each canal, 1/5000 for Prek Pol, 1/5000 for Prek Yourn, 1/5000 for Prek Chrey, 1/7000 for Koki Thom.

3) Embankment of canals

Embankment is constructed along the top of canal, as roads for farming activities and maintenance of canal. It is planned at both sides of canal, as same as at present. Width is 3.0 m, of which section of sediment pavement is 2.0 m. Height of road surface is set at 1/2 flood level, its slope is the same as the canal. Terminal point of embankment is set based on the average flood level of September which is considered as farmland elevation occurring silt-water flooding in normal flooding season.

4) Canal type

All length of present canal is unlined earth type. Its alignment and size of cross section are not uniform due to sediment and eroded slope. Provided that maintenance works before and after flood is done regularly, unlined earth canal will be able to function as silt-water conveyance. Lining canal is not feasible taking cost-benefit of project and provision of fish mitigation into consideration. In the excavation work, present large trees' and vegetation's developed root systems in the slope of canal should be left, not be eliminated, since their root systems are playing great role to prevent slope failure.

Allowable velocity of canal is basically set at less than 1.5 m/s, assuming temporary flooding flow in the unlined earth canal of clayey slope.

5) Appurtenant facility

Cross culvert is planned as intake conduit at the site of low elevation farmland along the canal and at the beginning of secondary colmatage canal which is allocated to supply silt-water into remote farmland.

Small movable pumps are usually used at the junction of canal and Mekong river to lift water from Mekong river into colmatage canal during the dry season. Pumping water is conveyed through the canal to supplement irrigation water. During the pumping work, the canal is blocked by temporary earth dike to prevent pumping water from overtopping. Under this condition, small weir is constructed at the entrance of canal to serve as control facility of water level in the canal.

(3) Gate and Cross Culvert Planning

1) Basic Concept for Gate Facility

Silt-bearing water can be generally supplied to farmland from middle of July. During the water supply period, however, some crops may be harvested in some low farmlands. In such farmlands, flood intrusion should be prevented to allow harvesting works under dry field condition. After harvesting, flooding water is allowed to be introduced into the farmlands. Canal should be also used as storage pond during the next dry season. Impounded water in the canal during flood season is lifted by private small portable pumps for supplement irrigation. On the other hand, the canal serves as fish habitat and mitigation route. Taking into account such functions, gate facility is needed to control water flow in the canals.

Scale of gate facility is planned based on the present size of installed gate and cross culvert. In the planning, all canals have three series of gates, as same as present. Gate and cross culvert provides up and down stream aprons and riprap to protect piping. Size of opening of cross culvert is set based on the designed canal discharge. Width of cross culvert is planned by taking account of the present width. Its height is set by considering clearance of gate operation and navigation of small boat.

2) Gate type

Gate facility is comprised of gate, guide and lift, which should be functional and reliable over long term operation and environmentally harmonized with local condition. Gate type of

colmatage canal is determined by considering the following.

- Operation and maintenance of gate installed should be done by beneficial farmers' group.
- Operation and maintenance cost should be imposed on the farmers' group.
- Electric service is not provided for the project site.
- Timing of opening and closing of gate is limited seasonally, and accurate operation is not required.

Taking the above conditions, requirement of gate facility is that operation and maintenance should be easy and low O/M cost, spare parts for repair is procured easily, opening and closing of gate is operated by manual.

Up-down lifting type of steel slide gate or fixed roller gate and stop log are considered for the canals. Out of them, stop log will not be applied assuming difficult operation under high water pressure from 2.0 to 2.5 m wide and from 3.5 to 5.0 m high.

In general, slide gate is applied in case of smaller opening size. It is shifted from slide one to roller one as the size becomes larger. In the project, therefore, slide or roller gate will be selected based on the designed opening size and water pressure. Operation time of hoisting gate is generally set based on operating load and operating power. In the project, long hoisting time for manual operation will be needed.

3) Cross culvert

Cross culvert is designed considering design standard of Highway Improvement Project. Its dimension is determined based on the following conditions.

- Width is designed wider than the present one.
- Height is designed based on the minimum earth coverage depth, cross-section of new national road and bed elevation of culvert. It is planned based on the freeboard of 1.5 m on the average water level of September—assuming navigation of small boat for fishing.
- Length is designed based on the width of 13.5 m of National Road

-Improvement Project. In the design, intersection angle between the canal and the road should be considered.

Apron is planned at downstream of culvert to prevent erosion of bed and slope caused by change of flow velocity.

4) Rip-rap

The scouring is caused by careless gate operation and change of flow at cross sectional area. Rip-rap is provided continuously at up and downstream aprons to prevent the scouring of canal. For rip-rap, gabion or rubble will be used due to easy procurement.

5) Basic condition for foundation works

According to the sounding survey, soil of foundation ground of 3 to 6 m below the surface is summarized as follows.

Table 2-3-4 Character of layer at each canal

Name of Colmatage Canal	Character of Soil
Prek Pol	Yellowish clay of N=3~12 is found on the layer from 3 to 6 m below the ground surface, soft clay of N=2~4 from 5 to 7.5 m, soft silt clay of N=1 ~2 from 7.5 to 10.5 m, grayish fine sand of N=10~38 is lain 16.5 m below the surface
Prek Yourn	Firm to stiff grayish clay existing 5 m below the ground surface is N-value of 7~17, soft grayish silt clay of N=2~5 is 10 m below, N-value of medium to dense grayish sand is found at level of 10~20 m below the surface, a change from 13 to 47.
Prek Chrey	Gray and yellow clay layer of N=9~5 exist from 4.5 to 6.5 m below the surface, silt clay, N=3~15, is found in 6.5~15.0 m below, gray silt clay layer of N=12~16 exists in 15~21 m below.
	Silt clay of N=7~5 is found down on the from 4 to 6.5 m below the ground surface, dark yellow clay, N=5~11, from 6.5 to 8.5 m below, gray fine sand of N=5~17 is found below the clay layer.

Detail is shown in Appendix 6-1

(4) National Road No. 1 Improvement Project

1) Road Planning of Highway Improvement Project

Cross culvert is designed considering road design of Highway Improvement Project. In the Project, basic condition of crossing points between canal and road is planned as follows.

Table 2-3-5 Design of National Road No.1

Colmatage canal	Length (m)	Road Surface (El m)	Intersection (°)	Width of Road (m)
Prek Pol	34021	10.28	90	13.5
Prek Yourn	36692	9.81	75	13.5
Prek Chrey	42700	10.00	75	13.5
Koki Thom	51335	9.56	90	13.5

Source : :Highway Improvement Project. Prek Chrey is planned based on the 1/50,000 map by B/D Study Team.

2) Rehabilitation of Road Surface

After construction of cross culvert, road surface should be rehabilitated. Rehabilitation works should be conducted based on the elevation of road surface and width planned by Highway Improvement Project. Road length rehabilitated is estimated by canal based on the necessary length for construction of cross culvert and connecting length with the present road. Plan of pavement is applied according to the Highway Improvement Project.

(5) Diversion road during construction

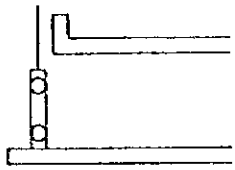
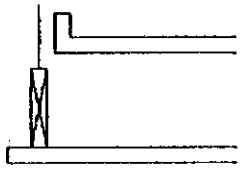
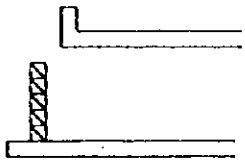
Temporary road is constructed during construction of cross culvert and installation of gate. Route of the road is planned in the river side, considering the length of cross culvert, up and down stream aprons and riprap. Earth embankment is generally constructed on the agricultural land. However, steel structure using steel sheet-pile and steel pile are applied at the crossing canal due to necessity of supplying water throughout the year. The route is planned considering location of houses and possibility of procurement of land. Land for

temporary roads shall be secured during construction.

(6) Design Manual Applied

In Cambodia, design manual for engineering works is not provided, so that design works are conducted based on Engineering Manuals for Canal Works and Head Works in Japan.

Table 2-3-6 Comparison between three types of gate

Item	Vertical lift gate		Stop-log
	Fixed wheel type gate	Slide type gate	
Shape			
Structure	Horizontal load is transmitted to a main horizontal girder through the skinplate and supporting horizontal and vertical girder. The load is finally transmitted to the wheel at each side of the gate leaf and guide flame. The gate moves vertically.	Horizontal load is transmitted to a main horizontal girder through the skinplate and supporting horizontal and vertical girder. The load is finally transmitted to the each side of the gate leaf and guide flame. The gate moves vertically.	Square timbers (100-200 mm) are heaped up or removed to block or control water flow.
Advantages	- easy to operate by using hoisting equipment - easy to control and block water flow - hoist load is small (1/4 of the slide gate) and easy to control - suitable for large scale canal	- same as the left - same as the left - suitable for small scale canal - structure is simple and easy to maintain	- structure is simple and construction cost is low - suitable for small scale canal and with small level of horizontal load
Disadvantages	- gate leaf becomes heavy in some condition of water pressure - roller including wheel has to be maintained	- hoist load becomes burden with large scale canal (4 times as heavy as fixed wheel type gate)	- difficult to control when water pressure becomes burden with large scale canal (equipment such as winch is needed to remove it) - stop-logs are often lost
Consideration	In general, slide gate is applied for the width of less than 1.5 m and fixed wheel type gate for more than 2.5 m. For the scale between 2.0-2.5 m, suitable one is generally selected based on the condition of water pressure, hoist load, etc. In this design, fixed wheel type gate with low hoist load is selected since it is manual-operated type and the gate has to be pulled up higher.		Span is 2.0-2.5 m and stop-logs become large scale. Consequently, its weight and water pressure becomes burden and it is difficult to hoist and remove. It is not suitable.
Evaluation	○	△	×

2-3-2 Basic Design

(1) Canal Works

1) Basic Design Dimensions

The basic dimensions of canal works are decided considering the following conditions mentioned in the Chapter 2-3-1.

- Bed elevation of intake canal is to be lower than the average water level in July.
- Embankment of canal is to be higher than the flood level of 1/2 year return period.
- Canal slope is decided based on the bed elevation of the present canal.
- Bottom width is decided based on the average bottom width of the present canal.
- Slope gradient is designed at 1:1.5 based on the present one.
- The designed discharge is more than the existing maximum flow at the flood level of 1/2 year return period and freeboard is 20 cm.

Table 2-3-7 Basic Canal Design Dimension

Colmatage Canal	Bed elevation (El m)	Top of Bank (El m)	Bottom Width (m)	Canal Height (m)	Canal Slope	Dis-Charge (m^3/s)	Velocity (m/s)	Canal length (m)	Bank length (m)
Prek Pol	4.00	8.20	8.0	4.20	1/5,000	48.7	0.87	1,420	2,840
Prek Yourn	3.70	8.00	8.0	4.30	1/5,000	51.1	0.88	2,620	5,240
Prek Chrey	3.70	7.80	8.0	4.10	1/5,000	46.5	0.86	1,920	3,840
Koki Thom	3.50	7.60	8.0	4.10	1/7,000	39.4	0.73	2,120	4,240

2) Storage Volume of Canal

Flooded water in the wet season can be impounded by gate operation. Although its volume is dependent on the timing of flow into Mekong river, fluctuation of inundated water level in the back swamp area and operation of gate, water depth of 1.5 m would be impounded in the canal provided that gate is closed in the middle of November. Storage volume of canal in some water depth is estimated as follows.

Table 2-3-8 Storage Volume by Water Depth

Colmatage Canal	Storage Canal Length (km)	Storage Volume (10^3m^3)		
		Depth (1.0 m)	Depth (1.5 m)	Depth (2.0 m)
Prek Pol	1.0	9.5	15.3	22.0
Prek Yourn	2.1	19.9	32.3	46.2
Prek Chrey	1.1	10.4	16.9	24.2
Koki Thom	2.0	19.0	30.8	44.0

(2) Gate and Cross Culvert

1) Design Dimensions

The dimensions of gate and cross culvert are decided from consideration of the following basic design conditions mentioned in the Chapter 2-3-1.

- Gate and culvert is the three series box culvert structure.
- Length of culvert is decided based on the Highway Improvement Project.
- Effective depth of culvert is designed to be higher than the 1/10 flood level.
- Earth coverage depth of culvert is set to be more than 0.6 m.
- Sill elevation of gate is decided based on the slope of intake canal.
- Height of gate leaf is decided based on the average water level of the end of August.
- Hoisting height of gate is decided based on the average water level of September and freeboard of 1.5 m for navigation.
- Width of gate is based on the span length of gate section.

Table 2-3-9 Gate Dimension

Colmatage Canal	Basic Condition			Gate Dimension			
	Sill Elevat.(El m)	Crest Elevat.(El m)	Hoisting Height(m)	Span (m)	Width (m)	Height (m)	Unit
Prek Pol	3.91	6.71	8.62	2.5	2.65	2.8	3
Prek Yourn	3.61	6.61	8.53	2.5	2.65	3.0	3
Prek Chrey	3.53	6.33	8.24	2.5	2.65	2.8	3
Koki Thom	3.46	6.16	8.00	2.5	2.65	2.7	3

Table 2-3-10 Design Dimension of Gate and Culvert (Unit: m)

Colmatage Canal	Gate		Culvert			Down Apron		Upper Apron	
	Width	Unit	Width	Height	Length	Width	Length	Width	Length
Prek Pol	2.5	3	9.1	5.0	20.0	9.1	20.0	9.1	5.0
Prek Yourn	2.5	3	9.1	5.2	23.5	9.1	20.0	9.1	5.0
Prek Chrey	2.5	3	9.1	5.0	23.5	9.1	20.0	9.1	5.0
Koki Thom	2.5	3	9.1	4.9	20.0	9.1	20.0	9.1	5.0

2) Length of upstream apron

To prevent scouring upstream of gate brought by gate operation, an upstream apron will be necessary. The length of apron is longer than the depth of designed flood water level and 5m of length at each canal is decided.

3) Length of downstream apron

To prevent scouring downstream of gate brought by gate operation, an apron is provided at downstream canal. In the projected colmatage canals, downstream apron is consisted of box culvert and downstream transition. The necessary length is studied hydraulically by the following two methods.

(a) Use of Blight's formula

$L=0.6\times C\times\sqrt{(H\times I)}$

L : total length of protection (m)

H : maximum head difference at upstream and downstream sides (m). In this case, it is the difference between the crest and sill of gate.

C : Blight's coefficient, C=18 of silt sand or clay is applied.

f : safety factor, 1.5

Table 2-3-11 Total Length of Protection by Blight's formula

Colmatage Canal	Silt Elevation (EL .m)	Crest Elevation (EL. m)	Head Difference (m)	Protection Length(L) (m)	Culvert Length (m)	Necessary a Apron Length (m)
Prek Pol	3.91	6.71	2.80	27.1	17.5	9.6
Prek Yourn	3.61	6.61	3.00	28.1	21.0	7.1
Prek Chrey	3.53	6.33	2.80	27.1	21.0	6.1
Koki Thom	3.46	6.16	2.70	26.6	17.5	9.1

(b) Length based on the hydraulic jump

In general, gate will be closed until the end of August to prevent flood intrusion. Later, water level of Mekong river rises with time and gate will be opened to let river water flow in. Flow situation will be changed as gate is open and phenomenon of unsteady flow, hydraulic jump, occurs at downstream gate. Provided that duration of exposed jet flow is longer, effect of local scouring become larger. Under this conditions, protection length is studied based on the conjugate depth. Design discharge for the study is assumed to be equivalent to the intake water at the end of August.

Flow condition from gate is decided by the following.

$$Q=C\times a\times B\times\sqrt{(2g\cdot\Delta H)}$$
$$a=Q/(C\times B\times\sqrt{(2g\cdot\Delta H)}$$

Q: discharge, m^3/s (cubic meters per second)
A: gate opening (m)
C: coefficient, 0.6
ΔH: maximum head difference at up and downstream sides (m)
g: Acceleration due to gravity (9.81 m/s^2)

Conjugate depth is calculated based on the following conditions :

$$D2=-(D1/2)+\sqrt{(D1^2/4+2V1^2D1/g)}$$

D1、D2 : water depth before and after hydraulic jump (m)
V1、V2 : velocity before and after hydraulic jump (m/s)

g : Acceleration due to gravity (9.8 m/s/s)

$D1=Cc\times a$、$V1=Q/D1\times B$

Cc : coefficient of contraction, 0.6

B : width of gate (m)

a : gate opening (m)

$F=V1/\sqrt{(g\times D1)}$

F : Freud number

Protection length is decided from the hydraulic table based on the calculated Freud number(F) and water depth(D2). Refer to Appendix 6-4

Table 2-3-12 Protection Length Estimated by Hydraulic Jump

Colmatage Canal	Water Head ΔH (m)	Width of Gate B (m)	Ids-charge Q (cu m./s)	Flow before Jump V1(m/s)	Depth after Jump D2(m)	Froude Number F	Protection Length L (m)	Culvert Length (m)	Apron Length (m)	Designed Protecton Length (m)
Prek Pol	2.8	7.5	24.6	7.45	2.13	3.58	25.6	17.5	8.1	20.0
Prek Yourn	3.0	7.5	27.8	7.56	2.28	3.45	27.1	21.0	6.1	20.0
Prek Chrey	2.8	7.5	24.6	7.45	2.13	3.58	25.6	21.0	4.6	20.0
Koki Thom	2.7	7.5	19.5	7.22	1.88	3.84	23.3	17.5	5.8	20.0

Based on the above two methods, apron length is long enough for local scouring. The length is set at 20 m, considering the length of the present apron and necessary length for transition.

4) Ensuring creep length

According to the soil survey, foundation of canal is consisted of sandy clay and silt. When constructing a gate facility on a permeable foundation, creep lengths to control the flow velocity to prevent the destruction of the foundation due to piping phenomenon should be ensured. The creep length to be ensured should be the larger value calculated by following Blight's method.

Lp=C×H

Lp: length of creep length (m)

C : coefficient, silt sand or clay 18

H : maximum head difference at up and down stream sides(m)

Table 2-3-13 Calculated Creep Length by Blight's Method (unit: m)

Colmatage Canal	Head difference(H)	Creep length(Lp)	Total apron length	Length by Sheet Pile	Necessary Length
Prek Pol	2.8	50.4	25.0	25.0	25.4
Prek Yourn	3.0	54.0	25.0	25.0	29.0
Prek Chrey	2.8	50.4	25.0	25.0	25.4
Koki Thom	2.7	48.6	25.0	25.0	23.6

To ensure the creep length longer than the length calculated from the above method, a cut off wall is provided to increase the vertical creep length. The cut off wall of 3.0 m by steel sheet-pile is constructed at up and down stream aprons to prevent scouring under the bed.

5) Rip-rap

Rip-rap is provided continuously on the downstream apron to prevent the scouring of the canal bed. The basic concept for preventing local scour at downstream canal is to waste the energy of high velocity flow passing under gate by using the resistance of rip-rap, and to make the flow velocity of downstream of rip-rap reduce into that of downstream canal following the rip-rap. In general, concrete block or rubble is used for rip-rap. In the project, gabion and mattress basket work with stone is used, considering possibility of procurement, implementation and local conditions. Rip-rap is required to be stable and resist against flowing force. The size and weight of gabion is necessary to satisfy the following formula.

$W>5.34\times A\times(V^2/2g)$

W : weight of gabion or mattress basket (t)

A : area of collision with flowing water (m^2)

V : velocity at which flowing water collides with rip-rap (m/s)

g : acceleration of gravity (m/s²)

Assuming that the size is 0.5m×1.2m×2.0m, specific gravity is 1.9 t/m³, filling up ratio is 90%, velocity (V) is calculated V<3.4 m/s. The size is safe the velocity at collision since the velocity of rip-rap section is less than 3 m/s.

Necessary length of rip-rap is estimated based on the Blight's formula.

$L = Lb - La$

$Lb = 0.67 \times C \times \sqrt{H q \times f}$

L : length of rip-rap (m)

Lb : total length of protection including length of apron (La) and L (m)

La : length of apron (m)

H : head difference between the crest of gate and sill of canal (m)

q : flow per unit width of design discharge (m³/s/m)

f : safety factor 1.5

C : Blight's coefficient 18

Table 2-3-14 Necessary Length of Rip-rap (Unit:m)

Colmatage canal	Water head H	Flow Q (m/s)	Unit flow q(m³/s/m)	Total length Lb	Apron length La	Estimated length L	Design length L
Prek Pol	2.8	24.6	3.28	54.8	37.5	17.3	30.0
Prek Yourn	3.0	27.8	3.77	60.4	41.0	19.4	30.0
Prek Chrey	2.8	24.6	3.28	54.8	41.0	13.8	30.0
Koki Thom	2.7	19.5	2.60	47.9	37.5	10.4	30.0

Length of rip-rap is designed based on the above calculation and present condition of erosion of canal bed and sediment.

(3) Basic Design for Gate

1) Design criteria

Fixed wheel gate of vertical lift type is used as mentioned in the basic condition, considering the size of gate leaf and its operation. The following conditions based on the functions of colmatage canal are to be considered in design.

- Leaf, guide frame, pivot and hoisting equipment of gate is designed based on the basic specification as shown in Table 1-3-6. When designing the leaf gate, the series of loads including self weight and hydrostatic pressure of from 2.7 to 3.0 m, should be considered.
- Lifting height is larger, from 4.5 to 5.0 m. When designing the hoisting equipment, structural stiffness against buckling, installation of support of center axle, etc. , should be considered.
- Long guide frame is needed. Since maintenance of guide frame is difficult generally, when designing the materials of guide frame, special conditions such as anti-corrosion and anti-wearing should be considered.
- Water tightness is needed at both of up and downstream sides. Materials of seal should have high durability.
- In designing, operation load should be small due to manual operation and gate facility should be designed to minimize harmful operation miss.
- Material of each part should be secured against the conditions such as anticipated load, water tightness and durability. Ease of operation and maintenance is also needed.

2) Selection of hoisting equipment

Since manual operation is applied, basic conditions of rotation gear and operation load are designed to be about 30/min. and less than 10 kgf. Operation load and operation speed is approximately planned as follows:

-Operation load about 4000 kgf in case of from close to open, 60 kgf from open to close.
-Operation time (for opening of the gate in case of spindle) from 5.5 to 6.5 hours

In general, screw spindle type, rack gear type and wire rope winding type can be used as hoisting equipment. In this gate, spindle type or rack gear type, which is attached to the leaf, is applied, considering the span and manual operation. Since the rack gear type requires shorter opening time, it is used in case of urgent operation needs. On the other

hand, due to longer operation time needed by the spindle type, in this gate, longer design hoisting height is required. Compared with both types for this gate, rack gear type has some disadvantages such as lower stiffness and ease buckling, its equipment becomes larger, and buckling may happen by miss operation. In this gate, urgent operation will not be needed. Spindle type is applied by considering easy and steady manual operation in Cambodia. Comparison of operation between spindle and rack type is summarized below.

Table 2-3-15 Comparison of Operation between Spindle and Rack Type

Screw Spindle Type	Rack Gear Type
-Longer operation time is need(6 hours)	-Opening time is short and urgent operation is effective.
-Stiffness is better than Rack type.	-Stiffness is lower and equipment becomes larger than Spindle type.
- Manual operation is easy and steady	-Bulking may happen by miss operation

(4) Foundation work

Foundation of gate and culvert is studied based on the soil conditions mentioned in 2-3-1. Allowable bearing capacity of the ground is estimated by Terzaghi's formula, and spread foundation is applied provided that design load is less than the allowable bearing capacity. In case of lack of the bearing capacity or occurrence of consolidated settlement, pile foundation will be adopted. Allowable bearing capacity for foundations are estimated by the following formula.

1) Formula for foundation

(a) Formula to calculate allowable bearing capacity

$qu=(1/n) \times qa$

$qa=\alpha \times C \times Nc+\beta \times \gamma 1 \times B \times Nr+\gamma 2 \times Df \times Nq$

qu : ultimate allowable bearing capacity (t/m^2)

qa : long-term allowable bearing capacity (t/m^2)

n : Safty Factor for long term(n=3)

C : cohesion of ground below foundation load surface (t/m^2)

$\gamma 1$: unit weight of ground below foundation load surface (t/m^3)

$\gamma 2$: average unit weight of ground above foundation load surface (t/m^3)

α, β :shape factor

Nc, Nr, Nq : coefficient of bearing capacity

Df : depth fro deepest ground surface adjacent to foundation (m)

B : minimum width of foundation load surface (m)

(b) Formula to calculate Pile Foundation

$Ra = 1/n \times Ru$

$Ru = qd \times Ap + U \times \Sigma (Li + Fi)$

Ra : Vertical allowable bearing capacity of pile(tf)

Ru : ultimate bearing capacity of pile(tf)

n : safty factor (3 for long term allowable bearing capacity)

qd : ultimate bearing capacity of ground at pile tip (tf/m^2)

Ap : area of pile tip(m^2)

U : circumference of pile(m)

Li : thickness of the layer for skin fricton of pile(m)

Fi : maximum friction resistance of Li(tf/m^2)

2) Calculation of foundation for upper and downstrea aprons

Calculation results of each canal is shown below. According to this, each canal foundation is adopted as spread foundation.

Canal name	Design load (tf/m^2)	long-term allowable bearing capacity (t/m^2)	Judgement
Prek Pol	5.19	7.40	◎
Prek Yourn	5.39	12.70	◎
Prek Chrey	5.15	5.70	◎
Koki Thom	5.07	5.70	◎

3) Study for Intake Gate Facilities' Foundation

(a) Calculation of spread foundation

Calculation result of each gates is shown in Table 2-3-16. According to the table, the design load is less than the long-term allowable bearing capacity at each foundation and spread foundation is acceptable.

(b) Calculation of consolidated settlement

In Prek Yourn, Prek Chrey and Koki Thom, estimated allowable bearing capacity is larger than that of designed load and the bearing capacity of Prek Pol is equal to the design load. Even though the bearing capacity is strong enough for the design load, settlement caused by consolidation may be occurred if soft ground exists below the constructed culvert and gate facility. In Prek Pol and Prek Yourn, land settlement may be occurred since the consolidation layer with few N-value exists. Table 2-3-16 also shows the results of consolidation settlement at each gate facility.

Based on the allowance of consolidated settlement (10 cm) in Japanese standard, the settlement value of Prek Yourn and Prek Chrey are exceeded the value of allowance.

(c) Plan of piling

In general, pile foundation, soil stabilization and replacement method are considered as a measurement for poor foundation. For four colmatage canals, the pile foundation is applied from the viewpoints of reliability, easy construction and construction cost. Calculation of pile foundation is described as below.

a. Basic condition

- Type and size in-situ reinforce concrete pile 300×300 mm, $\sigma = 400$ kg/cm^2
- Length maximum length L=12.0 m
- Bearing capacity single pile Pa=30 ton/pile, connected pile Pa=28.5 ton/pile
- Area of pile tip $Ap = 0.3 \times 0.3 = 0.09$ m^2
- Circumference of pile $U = 0.3 \times 4 = 1.2$ m

b. Calculation result

Calculation result is shown in Table 2-3-16. Judging from the table, pile foundation at each gate facility is adopted.

Table 2-3-16 Calculation of Allowable Bearing Capacity

Item	Calculation item	Prek Pol	Prek Youm	Prek Chrey	Koki Thom
Soil	① N-value	3	16	9	5
	② ϕ (°)	0	0	0	0
	③ C (t/m²)	1.8	6.0	5.4	3.0
	④ γ1 (t/m³)	1.8	1.8	1.8	1.8
	⑤ γ2 (t/m³)	1.8	1.8	1.8	1.8
Coeff-cient	⑥ α	1.0	1.0	1.0	1.0
	β	0.5	0.5	0.5	0.5
	⑦ Nc	5.3	5.3	5.3	5.3
	Nr	0	0	0	0
	Nq	3.0	3.0	3.0	3.0
	⑧ B (m)	10.3	10.3	10.3	10.3
	⑨ Df (m)	3.64	3.55	3.69	3.50
Load	Dead weight (t)	1256.5	1470.9	1463.3	1236.2
	Earth coverage depth (t)	246.4	167.6	276.3	197.0
	Water weight (t)	365.4	563.1	525.6	430.3
	Wheel load (tf)	130	130	130	130
	Total (tf)	1998.3	2331.6	2395.2	1993.5
	Area of Designed structure(m²)	206	242	242	206
	Load of designed structure W(tf/m²)	9.7	9.6	9.9	9.7
	Load of present structure	(9.4)	(11.0)	(-)	(8.9)
Bearing capacity	Load of designed structure W(tf/m²)	9.7	9.6	9.9	9.7
	Bearing capacity qa=1/3qu	9.7	17.0	16.2	11.6
	Judgement W ≦qa	○	○	○	○
Calculat.of Consolidated Settlement	Soft clay	Yes	Yes	Yes	None
	Settlement (mm) (**)	18.0>10.0	None	33.5>10.0	4.2<10.0
	Judgement	×	○	×	△
Pile Foundation	Bearing Capacity by Pile (tf/pile)	30.0	28.5	28.5	28.5
	Bearing Capacity by ground (tf/pile)	32.0	42.0	30.0	41.0
	Load per Pile (tf/pile)	28.55(95%)	27.76(97%)	26.61(93%)	28.48(99%)
	Type of Pile	RCPile 300x300mm L=12.0m 70 Nos.	RCPile 300x300mm L=15.0m 84 Nos.	RCPile 300x300mm L=14.0m 90 Nos.	RCPile 300x300mm L=16.0m 70 Nos.
Judgement		○	○	○	○

Note; ①:N-value of the base of footing. ②:angle of internal friction. ③:cohesion of ground below foundation load surface. ④,⑤:unit weight of ground below and above foundation load surface. ⑥:shape factor. ⑦:coefficoent of bearing capacity. ⑧:depth from deepest ground surface adjacent to foundation load surface. ⑨:minimum width of foundation load surface.

(**) Consolidation is estimated by boring date. Allowance of consolidation is adopted by Japanese Standard of 10cm.

(5) Appurtenant facilities

Intake conduit is planned along the embankment, as shown in the following.

Table 2-3-17 Type of Appurtenant Facilities

Type	Structure	Size (W×H×Unit)	Min. earth coverage
A	Box culvert	1.0x1.0x3	0.6m
B	Box culvert	1.0x1.0x2	0.6m
C	Concrete pipe	ϕ600 mm	0.6m
D	Box culvert	2.0x3.0x1, 1.0x3.0x1	-

Intake small weir is designed based on the anticipated pumping discharge in the dry season and its water depth in the canal. As the result, top elevation of the weir is set at 0.5 m high on the canal bed planned. The weir is a concrete structure, with stop-log to control water depth, the span is 1.3 m. Rip-rap is provided at up and downstream of weir to prevent local scouring of bed and slope.

(6) Rehabilitation Works for National Road No.1

Rehabilitation of the national road is planned based on the basic concept mentioned in 2-3-1. The rehabilitation length is designed by the canals, considering the scale of culvert constructed, as follows.

Table 2-3-18 Rehabilitation Works for National Road No.1 (Unit:m)

Colmatage Canal	Length (w=13.5 m)	Transition length
Prek Pol	30	5+5=10
Prek Yourn	40	〃
Prek Chrey	40	〃
Koki Thom	30	〃

Chapter 3. Implementation Plan

3-1 Implementation Plan

3-1-1 Implementation Concept

The project is to rehabilitate the canals including cross culvert under the national road. It includes demolition and removal of the existing structures, reconstruction of these structures such as gate and culvert, and reshaping of canal. Temporary works are also required to reconstruct the structures. Considering the nature and size of the rehabilitation works, its implementation shall be carried out on the contract bases by a general contractor.

Necessary equipment and materials for the Project is the gate facility, small pumps and steel sheet pile etc., which shall be procured in blanket orders including installation and adjustments under the contract.

Provided that the Project will be implemented under the Japan Grant Aid Program, a contractor shall be given the contract in principle. In the implementation, cooperation with contractor in Cambodia should be conducted within the framework of Japan grant aid system.

In Cambodia, there are such some constriction works as roads and bridges being implemented in the Phnom Penh city and around the city. Many Cambodian contractors or subcontractor under supervision of foreign enterprises have been working, however, their technical level is comparatively low. From such conditions, engineers shall be assigned for the construction works throughout the implementation period. Some engineers for special works such as construction using steel sheet or pile and gate installation shall be also required. The type of engineer, its number and necessary period should be estimated.

3-1-2 Implementation Conditions

(1) General Conditions

Meteorological conditions of the construction sites strongly influenced by tropical monsoon, are distinctively divided into two seasons, wet season with frequent and heavy rainfall lasting from mid-May to November, and dry season lasting from December to April. Agricultural land in the flood plain is flooded frequently by the flood cycle of Mekong river. It usually begins in mid-July and lasts until mid-December. Construction works shall be scheduled bearing in mind sufficient understanding of the physical conditions of construction sites in the wet and dry seasons. Therefore, the construction works of the project sites should be conducted effectively during dry season.

Agricultural land is located along the canal. In the land, silt-water is supplied in the flood season and irrigation water is supplemented by pumps through a canal during the dry season from Mekong river. Function of the canal, therefore, should be secured even in the reconstruction period. During the construction, a temporary plan shall be scheduled so that the canal can function as water supply canal throughout a year.

Most of the necessary construction facilities, excluding gates, will be procured in Cambodia. However, since the construction period is restricted to the dry season time and the sites are located along the national road, special attention should be paid to the construction schedule planning so in order to conduct construction works during dry season, the necessary equipment and materials for construction such as construction equipment, steel materials for temporary works, equipment and materials for foundation treatment, and concrete, etc., shall be procured on time.

(2) Precautions for Implementation

1) Construction Office

To carry out construction works smoothly, one construction office and one site office are provided. The construction office is set in the Phnom Penh city aiming for communication with the implementing agency, central GDIMH and related agencies, and arrangement of construction schedule. The site office is constructed at any convenient site among the canals to manage the construction works of each site. Communication among the offices will be done by using mobile phones to cover wide spread construction sites.

2) Temporary Roads

Temporary roads are required during the period of removal and reconstruction works of gate and cross culvert. The roads will be constructed in the area of river side. Necessary land for road construction shall be secured by GDIMH. In the canal section, structure design shall paid attention to water flow in the canal. Pump facility shall be provided to supply water during dry season. Construction of the road shall be also scheduled considering the timing of water supply into farmland.

3) Demolition and removal of the existing structures

The existing concrete structures shall be demolished and removed after construction of temporary roads. The works shall be executed without any negative impact on the surrounding sites and houses, and demolished concrete and steel materials shall be removed into area(s) prepared by Royal Government of Cambodia.

4) Reshaping Works for Canals

In the reshaping works for bottom and slope of canal, existing vegetation and tree developed its root system on the top of slope should be left as much as possible so as to prevent soil erosion on the slope and harmonize with the local environment. Before the reshaping works, discussion with related communes and farmers will be needed.

5) Power Supply for the Construction

No electric supply service exists in the project areas. Power sources required for the construction works shall be secured by the contractor. Concerning water supply for the works, the water can be obtained from Mekong river by pumps. Drinking water will be secured by exploiting wells at the site.

6) Quality Control of Necessary Equipment and Materials

For concrete works, ready mixed concrete shall be used. However, since the factory is located at a distance of 30 to 40 km from the construction sites, sufficient quality control of the concrete shall be necessary in order to meet the design strength specified in the design standard. Most of the steel sheet pile and reinforcing bars will be imported. In the procurement of such materials, necessary test for quality control shall be carefully conducted so as to secure the design strength defined in the specification.

3-1-3 Scope of Works

(1) Acquirement and Compensation for Land

Reconstruction of canal works requires expansion of land and the removal of some houses along the route of the canals. Royal Government of Cambodia has responsibility for expropriation of private land and providing compensation to owners of concern. Securing land for temporary roads shall be also executed by the Cambodian side.

(2) Transportation, Installation and Trial Run

Cost for transportation to the sites, installation, adjustment and trial run of procured facilities and equipment shall be born by the Japanese side

3-1-4 Consultants Supervision

(1) GDIMH

GDIMH shall select and negotiate with a consultant the fulfilling of a detailed design and supervision of the project. After the consultant conducted the detailed design, the design and tender documents prepared by the consultant shall be approved by GDIMH. GDIMH shall take responsibility of acquiring or securing necessary land in close cooperation with Kandal provincial and related district offices.

(2) Consultant

Provided that this project is implemented under the Japanese Grant Aid System, a Japanese consultant recommended by JICA will conduct the following works related to the detailed design and necessary supervision according to the contract with the implementation agency of Cambodian Government, GDIMH.

1) Detailed Design

- Preparation of detailed design and tender documents
- Conducting tender operation, evaluation of tender
- Attending preceding the contract negotiation between the Cambodia side and contractor and giving necessary for closing the contract advises
- Other necessary consulting services

2) Implementation of supervision

- Approval of construction drawings
- Supervision of construction progress and quality control
- Coordination with the implementation agency and related office
- Inspection of construction progress and issue of completion certificate

3-1-5 Procurement Plan

As the Construction materials such as pile, concrete, gravel, sand, reinforce bar, formed frame, etc. in Cambodia are produced and/or sold on the market, they can be easily procured for the Project except sheet pile. However, sheet pile is not produced in Cambodia and is imported from neighboring countries. Therefore, it may be considered that almost all construction materials for the Project will be procured in Cambodia. There are many construction firms which have experience and capabilities for canal facilities like the present Project. For construction equipment in Cambodia, general construction equipment procured from Japan, Russia and other developed countries are found. There are many rental equipment and although a lot of them are old, it is considered that the Project can be

implemented using such rental equipment. However, special equipment such as giant breaker, which is used for destruction of existing concrete facilities, are not available in Cambodia.

(1) Irrigation Pumps

This irrigation pump will be used for pumping water up to the main canal. The existing irrigation pumps used in the other canals of this Project are mobile type, i.e. the pump equipment are assembled but removed if necessary in the wet season. The old turbo pumps of 300 mm in diameter or new axial pumps of 550 mm diameter are locally produced and used. Parts, such as engine or universal joints, are used for equipment completion - second hand or new but foreign made. Locally produced pumps are considered to be very useful for operation. For this Project, locally assembled pumps should be considered for installation, operation and maintenance.

(2) Procurement from Other Countries

1) Equipment for Operation and Maintenance as well as Construction

Due to the fact that almost all equipment and materials necessary for the Project are easily found in Cambodia, they will be procured locally. However, sheet pile is not produced in the country and can not be procured locally. Since sheet pile will be used in the Project and a fair amount it required, so it is considered that sheet pile will be procured from the neighbor countries, especially Singapore where sheet pile is easily procured.

2) Gate

In Cambodia, many small slide gates are manufactured, however their quality are not satisfactory. Gate for this Project will be designed to be of roller type. Since the gate for this Project requires duration of both side pressure, protection of water leakage and approximate 8 m of pulling height, it is not found that the manufacturers in the neighbor countries are qualified enough to manufacture and deliver such a gate. Baring in mind the limitations (dry season) imposed on the construction time, and that manufacturing of a gate in a neighbor country will require certain time for training of the manufacturer's labor, it is considered that the gate is to be designed to be produced in Japan.

3) Equipment for Operation and Maintenance

In Cambodia, equipment for operation and maintenance are not manufactured, however, many such equipment, especially Japanese made, are found in major urban centers. Therefore, taking into consideration the local popularity of the Japanese equipment and the necessity of strict control of operation and maintenance, it is intended the equipment for operation and control to be procured from Japan.

(3) Transportation Route

Port in Cambodia for importation is Sihanoukvile (Kampong Saom) and where customs clearance can be obtained. Transportation route to the site is National Road No. 4 from Sihanoukvile to the east of 220 km up to Phnom Penh, moreover National Road No. 1 from which over the Bassac river to the southeast along the Mekong river. Site stands on the approximately 30 km to 50 km from Phnom Penh. In wet season, there is another route which is the route of Mekong river transportation from Vietnam to the North up to Phnom Penh, however, as it is limited season as well as high water level and velocity, it is inconvenient. Inland transportation form Vietnam is not suitable due to road conditions. There are inland route from Thailand using the National Road No. 5 and No. 6, however, is closed for security problem. Therefore, it is considered that Sihanoukvile port is the most convenient and safe site to be used. Moreover, National Road No. 4 from Sihanoukvile to Phnom Penh is well paved with enough width for use of large trucks.

3-1-6 Implementation Schedule

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

3-1-7 Obligation of the Royal Government of Cambodia

If the Japan's grant aid is extended, the following items shall be born by the Royal

Government of Cambodia.

(1) After the implementation of the Project is determined, necessary materials and information shall be provided to the Japanese consultant that conducts the detailed design study.

(2) The requisite necessary for the operation of the facilities in the Project such as land and access roads shall be secured.

Land Acquisition	3.8 ha
Access Road	470 m

(3) Based on the bank arrangement, necessary commissions shall be paid to the banks.

(4) Measures shall be provided for the prompt unloading, customs clearance, and the transportation within the Cambodia of the equipment to be delivered for the Project.

(5) The taxes, the domestic taxes, and other financial loads charged to the preparation of equipment and provision of services by the Japanese nation for the Project shall be exempted or born by the Royal Government of Cambodia.

(6) Necessary measures shall be taken for the entry to and the staying in Cambodia of Japanese nation to supply services for the implementation in the Project.

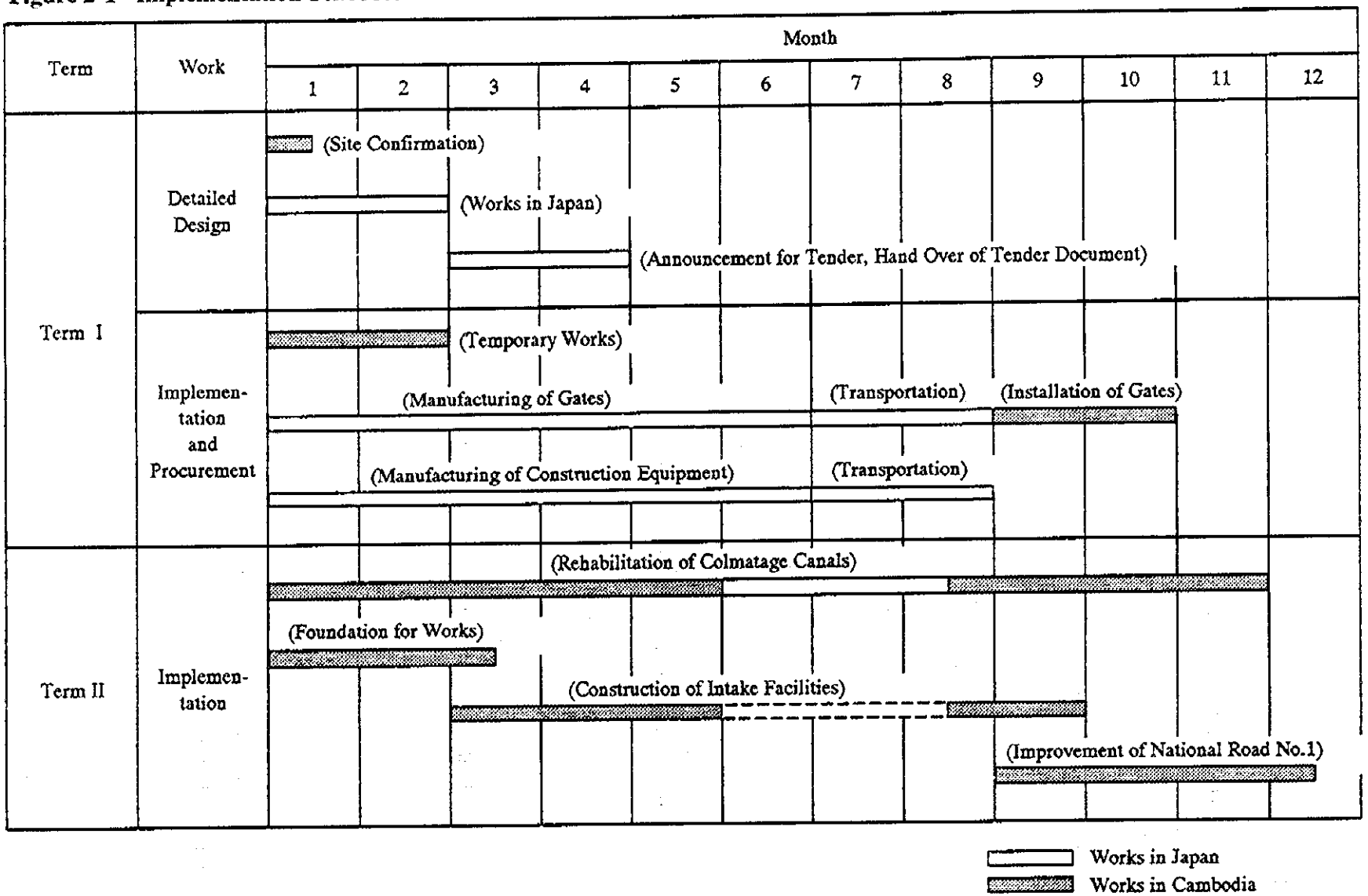
(7) The permit necessary for the implementation of the Project and ratification of the said permit shall be obtained in advance according to the laws of the Royal Government of Cambodia.

(8) Appropriate budget and staff members for proper and effective operation and maintenance of the facilities constructed under the Project shall be assigned.

(9) The equipment prepared for the Project shall be maintained and operated appropriately and effectively. The operating situation of equipment shall be reported to Japan as requested from Japan.

(10) All the other necessary expenses not included in the grant aid shall be born.

Figure 2-1 Implementation Schedule



3-2 Project Cost Estimation

3-2-1 Estimated Cost borne by the Government of Cambodia

Cost borne by the Government of Cambodia for project implementation is estimated as follows:

Table 3-2-1 Estimated Cost Borne by Cambodia

Item	Cost (US$)
1) Land acquisition	111,733
2) Banking commission	9,232
3) Customs clearance and inland transportation	25,075
Total:	146,040

Details of estimated cost borne by Cambodia are shown in Appendix 5 attached herewith.

3-2-2 Operation and Maintenance Cost

Yearly cost of operation and maintenance spent by Cambodia after the Project implementation is estimated as follows:

Table 3-2-2 Estimated Operation and Maintenance Cost spent by Cambodia

Item	Cost (US$)
1) Irrigation Pumps	47,400
2) Equipment of Operation and Maintenance	81,234
Total:	128,634

Details of estimated yearly cost of operation and maintenance spent by Cambodia are shown on Appendix 5 attached herewith.

Chapter 4 Project Evaluation and Recommendation

4-1 Project Effect

An encouragement of the agriculture and rural development is a top priority for Cambodia, so the Cambodian government has a plan to improve the deteriorated irrigation facilities. The Project is lined with the policy, benefits after implemented the Project are effect through the rehabilitation of colmatage irrigation facilities and effect of using mobile pumps (ϕ=300 mm,75 HP,Q=2,200 cu.m/hr) for irrigation in the dry season.

Effect of rehabilitation of irrigation facilities in the Project is expected to be an increase in cropping intensity and agricultural production due to improvement of farming practices. And also due to the operation of the gates, it could store the water in the canals. Storage water will use for the dry season irrigation along the colmatage canals during December and March.

It will be able to provide the fertile soils and preserve water in the existing farmlands through the rehabilitation of 4 colmatage irrigation facilities in the Project. Because of improvement of colmatage irrigation facilities, it will be possible to increase the farmlands from 1,993ha(cropping intensity 107%) to 2,122ha (cropping intensity 114%) in the existing farmlands of 1,862ha (100%) in the Project area and 2,782 families or 14,744 persons are benefited directly. And also providing 5 mobile pumps at the beginning of colmatage canals along the Mekong river, 550 ha of farmlands could use for irrigation in the dry season and 1,573 families or 8,337 persons are benefited directly.

At present about 10% of farmers in the Project area have a small mobile pumps for supplementary irrigation water in the wet season cropping. After establishment of the Farmers Water Users' Association (FWUA), FWUA will have a plan to rent small mobile pumps to the beneficially farmers. In the near feature, due to the lifting of water by pumps at the beginning point of the Mekong river, colmatage farming practice in the dry season will be developed remarkably and due to the construction of the feeder canals perpendicular to the colmatage canal, new farmlands along the feeder canals could be expanded in the dry season.

Species of fishes inhabited and wanders at the hinterland of swamps, ponds and streams are Sheatfish、Catfish、Silver Barb、Smith Barb,etc. These fishes are captured with a variation of the water surface area from the end of wet season to the dry season. After

completion of the rehabilitation of the canals, water surface area will be increased during the end of wet season to the dry season, so fish production as a protein resources for residents will be increased during 6 momths in the dry season.

Considering the above effects, the Project contributes not only to activation and expansion of the agricultural production and improvement of living condition but also to a model to other colmatage agricultural development projects in Cambodia. The Project will expect to contribute to the First Socioeconomic Development Plan (1996-2000) and it is, therefore judged that the Grant Aid cooperation is necessary and adequate.

4-2 Recommendation

For the smooth implementation of the Project, the following points should be considered.

(1) Before the commencement

① To confirm the completion of land acquisition by the Cambodian government.

② To confirm the land to place and manage the spoiled materials such as the concrete and reinforced bars, etc., of demolition of existing intake facilities.

(2) During the Construction

① The consultant shall support the activity of the Farmers Water Users' Associations (FWUA), which will be established by the GDIMH's leading. O&M for the irrigation facilities shall be properly carried out by the FWUA.

② And also in order to decide the proper water fee, inventories such as beneficiaries' farm land, kind of crops and these production and prices, annual incomes, etc., shall be carried out by the GDIMH and district agricultural office staff in cooperation with the Consultant.

③ To train the pump and gate operation to the GDIMH and related organization.

④ To pay attention to environment caused by construction works.

(3) After completion of the Project

① To carry out the O&M for irrigation facilities properly by the GDIMH, District Offices, Communes and FWUA.

② In order to maintain the irrigation facilities, regular inspection and repair works for equipment and facilities of pumps and gates should be carried out by the Cambodian side.

③ GDIMH and district agricultural office staff shall advise properly to the farmers to distribute the water system at main, feeder, and on farm level and to practice the farming and fisheries.

④ To carry out a continuous monitoring for the farming practice, living environment, and fluctuation of water levels etc., at the hinterland due to the operation of mobile pumps and gates.

DRAWINGS

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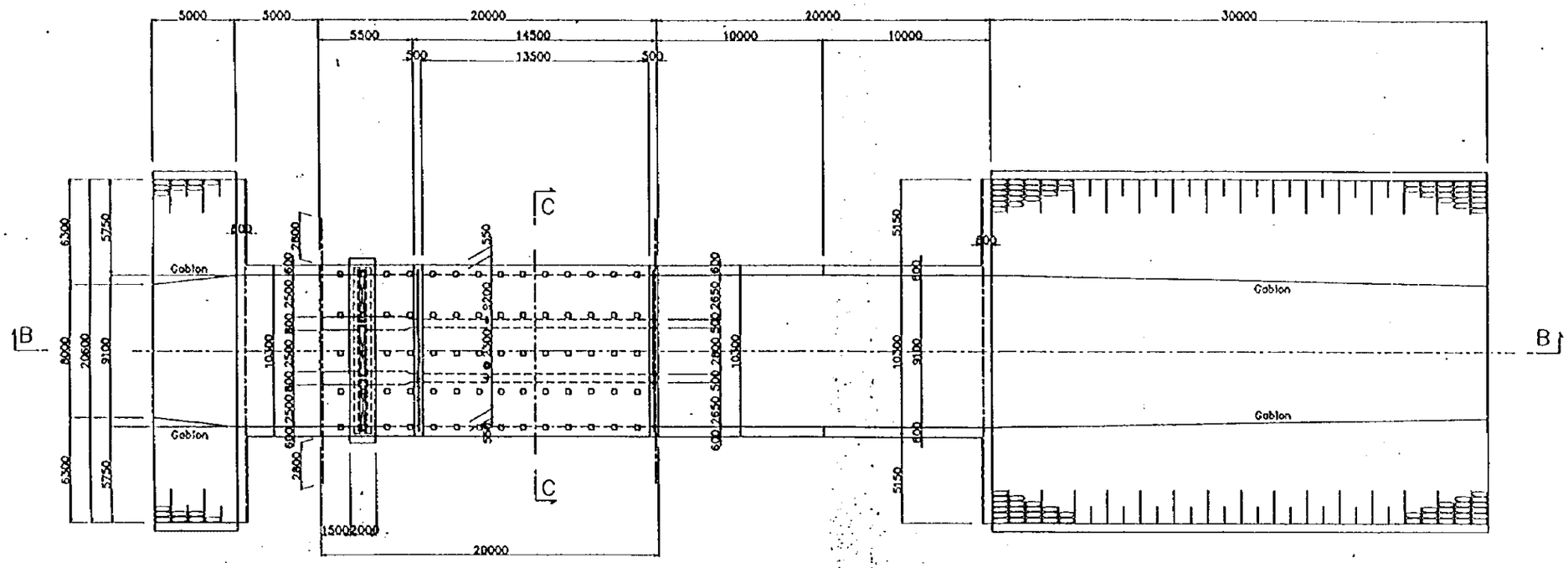

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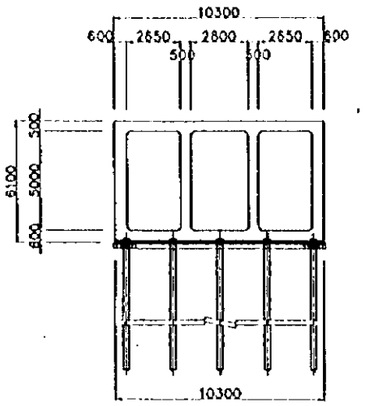
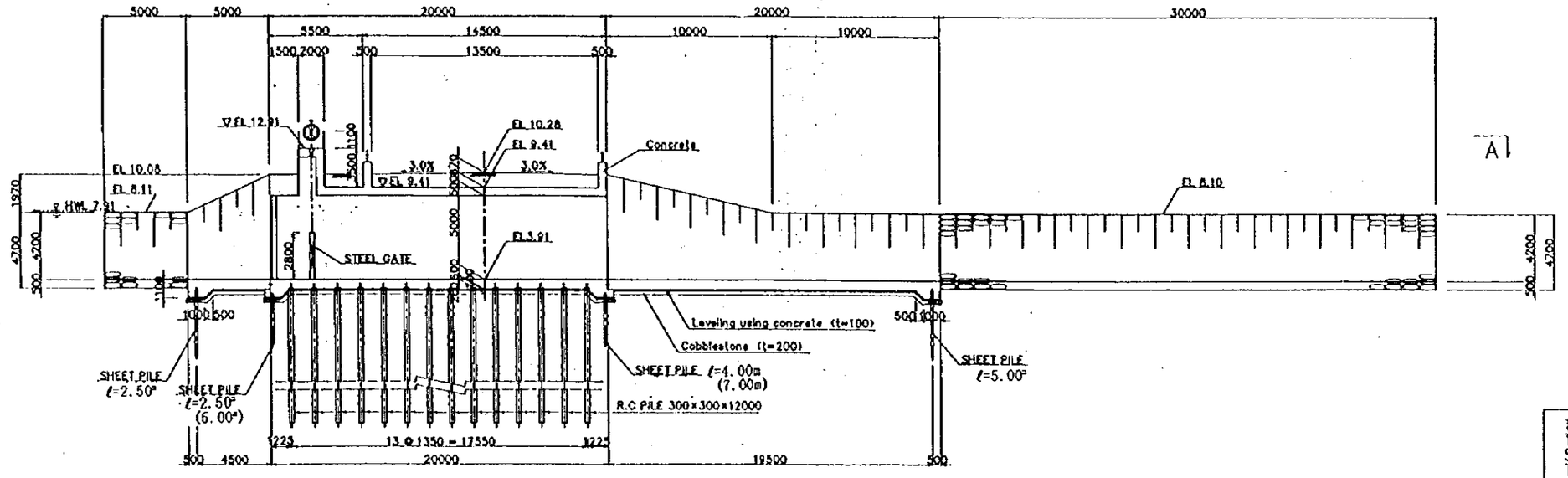


PROFILE OF INTAKE STRUCTURE (SECTION B–B) S=1:150



( ) Out Side Sheet Pile

THE PROJECT FOR THE IMPROVEMENT OF THE FACILITIES OF THE COLMATAGE SYSTEMS IN KANDAL PROVINCE ALONG THE MEKONG RIVER	
(PREK POL)	DRW.NO 1/12
JAPAN INTERNATIONAL COOPERATION AGENCY	

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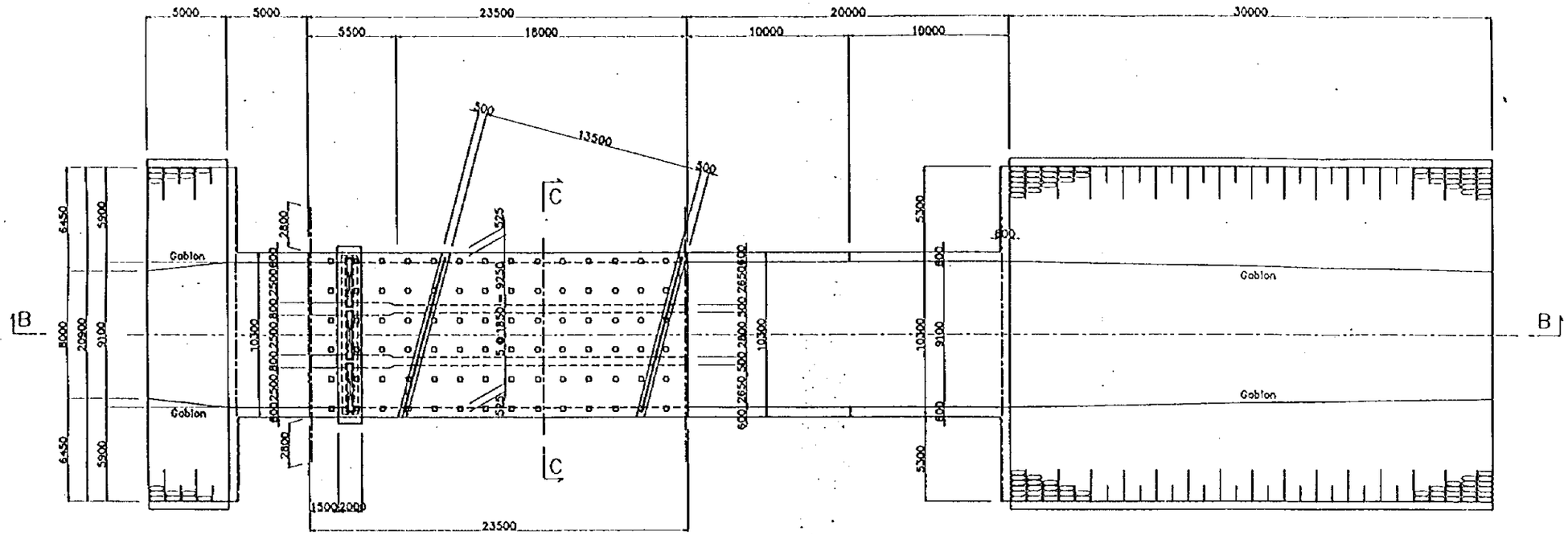

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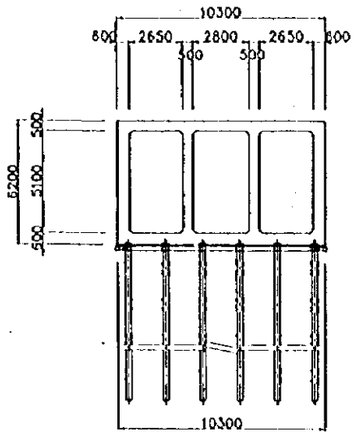
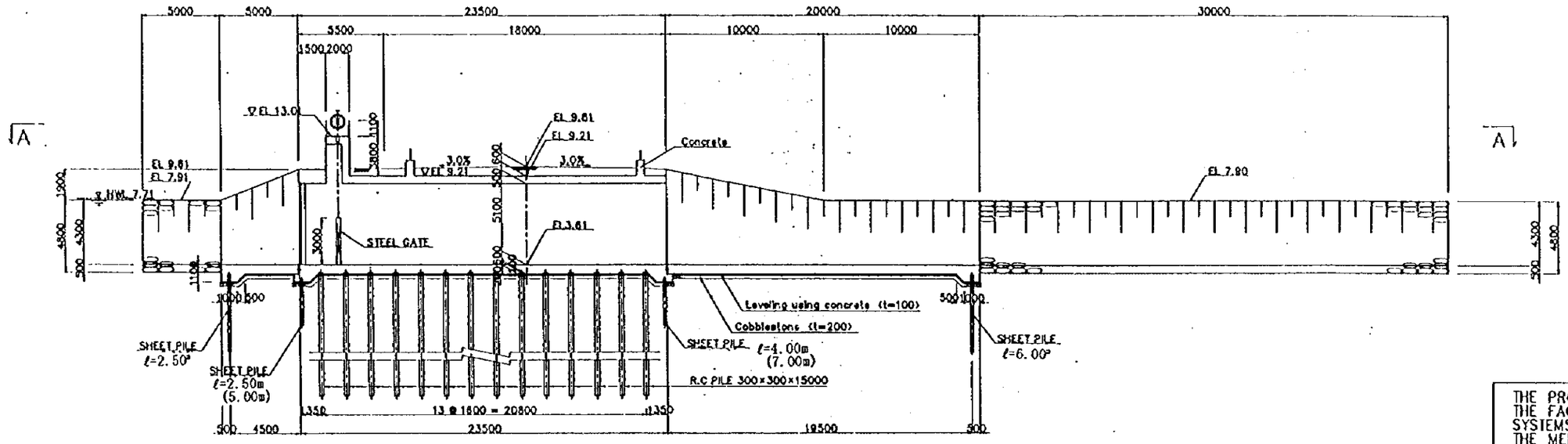


PROFILE OF INTAKE STRUCTURE (SECTION B–B) S=1:150



( ) Out Side Sheet Pile

THE PROJECT FOR THE IMPROVEMENT OF THE FACILITIES OF THE COLMATAGE SYSTEMS IN KANDAL PROVINCE ALONG THE MEKONG RIVER	
(PREK YOURN)	DRW.NO 2/12
JAPAN INTERNATIONAL COOPERATION AGENCY	

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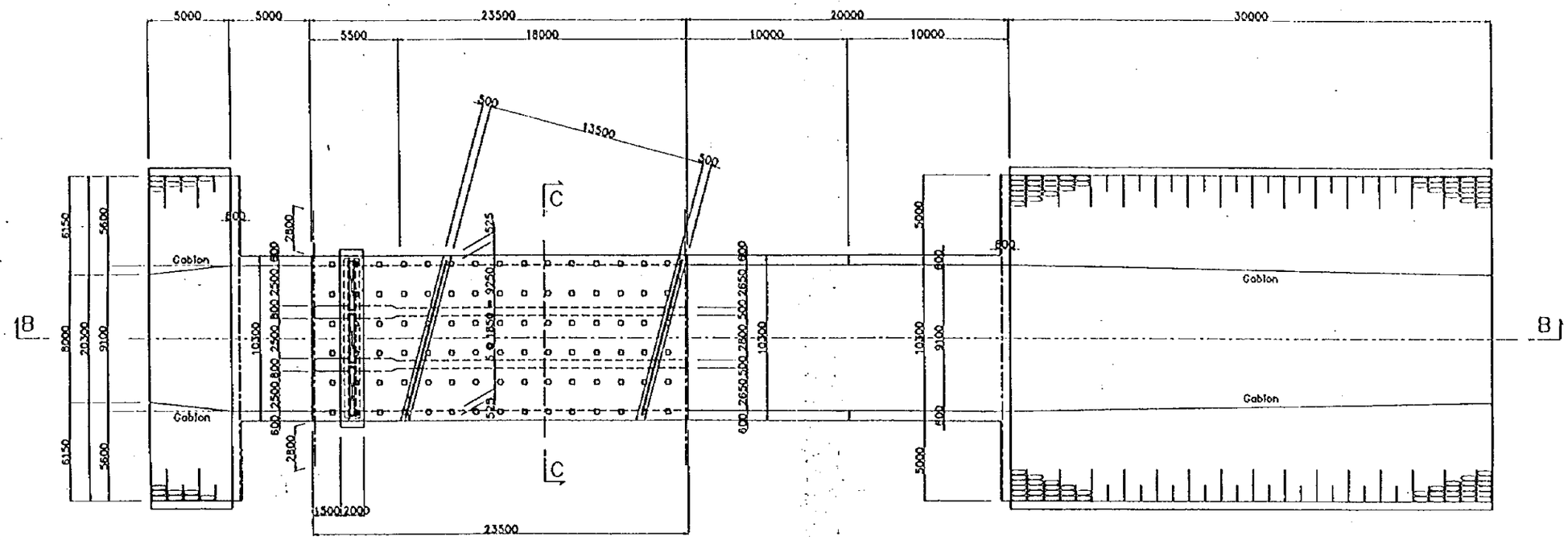
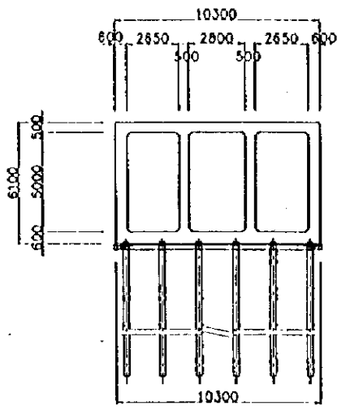
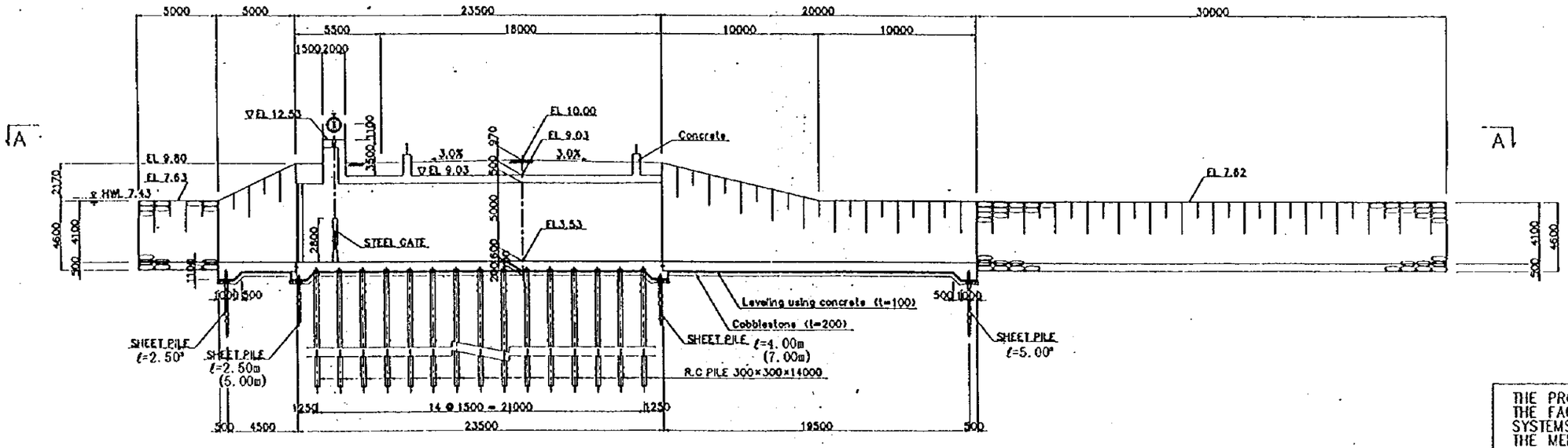


(SECTION C–C) S=1:150



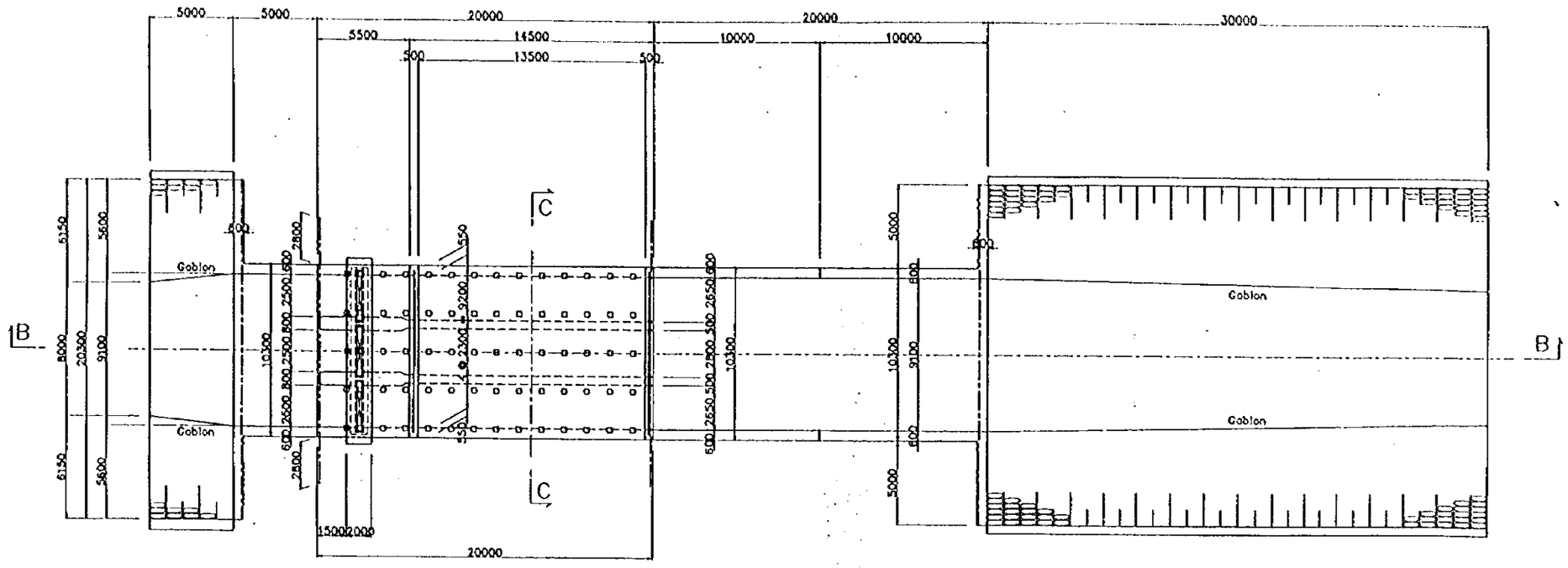
PROFILE OF INTAKE STRUCTURE (SECTION B–B) S=1:150



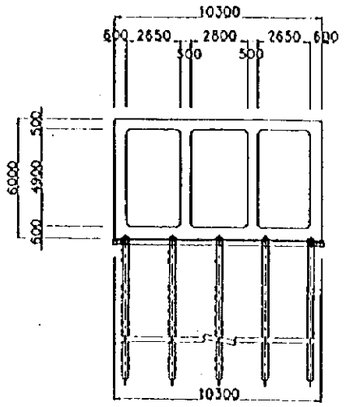
( ) Out Side Sheet Pile

THE PROJECT FOR THE IMPROVEMENT OF THE FACILITIES OF THE COLMATAGE SYSTEMS IN KANDAL PROVINCE ALONG THE MEKONG RIVER	
(PREK CHREY)	DRW.NO 3/12
JAPAN INTERNATIONAL COOPERATION AGENCY	

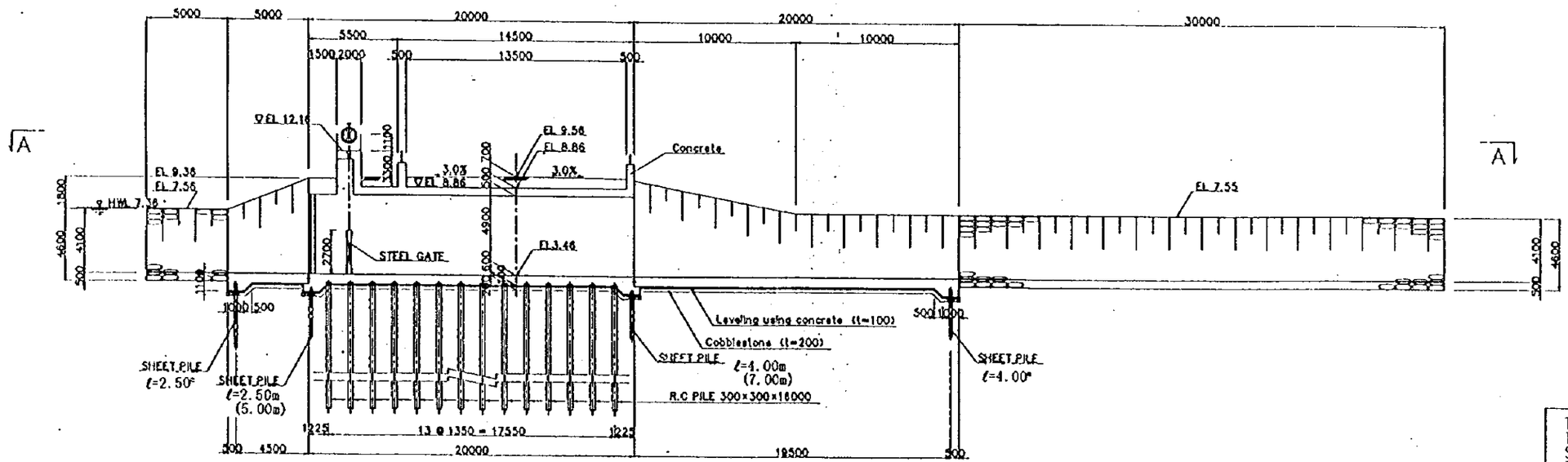
PLAN (SECTION A-A) S=1:150



(SECTION C-C) S=1:150



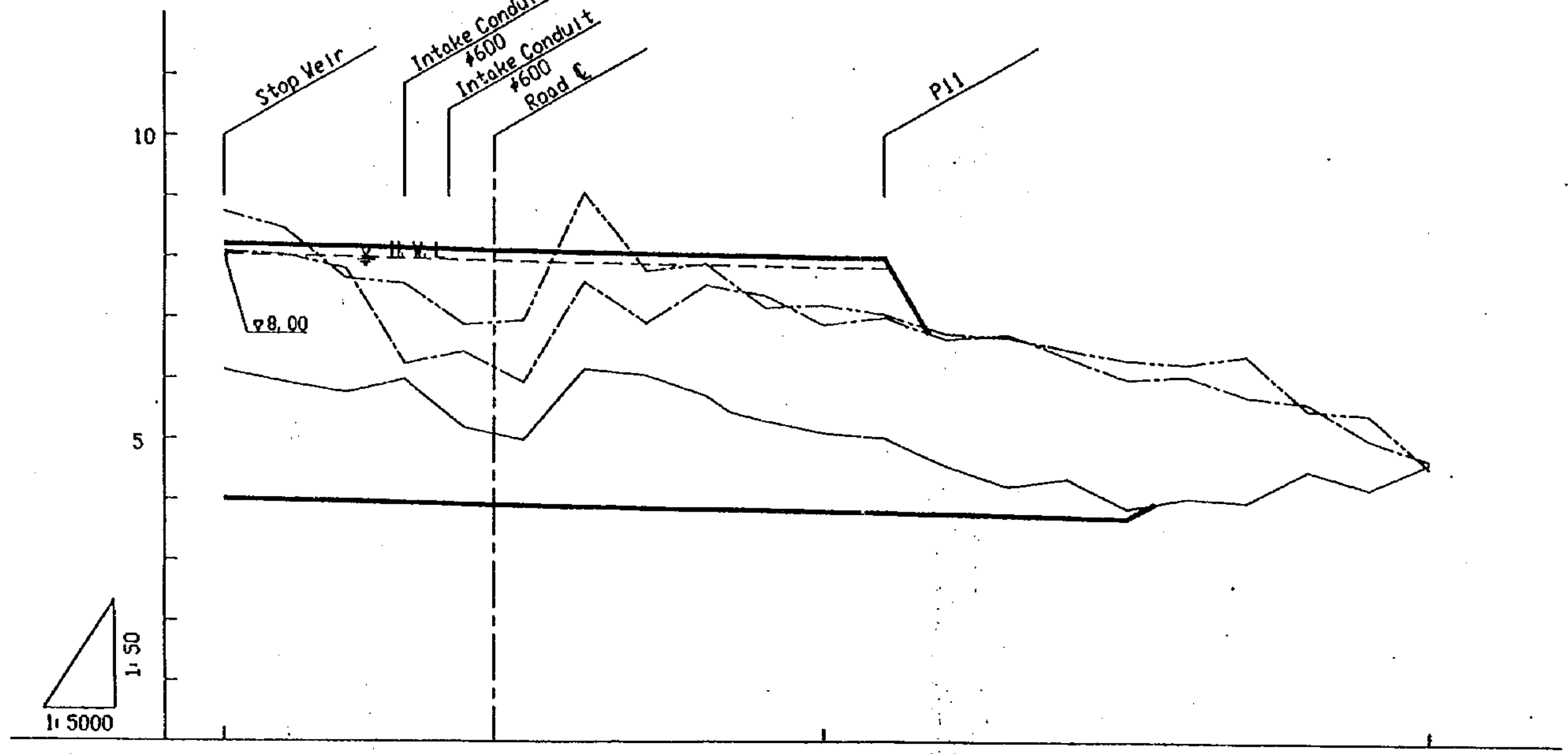
PROFILE OF INTAKE STRUCTURE (SECTION B-B) S=1:150



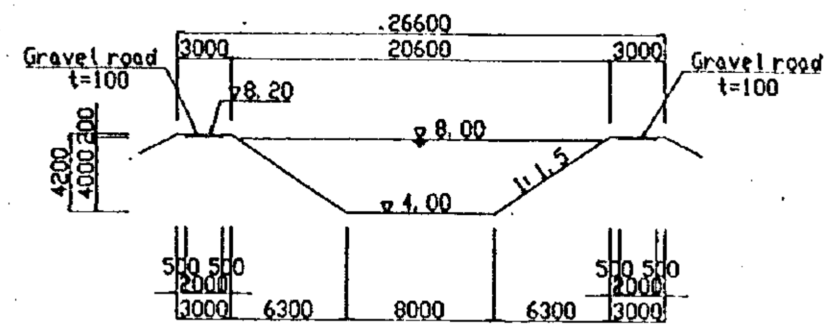
( ) Out Side Sheet Pile

THE PROJECT FOR THE IMPROVEMENT OF THE FACILITIES OF THE COLMATAGE SYSTEMS IN KANDAL PROVINCE ALONG THE MEKONG RIVER	
(PREK KOKI THOM)	DRW.NO 4/12
JAPAN INTERNATIONAL COOPERATION AGENCY	

LONGITUDINAL OF PREK POL



TYPICAL CROSS SECTION S=1:200



(unit: mm)

Design	Gradient	4.00	i=1/5000 l=2000m																					3.60
Design	Right Bank Level	8.20					8.11	8.10						8.00					7.90					7.80
Design	River bed Level	4.00					3.91	3.90						3.80					3.70					3.60
Design	Left Bank Level	8.20					8.11	8.10						8.00					7.90					7.80
Design	Water Level	8.00					7.91	7.90						7.80										
Existing	Right Bank Level	8.08	8.03	7.80	6.24	6.44		5.94	7.60	6.92	7.54		7.37	6.88	7.00	6.64	6.72	6.36	5.99	6.05	5.72	5.61	5.02	4.69
Existing	River bed Level	6.13	5.93	5.76	5.98	5.19		4.99	6.16	6.06	5.72	5.45	5.30	5.10	5.02	4.56	4.22	4.35	3.86	4.04	3.98	4.50	4.21	4.64
Existing	Left Bank Level	8.74	8.46	7.64	7.56	6.89		6.96	9.06	7.78	7.89		7.17	7.21	7.05	6.73	6.67	6.48	6.31	6.25	6.39	5.50	5.43	4.57
Existing	Alignment																							
Accumulate Distance		0.00					450	500				940		1000	1100				1500					2000
Distance		0.00					450	50				340		160	100				500					500
Station		P0						P5						P10	P11				P15					P20

Line	Legend
-·-·-·-	Existing Right Bank
—·—·—	Existing Left Bank
———	Existing River Bed
━━━	Design Bank & Bed
- - - -	H.W.L (1/2)

THE PROJECT FOR THE IMPROVEMENT OF THE FACILITIES OF THE COLMATAGE SYSTEMS IN KANDAL PROVINCE ALONG THE MEKONG RIVER

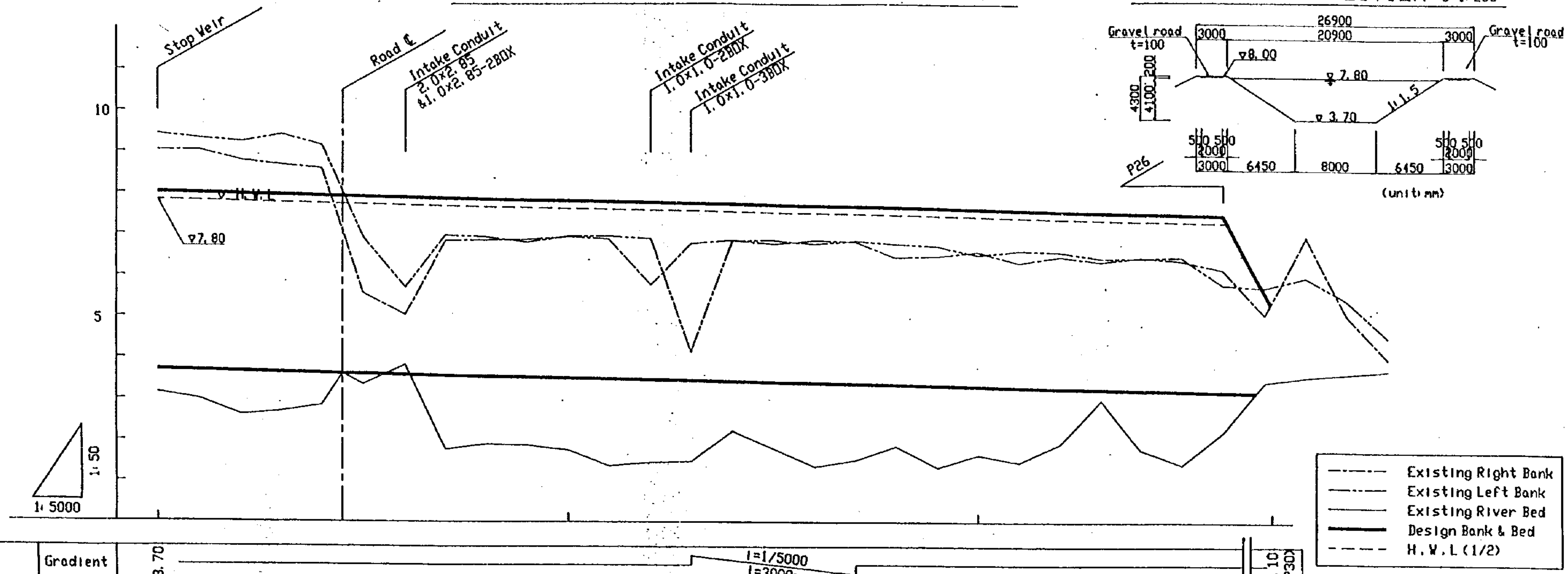
LONGITUDINAL OF PREK POL

DRW. NO 5/12

JAPAN INTERNATIONAL COOPERATION AGENCY

LONGITUDINAL OF PREK YOURN

TYPICAL CROSS SECTION S=1:200



Design — Gradient: 3.70 (P0); I=1/5000, l=3000m; 3.10 (P30)

Station	Accumulate Distance	Distance	Design Right Bank Level	Design River Bed Level	Design Left Bank Level	Design Water Level	Existing Right Bank Level	Existing River Bed Level	Existing Left Bank Level
P0	0.00	0.00	8.00	3.70	8.00	7.80	9.03	3.15	9.42
							9.02	2.99	9.31
							8.78	2.61	9.23
							8.67	2.69	9.41
							8.58	2.84	9.15
	450	450	7.91	3.61	7.91	7.71	7.07	3.10	8.03
P5	500	50	7.90	3.60	7.90	7.70	5.56	3.35	6.91
							5.04	3.82	5.71
							6.84	1.77	6.97
							6.85	1.90	6.93
							6.87	1.87	6.80
P10	1000	500	7.80	3.50	7.80	7.60	6.93	1.75	6.95
							6.88	1.36	6.95
							5.77	1.45	6.89
							6.77	1.47	4.14
							6.85	2.22	6.84
P15	1500	500	7.70	3.40	7.70	7.50	6.76	1.79	6.85
							6.85	1.35	6.76
							6.81	1.51	6.83
							6.43	1.85	6.76
							6.47	1.33	6.71
P20	2000	500	7.60	3.30	7.60	7.40	6.58	1.64	6.50
							6.32	1.46	6.61
							6.48	1.92	6.59
							6.36	2.99	6.44
							6.47	1.78	6.45
P25	2500	500	7.50	3.20	7.50	7.30	6.38	1.41	6.47
P26	2600	100					6.17	2.21	5.80
(P30)			7.40	3.10	7.40		4.02	3.73	4.54

Alignment

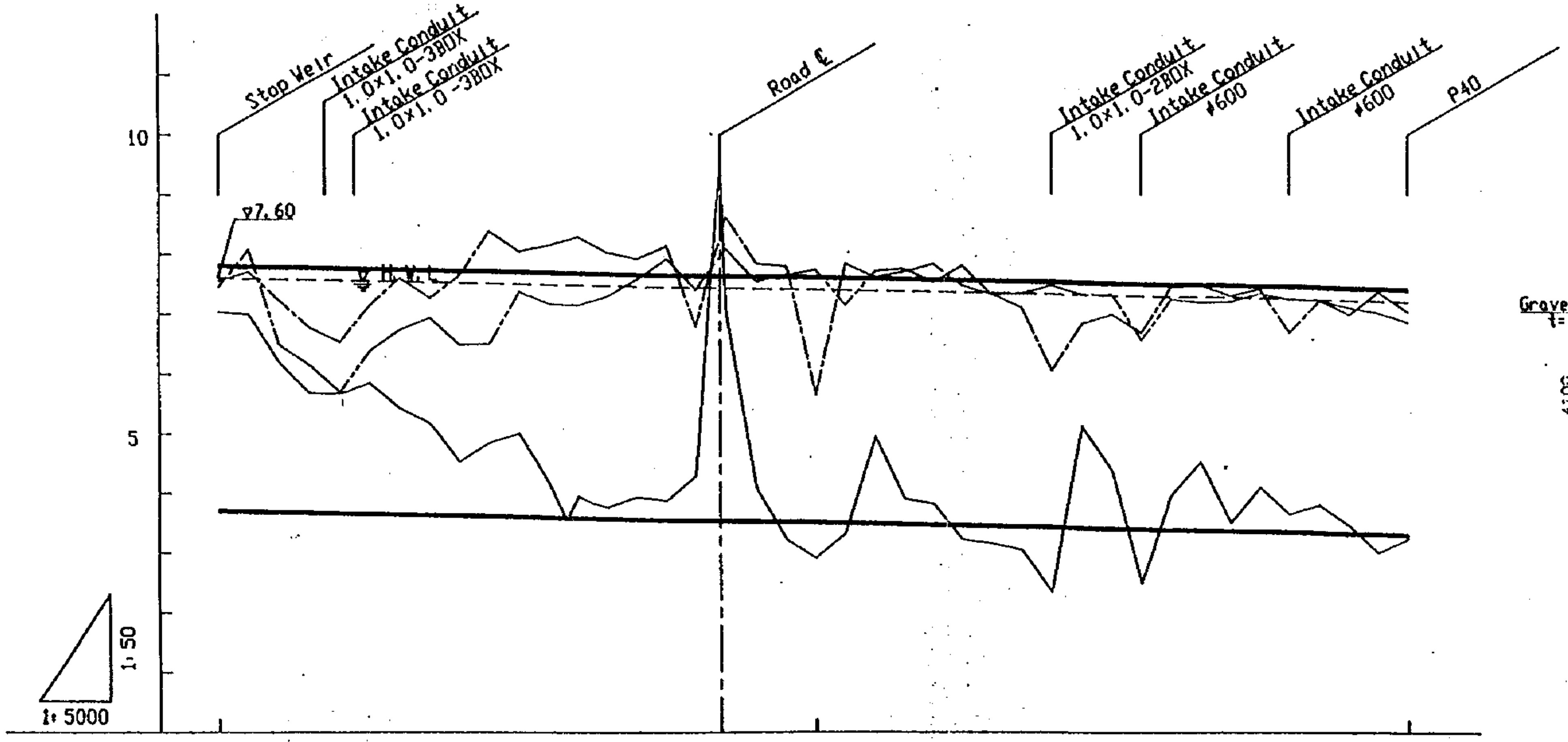
THE PROJECT FOR THE IMPROVEMENT OF THE FACILITIES OF THE COLMATAGE SYSTEMS IN KANDAL PROVINCE ALONG THE MEKONG RIVER

LONGITUDINAL OF PREK YOURN

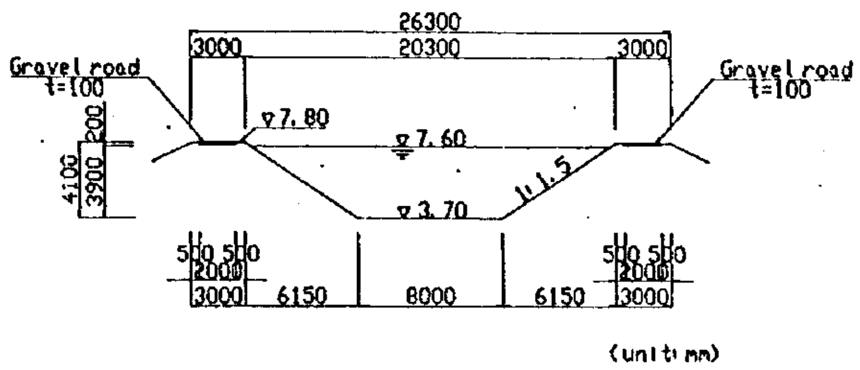
DRW. NO 6/12

JAPAN INTERNATIONAL COOPERATION AGENCY

LONGITUDINAL OF PREK CHREY



TYPICAL CROSS SECTION S=1:200



		P0					P10						P20					P30					P40
Design	Gradient	3.70								i=1/5000 l=2000m													3.30
Design	Right Bank Level	7.80					7.70				7.63		7.60					7.50					7.40
Design	River Bed Level	3.70					3.60				3.53		3.50					3.40					3.30
Design	Left Bank Level	7.80					7.70				7.63		7.60					7.50					7.40
Design	Water Level	7.60					7.50				7.43		7.40					7.30					7.20
Existing	Right Bank Level	7.55	7.23	6.54	7.60	7.65	8.05	8.29	7.93	6.80		7.85	5.65	7.60	7.83	7.32	6.05	6.99	7.44	7.29	6.69	7.10	6.87
Existing	River Bed Level	7.03	6.20	5.67	5.43	4.53	5.00	3.55 / 3.[illegible] / 3.84	3.94	4.30	9.60	4.08	2.91	4.94	3.82	3.15	2.35	4.38	3.96	3.50	3.65	3.46	3.24
Existing	Left Bank Level	7.45	6.49	5.70	6.74	6.49	7.37	7.15	7.58	7.41		7.54	7.73	7.71	7.52	7.31	7.46	7.32	7.24	7.19	7.23	6.99	7.04
Existing	Alignment																						
Accumulate Distance		0.00					500	580 / 600 / 624			841		1000					1500					2000
Distance		0.00					500	80 / 20 / 24			217		159					500					500
Station		P0					P10						P20					P30					P40

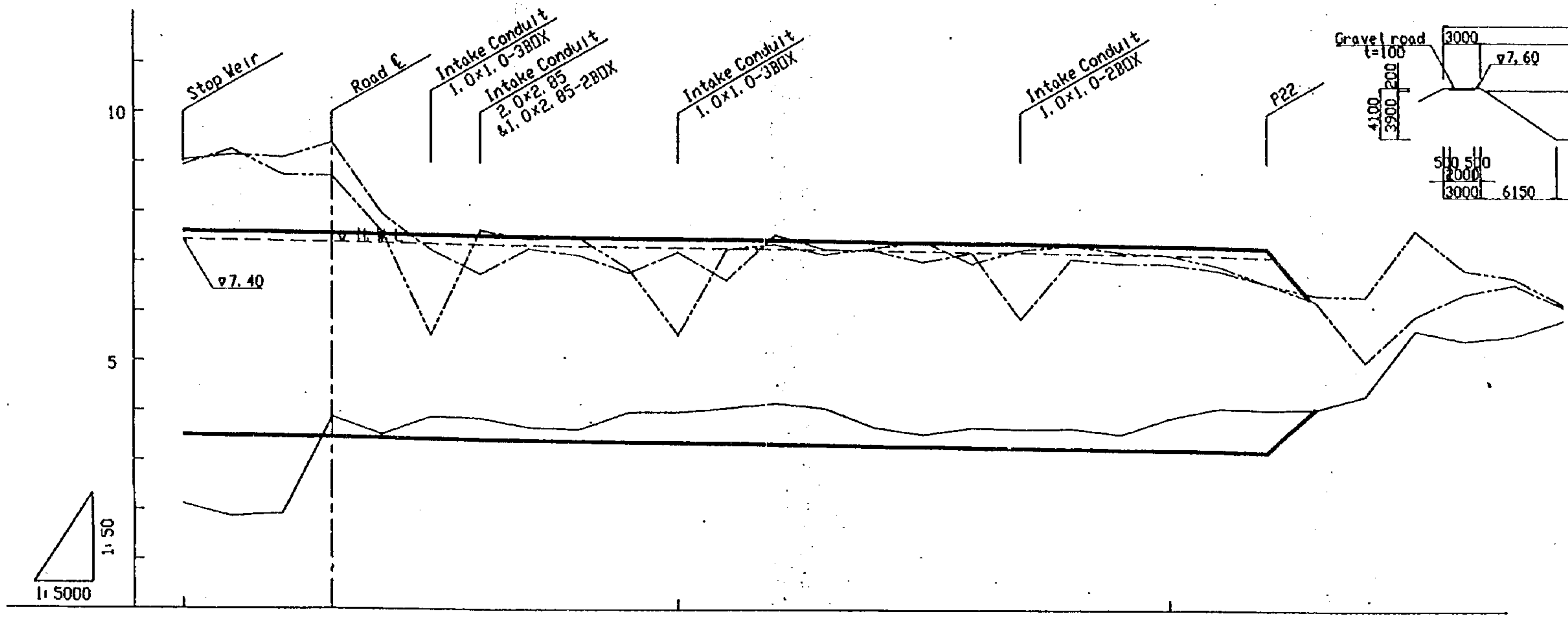
- Existing Right Bank (dash-dot line)
- Existing Left Bank (dash-double-dot line)
- Existing River Bed (thin line)
- Design Bank & Bed (thick line)
- H.W.L(1/2) (dashed line)

THE PROJECT FOR THE IMPROVEMENT OF THE FACILITIES OF THE COLMATAGE SYSTEMS IN KANDAL PROVINCE ALONG THE MEKONG RIVER

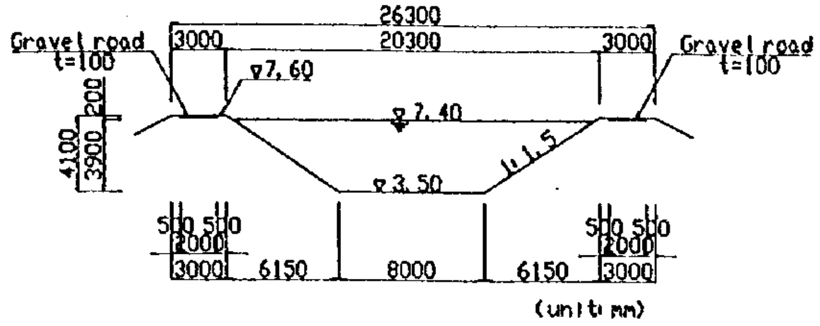
LONGITUDINAL OF PREK CHREY	DRW. NO 7/12

JAPAN INTERNATIONAL COOPERATION AGENCY

LONGITUDINAL OF PREK KOKI THOM



TYPICAL CROSS SECTION S=1:200



Design	Gradient	3.50														I=1/7000 I=2800m												3.10
	Right Bank Level	7.60			7.56		7.53					7.46					7.39					7.31					7.24	7.20
	River Bed Level	3.50			3.46		3.43					3.36					3.29					3.21					3.14	3.10
	Left Bank Level	7.60			7.56		7.53					7.46					7.39					7.31					7.24	7.20
	Water Level	7.40			7.36		7.33					7.28					7.19					7.11						
Existing	Right Bank Level	9.03	9.13	9.08	9.38	7.96	7.24	6.76	7.26	7.14	6.79	7.20	6.64	7.54	7.25	7.23	7.01	7.19	5.86	7.06	6.98	6.97	6.84	6.59	6.25	5.02	5.95	6.15
	River Bed Level	2.11	1.86	1.92	3.87	3.52	3.88	3.85	3.67	3.63	3.98	3.98	4.06	4.16	4.06	3.68	3.54	3.68	3.64	3.66	3.54	3.87	4.07	4.04	4.07	4.34	5.66	5.87
	Left Bank Level	8.93	9.24	8.73	8.71	7.61	5.53	7.63	7.45	7.49	6.87	5.54	7.25	7.35	7.15	7.28	7.42	6.98	7.24	7.33	7.20	7.14	6.93	6.59	6.37	6.34	7.67	6.20
	Alignment																											
Accumulate Distance		0.00			300		475 500					1000					1500					2000		2200			2500	2800
Distance		0.00			300		175 25					500					500					500		200			500	300
Station		P0					P5					P10					P15					P20		P22			P25	P28

THE PROJECT FOR THE IMPROVEMENT OF THE FACILITIES OF THE COLMATAGE SYSTEMS IN KANDAL PROVINCE ALONG THE MEKONG RIVER

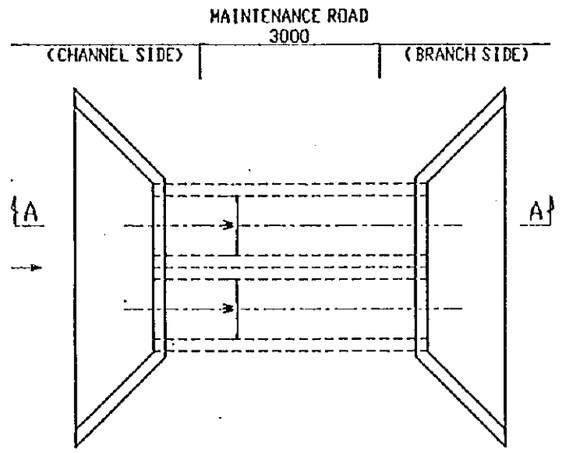
LONGITUDIAL OF PREK KOKI THOM	DRV. NO 18/12

JAPAN INTERNATIONAL COOPERATION AGENCY

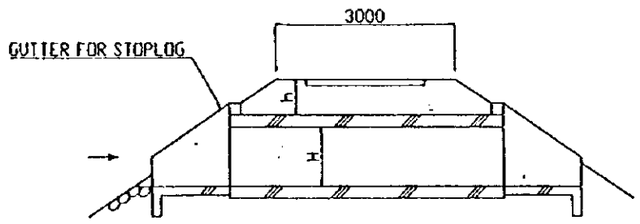
INTAKE CONDUIT S=1:50

(TYPE-A)

PLAN



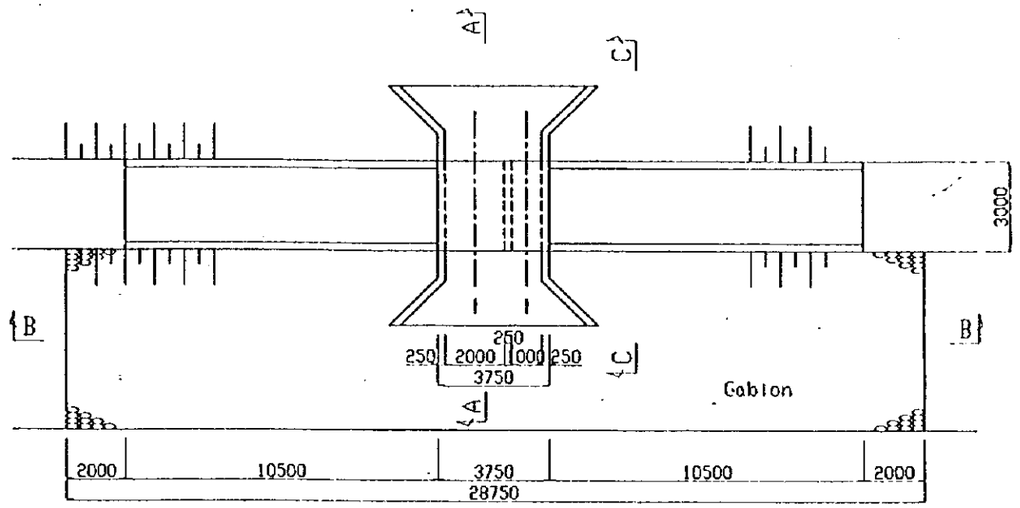
SECTION A-A



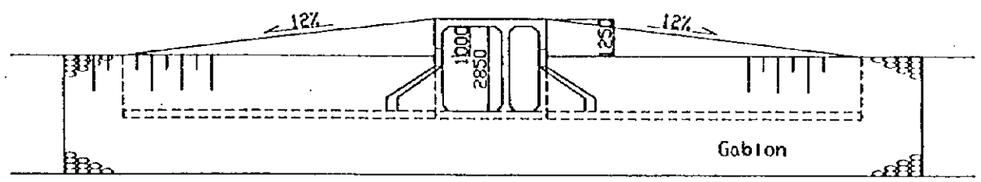
MARK	DESCRIPTION	WIDTH (m)	HEIGHT (m)	EARTH COVERING (m)
A	BOX CULVERT	1.0×3	1.0	0.6
B	BOX CULVERT	1.0×2	1.0	0.6
C	CONCRETE PIPE	ϕ600mm		0.6
D	BOX CULVERT	2.0×1 1.0×2	2.85	——

(TYPE-B)

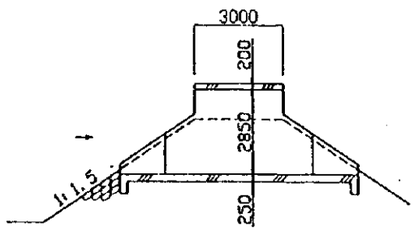
PLAN



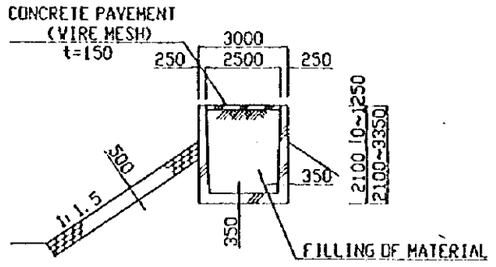
SECTION B-B



SECTION A-A



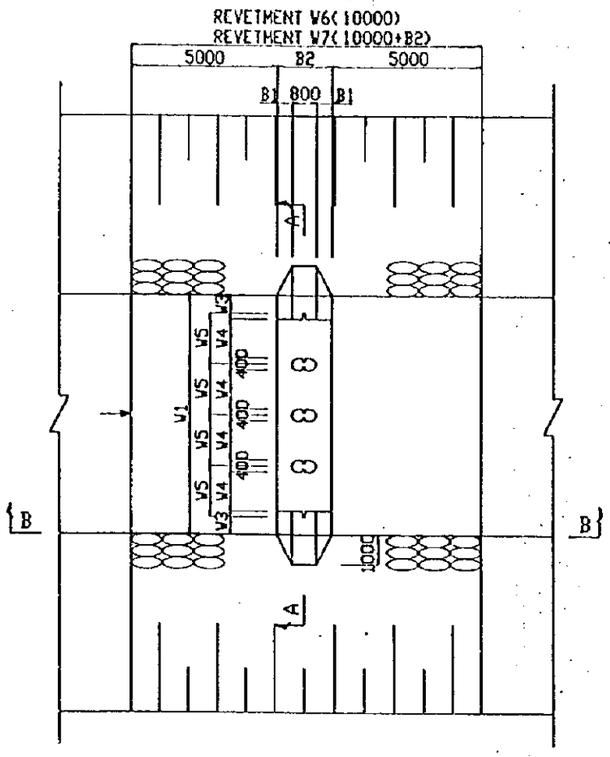
SECTION C-C



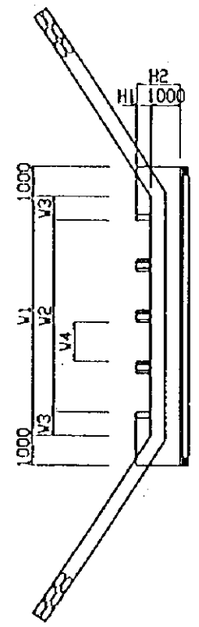
THE PROJECT FOR THE IMPROVEMENT OF THE FACILITIES OF THE COLMATAGE SYSTEMS IN KANDAL PROVINCE ALONG THE MEKONG RIVER	
INTAKE CONDUIT	DRW. NO 9/12
JAPAN INTERNATIONAL COOPERATION AGENCY	

STOP WEIR S=1:100

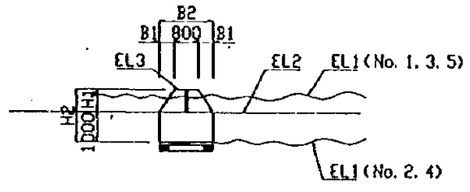
PLAN



SECTION A-A



SECTION B-B



No.		WIDTH						BREADTH			HEIGHT			ELEVATION				WIDTH		
		V1	V2	V3	V4	V5		B1	B2		H1	H2		EL1	EL2	EL3		V6	V7	
1	Prek Pol	8.0	6.4	0.8	1.3	1.7		1.0	2.8		1.0	2.0		6.13	4.00	4.50		10.0	12.8	
2	Prek yuon	8.0	6.4	0.8	1.3	1.7		1.0	2.8		1.0	2.0		3.15	3.70	4.20		10.0	12.8	
3	Prek Chrey	8.0	6.4	0.8	1.3	1.7		1.0	2.8		1.0	2.0		7.03	3.70	4.20		10.0	12.8	
4	Koki Thon	8.0	6.4	0.8	1.3	1.7		1.0	2.8		1.0	2.0		2.11	3.50	4.00		10.0	12.8	
5	Konpong Phnon	6.0	6.0	0	1.2	1.6		1.0	2.8		1.0	2.0		6.23	3.40	3.90		10.0	12.8	

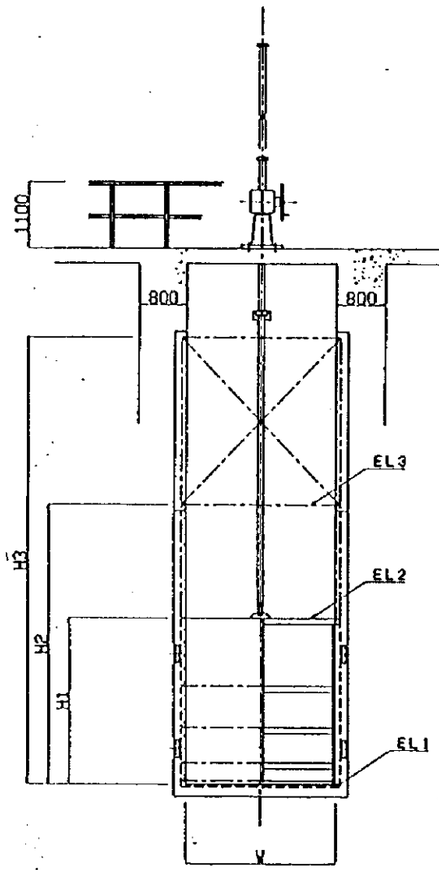
THE PROJECT FOR THE IMPROVEMENT OF THE FACILITIES OF THE COLMATAGE SYSTEMS IN KANDAL PROVINCE ALONG THE MEKONG RIVER

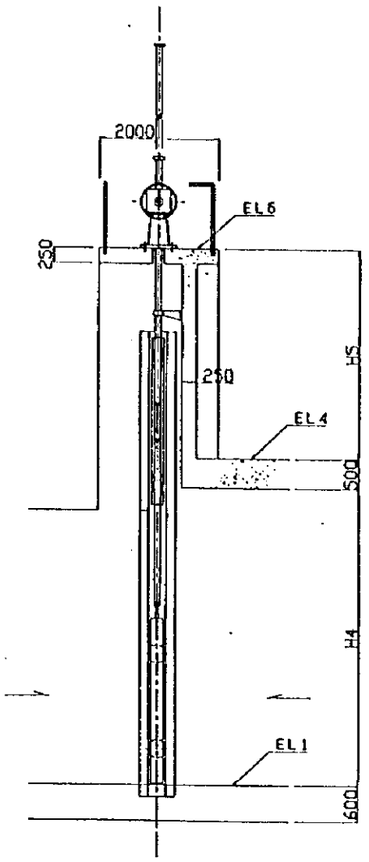
STOP WEIR

DRV. NO 10/12

JAPAN INTERNATIONAL COOPERATION AGENCY

ROLLER GATE S=1:50





(m)

ITEM	PREK POL	PREK YOURN	PREK CHREY	KOKI THOM	KAMPONG PHNOM
Gate Width (w)(m)	2.5	2.5	2.5	2.5	2.0
Bottom Elevation (EL1)(EL,m)	3.91	3.61	3.53	3.46	3.31
Crest Elevation (EL2)(EL,m)	6.71	6.61	6.33	6.16	6.01
Botton of Hoisting Gate (EL3)(EL,m)	8.62	8.53	8.24	8.0	7.84
Surface of Culvert (EL4)(EL,m)	9.41	9.21	9.03	8.86	8.41
Operation Decks (EL4)(EL,m)	12.91	13.01	12.53	12.16	12.01
Gate Height (H1)(m)	2.8	3.0	2.8	2.7	2.7
Hoisting Height (H2)(m)	4.71	4.92	4.71	4.54	4.53
Movable Height (H3)(m)	7.51	7.92	7.51	7.24	7.23
Clearance of Box Culvert (H4)(m)	5.0	5.1	5.0	4.9	4.6
Height of Operation Decks (H5)(m)	3.5	3.8	3.5	3.3	3.6

THE PROJECT FOR THE IMPROVEMENT OF THE FACILITIES OF THE COLMATAGE SYSTEMS IN KANDAL PROVINCE ALONG THE MEKONG RIVER

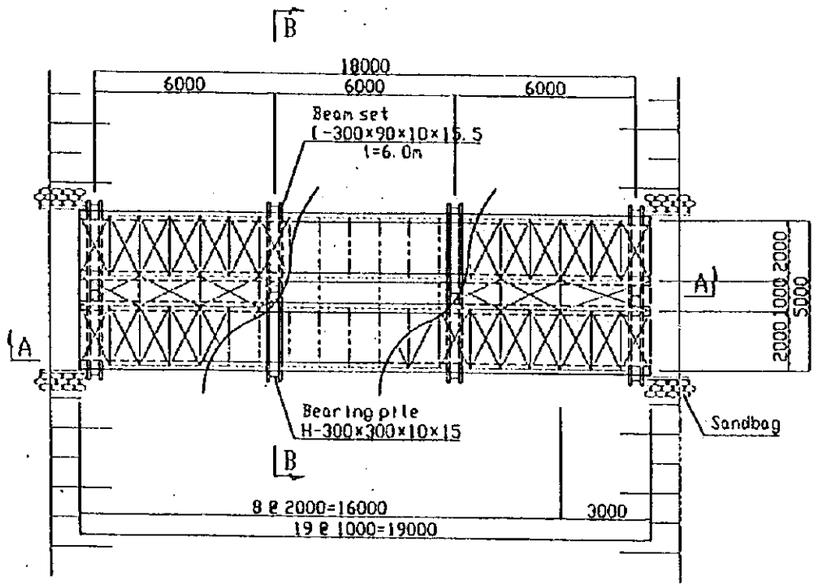
ROLLER GATE

DRW. NO 11/12.

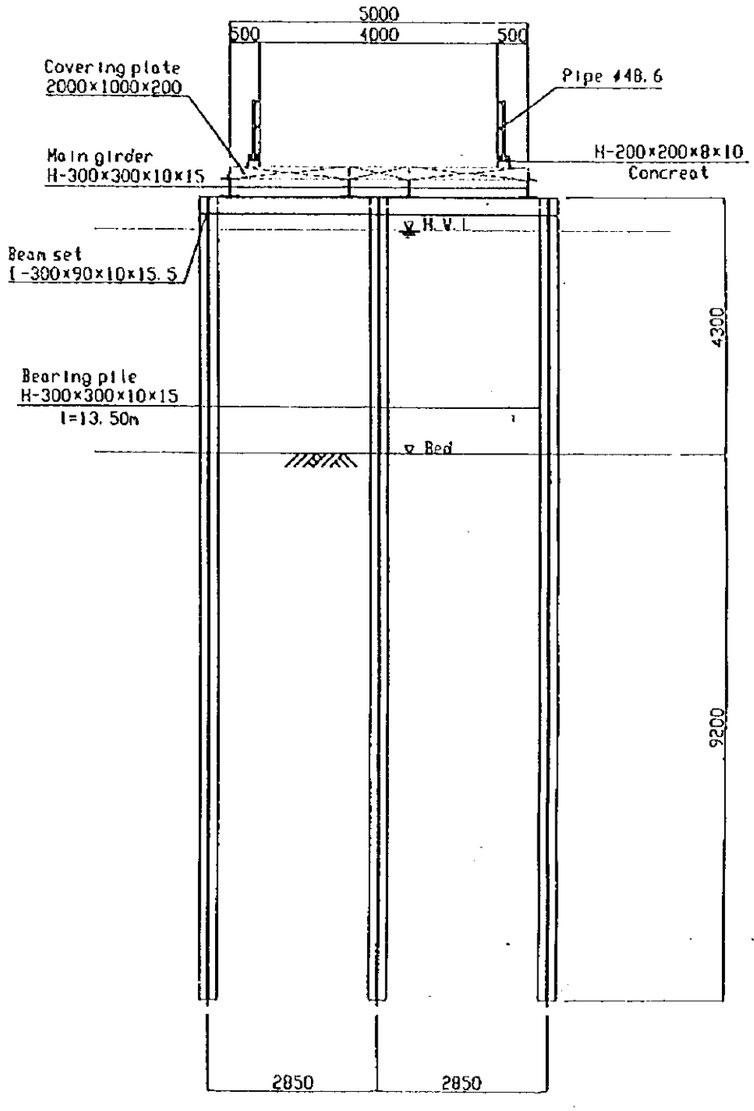
JAPAN INTERNATIONAL COOPERATION AGENCY

TEMPORARY BRIDGE

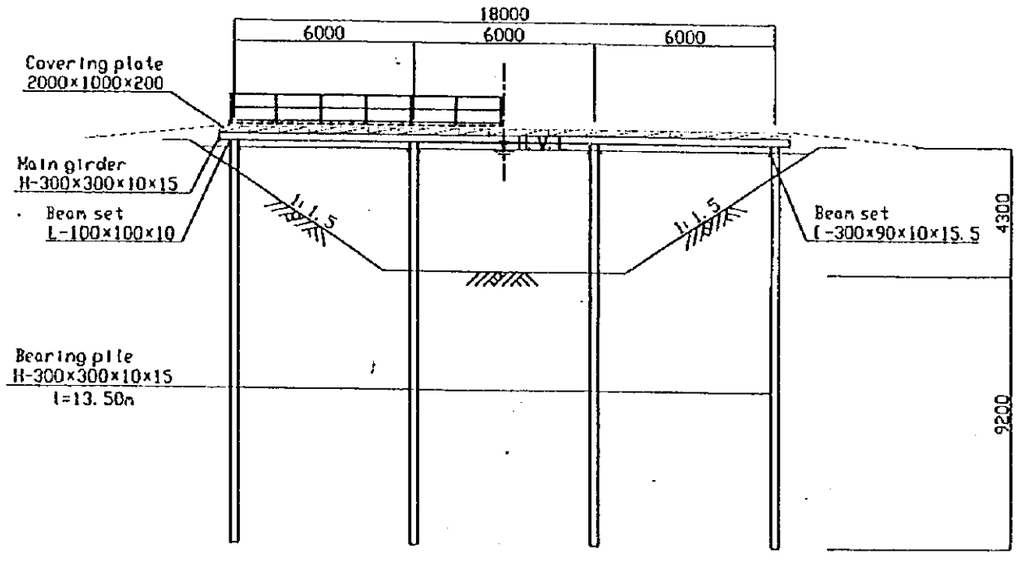
PLAN S=1:100



SECTION B-B S=1:50



SECTION A-A S=1:100



THE PROJECT FOR THE IMPROVEMENT OF THE FACILITIES OF THE COLMATAGE SYSTEMS IN KANDAL PROVINCE ALONG THE MEKONG RIVER	
TEMPORARY BRIDGE	DRV. NO 12/12
JAPAN INTERNATIONAL COOPERATION AGENCY	