MINISTRY OF WATER RESOURCES
AND METEOROLOGY
THE KINGDOM OF CAMBODIA

BASIC DESIGN STUDY REPORT
ON
THE PROJECT FOR IMPROVEMENT
OF
ROLEANG CHREY HEADWORKS
IN
THE KINGDOM OF CAMBODIA

JULY 2008

JAPAN INTERNATIONAL COOPERATION AGENCY

NIPPON KOEI CO., LTD.

PREFACE

In response to a request from the Royal Government of Cambodia, the Government of Japan decided to conduct a basic design study on the Project for Improvement of Roleang Chrey Headworks in the Kingdom of Cambodia and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to Cambodia a study team from November 15, 2007 to December 17, 2007.

The team held discussions with the officials concerned of the Royal 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 Royal Government of Cambodia for their close cooperation extended to the teams.

July 2008

Masafumi KUROKI
Vice-President,
Japan International Cooperation Agency

July 2008

LETTER OF TRANSMITTAL

We are pleased to submit to you the basic design study report on the Project for Improvement of Roleang Chrey Headworks in the Kingdom of Cambodia.

This study was conducted by Nippon Koei Co., Ltd., under a contract to JICA, during the period from November 2007 to July 2008. 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,

Toshikazu HIGASHIKAWA

Project manager,

Basic design study team on
The Project for Improvement of
Roleang Chrey Headworks
in the Kingdom of Cambodia

Nippon Koei Co., Ltd.

SUMMARY

1 Background of the Project

1 The agriculture sector in the Kingdom of Cambodia employs 71% of the workable population and contributes to 34% of the GDP. The GDP per capita has been increasing but it is as low as US$ 448. Agriculture in Cambodia depends on rainfall, and agricultural production is largely influenced by weather conditions. The agricultural productivity is still at a low level and unstable. The main crop in Cambodia is paddy rice. The cultivation area is 2.37 million ha and the irrigated area is 25 %.

2 The Cambodian Government has policy that steady growth of the country needs poverty reduction. For this attainment, the Government has already established strategy of "growth, employment, fairness and efficiency." The Third National Strategy Development Plan 2006-2010 (NSDP) presenting the strategic framework for the preparation of the policy, programs or development projects, states that poverty reduction and sustainable self-sufficiency of food are the major goals to be accomplished through agriculture and rural development. In order to achieve the goals, improvement of the agriculture productivity has been targeted. In irrigation and agriculture sector's development policy and programs, increase in agricultural productivity by construction and rehabilitation of irrigation facilities and enlargement of irrigated field area have been stressed. In irrigation and agriculture development plans in Cambodia, top priority has been put on the rehabilitation of existing irrigation facilities because of high economic efficiency.

3 Under such economic and social circumstances, JICA has carried out "the Study on Comprehensive Agricultural Development of Prek Thnot River Basin" and the Study has proposed "The Project for Improvement of Roleang Chrey Headworks" as a top priority urgent project.

4 The Project aims to maintain present agricultural productivity and farmers' income by stable irrigation water supply to the beneficial area of about 10,000 ha through improvement of the existing irrigation facilities. In accordance with the JICA Study results, the Royal Government of Cambodia (RGOC) requested grant aid assistance to the Government of Japan (GOJ) for the Project of Improvement of Roleang Chrey Headworks in July 2006.

5 GOJ made JICA dispatch a basic design study team for the Project to Cambodia from November 15, 2007 to December 17, 2007. JICA basic design study team discussed the requested items with the Ministry of Water Resources and Meteorology (MOWRAM) and examined the adequacy of the requested items. The adoption of a grand aid scheme requires

high degree of urgency and that the project effects must be realized soon after the construction. As a result, it was agreed upon between the JICA team and MOWRAM on November 21, 2007 that the improvement works marked with asterisk (*) are considered for the Japan's grant aid scheme.（See the attached minutes of June 12, 2008.）

Requested Items for the Project for Improvement of Roleang Chrey Headworks

(1) Rehabilitation of Roleang Chrey Regulator	
*	Rehabilitation of all gates and hoist systems
*	Rehabilitation of the downstream river bank protection
*	Construction of the downstream river bed protection
*	Construction of a river outlet structure at the right side of the regulator
	Construction of a operators hut
(2) Reconstruction of the Intakes with Gates	
	Rehabilitation of the north approach channel to Andong Sla intake
*	Reconstruction of Andong Sla intake with gates
	Rehabilitation of the south approach channel to the intake
	Reconstruction of Vat Krouch intake with gates
	Construction of a power transmission line from the regulator to intakes
(3) Engineering Supporting Services	
	Survey, design , preparation of tender documents and construction supervision
*	To prepare operation rules and an operation manual for the facilities
	To reinforce the organization for the operation and maintenance of the project facility

Preparation of operation manual, etc. will be conducted under a soft component plan.

6 JICA team conducted a survey and investigation about the present status of Roleang Chrey regulator and Andong Sla intake, natural conditions, construction price/equipment and local contractors, and operation and maintenance status of Roleang Chrey regulator and Andong Sla intake in order to identify the present problems and collect data and information necessary for the basic design.

7 In Japan, the JICA team has carried out the basic design based on the collected data and information, and prepared a draft basic design study report. JICA again dispatched a study team to Cambodia from June 9, 2008 to June 14, 2008 in order to explain the content of the draft report. As a result, it was agreed upon between JICA study team and MOWRAM on June 12, 2008 that the content of the draft report is acceptable. (See the attached minutes of June 12, 2008.)

2 Basic Design Policy

8 The Project purposes are as follows:

(1) To maintain present agricultural productivity and farmers' income by stable irrigation water supply to the beneficial area of about 10,000 ha through improvement of the existing irrigation facilities and to contribute to poverty reduction in rural area of Cambodia

(2) To supply irrigation water to Kandal Steung irrigation area of about 1,950 ha , which is located about 40 km downstream, through construction of the river outlet structure

(3) To mitigate inundation and flood damage in the upstream and downstream areas of the regulator through the rehabilitation of the regulator's gates

9 The Project aims to rehabilitate Roleang Chrey regulator including the existing gates, which can not be operated smoothly for irrigation and floods, in order to attain the Project purposes described above. The Japan's grant aid scheme will assist MOWRAM in implementing the Project through the rehabilitation of Roleang Chrey regulator and Andong Sla intake, and in strengthening O&M of the regulator and intake under a soft component plan including preparation of O&M manual of the gates and guidance of the gate operation. The following basic concepts for the design for improvement of the existing facilities have been determined based on the requested items for the grant aid assistance, field survey outputs and discussion results:

(1) The basic design policy for the improvement of the existing facilities

① The function of the existing facilities should be recovered to its original design level.

② The water cut-off period should not be implemented during the rainy season of May to November, while it should be implemented during the dry season of December to April and it should be kept to a minimum, since farmers' income comes mainly from irrigated rainy season paddy cultivation.

③ The main rehabilitation works of Roleang Chrey regulator in the Prek Thnot river for about 10,000 ha are as follows:

- To replace all the pins and bushing (40 sets) of the regulator's gate with new ones, since all the pins and bushings have firmly rusted and the gates can not be operated smoothly for irrigation and flood.
- To construct one river outlet structure for stable irrigation water supply to Kandal Steung irrigation area (about 1,950 ha) located at 40 km downstream of the regulator, since the regulator's gates can not regulate a discharge of 5 m^3/sec. (When such discharge is regulated with a gate, a gate opening is only 4 to 5 cm, and the gate produces mechanical noise and vibration, which should be avoided for safety of the

gates.)

④ The reconstruction works of Andong Sla intake on the left bank area for about 6,500 ha are as follows:

- To demolish all the four sets of the existing gates and install new two sets of radial gates in accordance with the design discharge (10.4 m^3/ses), since two out of the four sets of gates have already been useless and the remaining two sets of gates have caused a lot of leakage due to deterioration of four-edge seal. (Thus the intake can not regulate irrigation water discharge and can not prevent flood entrance to the north main canal.)

(2) The basic policy for the soft component plan

The soft component plan should be implemented to assist MOWRAM in strengthening O&M of the improved facilities. The soft component plan should include preparation of O&M guideline, irrigation water supply plan and gate operation manual, and guidance/training of gate operation. In addition, a gate operation network among Roleang Chrey regulator and other gated structures located in the downstream of the regulator should be formed in order to mitigate flood damage in the downstream area of the regulator with closely coordinated gate operations.

10 According to MOWRAM's explanation, since Initial Environmental Examination (IEE) was accomplished by the JICA study team on comprehensive agricultural development of Prek Thnot river basin and the IEE results have been approved by the Ministry of Environment, Environmental Impact Assessment (EIA) for the Project is no longer required in Cambodia. However, in order to mitigate the negative impacts to a possible extent for the successful implementation of the Project, the IEE results and the anticipated social impacts have been further reviewed and the possible measures against the impacts have been reflected in the basic design. The reviewed negative impacts are air pollution, increase of accident, water pollution, generation of waste, disturbance of fish and fishery, disturbance of wildlife that use river, deterioration of sanitation condition, increase of risk diseases, traffic disturbance, change of hydraulic situation, limitation of water usage for irrigation by the water cut-off, limitation of water usage for domestic use by the water cut-off, limitation of water usage for domestic use by operating regulator's gates for gate tests and gate operation training under soft component plan, and land acquisition.

3 Outline of the Project

11 The outline of the Project is shown in the following table:

SUMMARY

Improvement of Roleang Chrey Headwork

Subject		Scale of the Facilities
(1)	Rehabilitation of Roleang Chrey Regulator	
1.1	Rehabilitation of all gates and hoist system Gate type:Steel roller gate Clear span: 12.5m Gate hight: 6.7m Gate nos: 5 sets	Replacement of wheel bushings and pins : 40 sets (8sets/gate x 5 gates) Rust removal and re-painting of gate leaf : 5 sets of gates Replacement of rubber seals : 5 sets of gates Replacement of all hoist systems : 5 sets (electric wire-rope winch type with counter weight) Replacement of local control panels : 5 sets Installation of new remote control panels at O&M office : 1 set (including main distribution panels, distribution panels for room lighting, connection cables between control panels and hoist system) Installation of lightning arrestors: 3 sets Installation of staff gauge: 5 sets Core-drilling and recovery work on gate piers: 10 locations (Dia. 40 cm x L 50 cm)
1.2	Construction of the downstream river bed protection	Additional ground sill consolidation work : W 72.5 m x L 8 m x H 1.25 m Grouted riprap work : W 40 m x L 42 m x Thickness 0.5 m
1.3	Rehabilitation of the downstream river bank protection	Toe foundation work : W 2 m x H 2m x L 110 m (right bank), L 90 m (left bank) Riprap work : H 6 m x L 89 m (right bank), L 78 m (left bank)
1.4	Construction of river outlet structure	Inlet : W 4.6～2.6m x H 6.0～8.0 m x L 13.9 m Outlet : W 4.0 m x H 4.7～6.0 m x L 10.9 m Culvert : Double lane concrete pipes Dia. 1.0 m x L 83 m Manufacturing and Installation of new steel slide gates: 4 sets (total) (Clear span 1.0 m x H 1.0 m, 4 edge-rubber seal, manual operation hoist system with rack pinion/ screw spindle type. Discharge regulation gate: 2 sets, Maintenance gate: 2 sets)
(2)	Reconstruction of Andong Sla Intake	
2.1	Reconstruction of the intake	Curtain walls: W 4.0 m x H 2.5 m x 2 nos (w/ new gate sections) W 4.0 m x H 5.2 m x 2 nos.(gate-dismantled sections) Operation deck: W 2.0 m x Clear span 4.0 m x 4 nos. Upstream Transition work: W 18.6 ～43 m x H 5.2 m x L 5 m Downstream river bed protection work: W 18.6～33.8 m x Thickness 0.5 m
2.2	Replacement of gates Gate type:Steel radial gate Clear span: 4.0m Gate hight: 2.7m	Removal of existing steel radial gates : 4 sets Manufacturing and Installation of new steel radial gates: 2 sets (4 edge-rubber seal, swing type manual operation hoist system with rack pinion/ screw spindle)

W: Width, H: Height, L= Length, Dia. : Diameter

Outline of Soft Component Plan

Expert	Major Activity
O&M Expert (Japanese consultant: 4 M/M) who will prepare gate operation manual, etc. and provide seminar and technical guidance of gate operation to 10 O&M staff (including gate operators) in MOWRAM	1) Preparation of O&M guideline of the improved facilities 2) Preparation of irrigation water supply schedule 3) Preparation of gate operation manual for the regulator, river outlet structure and Andong Sla intake 4) Provision of seminars based on the above documents 5) Provision of Technical guidance /training of gate operation against flood with the use of the communication network between Roleang Chrey regulator and related gate structures in the downstream of the regulator

4 Implementation Plan

12 The Project will be implemented under the following stages, and a total implementation period from E/N about the detailed design is estimated at 34 months.

(1) Detailed Design Stage

① Detailed design : 3 months

② Preparation of tender documents : 1.83 months

(2) Construction Stage

① PQ and tender : 3 months

② Construction : 19 months

(3) Soft Component Plan : 4 months

13 MOWRAM will be responsible for the implementation of the Project and the implementing agency will be the National Project Management Office (NPMO) including the Project Management Unit (PMU) for North Western Area, which was established in October 2007. O&M of the facilities, namely the regulator and intake, which will be improved under the Project, will be conducted by the regulator and intake O&M office under the supervision of Kampong Speu PDOWRAM. For the main canals, O&M will be conducted by Kampong Speu PDOWRAM.

14 O&M cost of Kampong Speu PDOWRAM, and the regulator and intake O&M office are provided by MOWRAM. Annual O&M cost of the regulator and intake O&M office is estimated at about US$2,000 to US$ 3,000, which could be secured by MOWRAM since the value range is still within their financial capacity.

5 Evaluation of the Project and Recommendations

15 The direct effects of the Project are as follows:

(1) The present agricultural productivity of irrigated rainy season paddy of 2.3～2.4 tons/ha and gross farmers' income of US$ 450～US590 /household will be maintained due to a stable water supply to about 10,000 ha through the improvement of the regulator.

(2) The stable irrigation water supply with a discharge of about 5 m^3/sec will become possible to Kandal Steung irrigation area of about 1,950 ha (located at about 40 km downstream of the regulator) through the construction of the river outlet structure.

(3) Flood entrance to the north approach channel will be prevented, and adequate irrigation water regulation, based on an irrigation water supply schedule, will become possible through the reconstruction of Andong Sla intake.

(4) Flood damage in the downstream area of the regulator will be mitigated since communication network among the related gate facilities located in the downstream area will be formulated.

(5) The inundation risk to the upstream area of the regulator will be prevented since flood will more timely flow down owing to the smooth opening of the regulator's rehabilitated gates.

16 The indirect effects of the Project are to contribute to poverty alleviation in the rural area, and stable rice supply in Cambodia, by maintaining present agricultural productivity and farmers' income. In addition, the major irrigation facilities to be improved under the Project will become irrigation infrastructures, which will have possibility of increasing agricultural production of irrigated rainy season paddy and farmers' income through future improvement of water management and farming practice.

17 As stated above, the Project is expected to realize many effects, which will contribute to the implementation of RGOC's top policy. The contents and goals of the Project are in line with the guideline of Japan's grant aid scheme. Therefore, the implementation of the Project under Japan's grant aid scheme is highly recommended.

Contents

Preface
Letter of Transmittal
Summary
Contents
Location Map/Perspective
List of Tables and Figures
Abbreviations

Chapter 1 Background of the Project ····· 1-1
1-1 Background of the Project ····· 1-1
1-2 Environmental and Social Considerations ····· 1-3

Chapter 2 Contents of the Project ····· 2-1
2-1 Basic Concept of the Project ····· 2-1
2-1-1 Overall Goals and Project Purposes ····· 2-1
2-1-2 Outline of the Project ····· 2-1
2-2 Basic Design of the Requested Japanese Assistance ····· 2-3
2-2-1 Design Policy ····· 2-3
2-2-1-1 Basic Policy ····· 2-3
2-2-1-2 Natural Conditions ····· 2-4
2-2-1-3 Environmental and Social Conditions ····· 2-5
2-2-1-4 Construction Equipment and Materials ····· 2-9
2-2-1-5 Employment of Local Contractors ····· 2-10
2-2-1-6 Operation and Maintenance of the Implementing Agency ····· 2-10
2-2-1-7 Determination of Grades for Facilities and Materials ····· 2-10
2-2-1-8 Construction/ Procurement Method and Construction Schedule ····· 2-11
2-2-2 Basic Plan ····· 2-12
2-2-2-1 Outline of Japanese Assistance ····· 2-12
(1) Final Contents of Japanese Assistance ····· 2-12
(2) Complex Features and Technical Difficulties of Gate Rehabilitation Work of the Regulator ····· 2-12
(3) Temporary Diversion Plan for Gate Rehabilitation Work of the Regulator ····· 2-15
(4) Alternative Study on Gate Rehabilitation Work of the Regulator ····· 2-16
2-2-2-2 Rehabilitation Plan of Roleang Chrey Regulator ····· 2-19
(1) Rehabilitation of All Gates and Hoist System ····· 2-19
(2) Rehabilitation of Downstream River Bank Protection ····· 2-20
(3) Construction of Downstream River Bed Protection ····· 2-21
(4) Construction of River Outlet Structure ····· 2-22
(5) Miscellaneous Works ····· 2-24
2-2-2-3 Reconstruction Plan of Andong Sla Intake ····· 2-24
(1) Replacement of Gates ····· 2-24
(2) Reconstruction of the Intake ····· 2-25
2-2-3 Basic Design Drawings ····· 2-27
2-2-4 Implementation Plan ····· 2-57
2-2-4-1 Implementation Policy ····· 2-57
2-2-4-2 Implementation Conditions ····· 2-58
(1) Negative Environmental Impacts during Construction ····· 2-58
(2) Water Cut-Off ····· 2-58
(3) Scope of Works ····· 2-59

(4) Construction Supervision ····· 2-59
(5) Quality Control Plan ····· 2-60
(6) Procurement Plan ····· 2-61
(7) Soft Component Plan ····· 2-62
(8) Implementation Schedule ····· 2-63

2-3 Obligations of Recipient Country ····· 2-64
2-3-1 Items to Be Undertaken by Recipient Country ····· 2-64
2-3-2 Practicability of RGOC's Obligations ····· 2-65
(1) Official Procedures Required for the Project Implementation ····· 2-65
(2) Land Acquisition ····· 2-65
(3) Water Cut-Off and Compensation/Measures due to Water Cut-Off ····· 2-65
(4) Permission for Operating Regulator's Gates ····· 2-65
(5) O & M of the Improved Facilities ····· 2-66

2-4 Project Operation Plan ····· 2-66

2-5 Project Cost Estimation ····· 2-67
2-5-1 Initial Cost Estimation ····· 2-67
(1) Land Acquisition ····· 2-68
(2) Water Cut-off Compensation ····· 2-68
(3) Banking Cost ····· 2-69
(4) Customs Clearance Cost ····· 2-69
2-5-2 Operation and Maintenance Cost ····· 2-69
(1) Annual O & M Cost of the Regulator and Intakes O & M Office ····· 2-69
(2) Financial Practicability of the Project ····· 2-70
2-6 Other Relevant Issues ····· 2-70

Chapter 3 Project Evaluation and Recommendations ····· 3-1

3-1 Project Effect ····· 3-1
3-1-1 Direct Effect ····· 3-1
3-1-2 Other Effect ····· 3-1

3-2 Conclusions ····· 3-1

3-3 Recommendations ····· 3-2
3-3-1 Issues to Be Resolved by MOWRAM ····· 3-2
3-3-2 Collaboration with Technical Cooperation and Other Donors ····· 3-2

List of Attached Tables

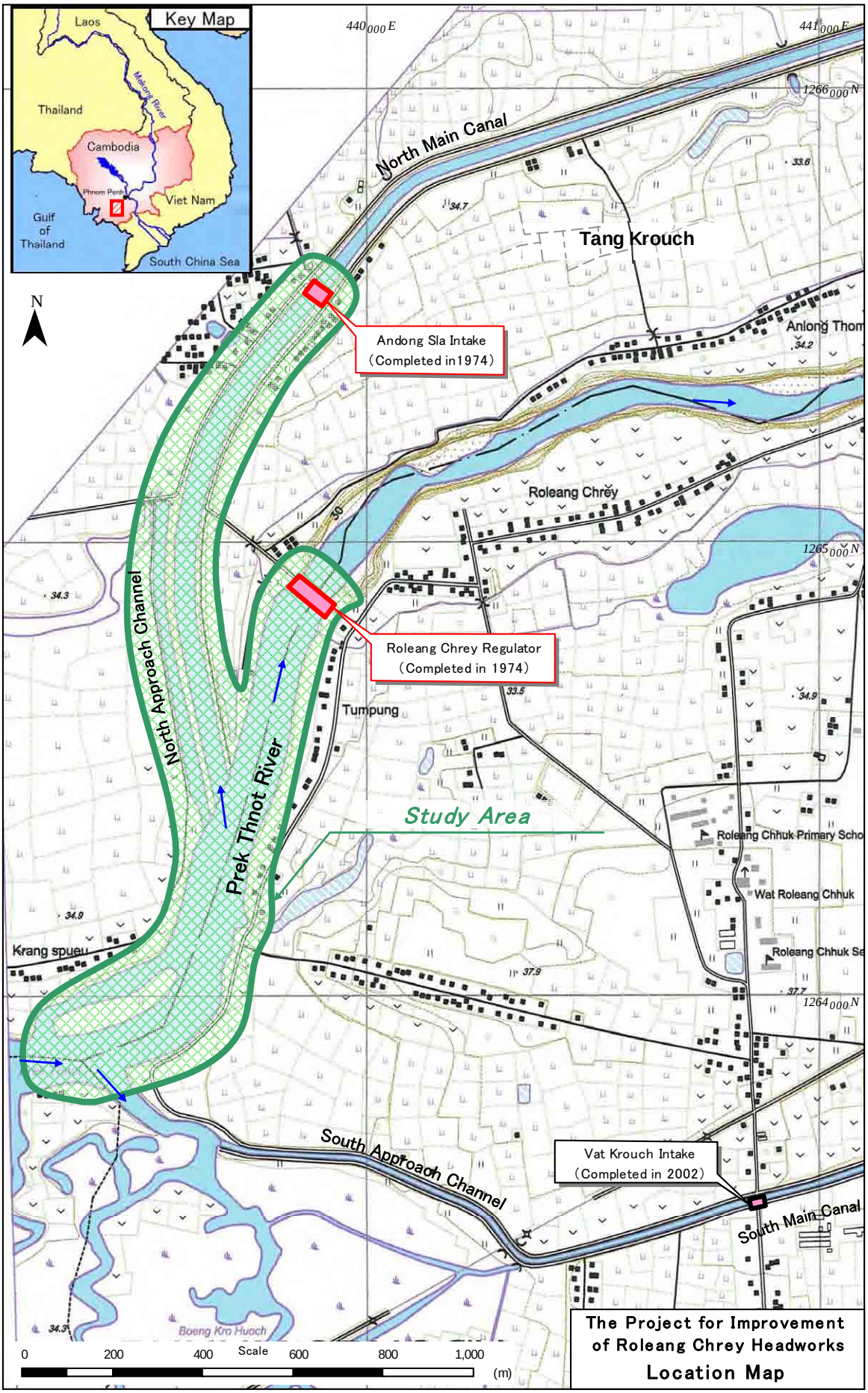
Table 2.2.1 Monthly Average Runoff of the Prek Thnot River at Peam Khley ····· T-1
Table 2.2.2 Environment Related Laws and Regulations ····· T-2
Table 2.2.3 Work Sequence of the Regulator's Gates ····· T-4
Table 2.2.4 Transportation Required for Gate Rehabilitation ····· T-5
Table 2.2.5 Comparison of Temporary Diversion Plan ····· T-6
Table 2.2.6 Alternative Study on the Gate Rehabilitation Work of the Regulator ····· T-7

List of Attached Figures

Figure2.2.1 Hydrograph ····· F-1
Figure2.2.2 Detail of Wheel ····· F-2
Figure2.2.3 Standard Work Flow of Gate Rehabilitation ····· F-3
Figure2.2.4 Typical Cross Sections of Temporary Coffer Dam and Access road ····· F-4
Figure2.2.5 Steel Stoplog ····· F-5
Figure2.2.6 Alternative Plan 1 ····· F-6
Figure2.2.7 Alternative Plan 2 ····· F-7
Figure2.2.8 Alternative Plan 3-1 ····· F-8
Figure2.2.9 Alternative Plan 3-2 ····· F-9
Figure2.2.10 Alternative Plan 3-3 ····· F-10
Figure2.2.11 Downstream Area of the Regulator ····· F-11

Appendices

Appendix-1 Member List of the Study Team ····· A1-1
Appendix-2 Study Schedule ····· A2-1
Appendix-3 List of Parties Concerned in Cambodia ····· A3-1
Appendix-4 Minutes of Discussions ····· A4-1
4-1 At Basic Design Study ····· A4-2
4-2 At Explanation on Draft B/D Report ····· A4-2
Appendix-5 Soft Component Plan ····· A5-1
Appendix-6 Other Relevant Data ····· A6-1
6-1 Basic Design Conditions ····· A6-2
6-2 Basic Design of Roleang Chrey Regulator ····· A6-4
6-3 Basic Design of Andong Sla Intake ····· A6-16
6-4 Water Level Observation Record and Gates Operation Record ····· A6-29
6-5 Hydraulic Calculation Results ····· A6-47
6-6 Basic Design of Temporary Coffer Dam ····· A6-52
6-7 Basic Design of Gate and Mechanical Works ····· A6-56


Key Map
Laos
Thailand
Cambodia
Mekong River
Phnom Penh
Viet Nam
Gulf of Thailand
South China Sea
N
440 000 E
441 000 E
1266 000 N
1265 000 N
1264 000 N
North Main Canal
Tang Krouch
Andong Sla Intake
(Completed in1974)
Anlong Thom
Roleang Chrey
Roleang Chrey Regulator
(Completed in 1974)
North Approach Channel
Prek Thnot River
Tumpung
Study Area
Roleang Chhuk Primary Scho
Wat Roleang Chhuk
Roleang Chhuk Se
Krang spueu
South Approach Channel
Vat Krouch Intake
(Completed in 2002)
South Main Canal
Boeng Kra Huoch
0
200
400
Scale
600
800
1,000
(m)
The Project for Improvement of Roleang Chrey Headworks
Location Map

Andong Sla Intake

Roleang Chrey Regulator

PERSPECTIVE

List of Tables and Figures

List of Figure

Figure 1-1	General Layout of Present Irrigated Area by the Regulator	1-2
Figure 2-1	Implementation Schedule	2-63

List of Table

Table 1-1	Contents of the Request Items	1-3
Table 2-1	Final Contents of Japanese Assistance	2-2
Table 2-2	Monthly Average River Discharge	2-4
Table 2-3	Monthly Average Rainfall and the Number of Rainy Days	2-5
Table 2-4	Environmental and Social Considerations	2-5
Table 2-5	Comparison of 5 Alternative Plans	2-17
Table 2-6	List of Basic Design Drawings	2-27
Table 2-7	Test Items	2-61
Table 2-8	In-Land Transportation Route and Distance	2-62
Table 2-9	Cost to Be Borne by the Cambodian Side	2-67
Table 2-10	Annual O&M Cost of Regulator and Intakes O&M Office	2-69

Abbreviations

EIA	Environmental Impact Assessment
E/N	Exchange of Notes
FWUC	Farmer Water User Community
GDP	Gross Domestic Product
GOJ	Government of Japan
H.E	His Excellency
HYV	High Yielding Variety
IAIMP	Irrigated Agriculture Improvement Model Project
IEE	Initial Environmental Examination
IRC	Inter-ministerial Resettlement Committee
ISF	Irrigation Service Fee
ISO	International Organization for Standardization
JICA	Japan International Cooperation Agency
JIS	Japanese Industrial Standard
Kg Speu	Kampong Speu
KOICA	Korea International Cooperation Agency
LNMC	Lower North Main Canal Irrigated Agriculture Improvement Project
LSMC	Lower South Main Canal Irrigated Agriculture Improvement Project
MAFF	Ministry of Agriculture, Forestry and Fisheries
MOE	Ministry of Environment
MOWRAM	Ministry of Water Resources and Meteorology
M/P	Master Plan
NGO	Non Government Organization
NMC	North Main Canal
NPMO	National Project Management Office
NPRS	National Poverty Reduction Strategy
O & M	Operation and Maintenance
Ou Krang Ambel	Ou Krang Ambel Irrigated Agriculture Improvement Project
PDOWRAM	Provincial Department of Water Resources and Meteorology, MOWRAM
PMU	Project Management Unit
RGOC	Royal Government of Cambodia
PQ	Prequalification
SDP-WS	Strategic Development Plan for the Water Sector
SMC	South Main Canal
TSC	Technical Service Center
UNMC	Upper North Main Canal Irrigated Agriculture Improvement Project
USMC	Upper South Main Canal Irrigated Agriculture Improvement Project
WPPIDCP	Western Phnom Penh Integrated Development Center Project

Units

Area
cm^2 = Square-centimeters (1.0 cm x 1.0 cm)
m^2 = Square-meters (1.0 m x 1.0 m)
km^2 = Square-kilometers (1.0 km x 1.0 km)
ha = Hectares (10,000 m^2)

Length
mm = Millimeters
cm = Centimeters (cm = 10 mm)
m = Meters (m = 100 cm)
km = Kilometers (km = 1,000 m)

Electricity & Energy
A = Ampere
V = Volt
W = Watt
kWh = Kilowatt hour
GWh = Gigawatt hour
kVA = Kilovolt Ampere
HP = Horse power

Stress
N/mm^2 = Newton per square millimeter
Kg/cm^2 = Kilogram per square centimeter

Volume
cm^3 = Cubic-centimeters
(1.0cm x 1.0cm x 1.0cm)
m^3 = Cubic-meters
(1.0 m x 1.0 m x 1.0 m)
l lit = Liter (1,000 cm^3)
MCM = Million cubic meter

Weight
gr = Grams
kg = Kilograms (1,000 gr.)
ton = Metric ton (1,000 kg)

Time
sec = Seconds
min = Minutes (60 sec.)
hr = Hours (60 min.)

Others
ppm = parts per million
^{o}C = degree centigrade
% = percent

Currency
US$ = United State Dollars
¥, Y, Yen = Japanese Yen
R, Riel = Cambodian Riel

Exchange Rate
As of December 2007
US$ 1.00 = Yen 118.27

Chapter 1 Background of the Project

Chapter 1 Background of the Project

1-1 Background of the Project

(1) Background of the Project

The agriculture sector in the Kingdom of Cambodia employs 71% of the working population and contributes to 34% of the GDP. The GDP per capita has been increasing but it is as low as US$ 448. Agriculture in Cambodia depends on rainfall, and agricultural production is largely influenced by weather conditions. The agricultural productivity is still at a low level and unstable. The main crop in Cambodia is paddy rice. The cultivation area is 2.37 million ha and the irrigated area is 25 %. The Cambodian government has a policy that steady growth of the country needs poverty reduction. In order to attain this, the Government has already established a strategy of "growth, employment, fairness and efficiency." The Third National Strategy Development Plan 2006-2010 (NSDP) presenting the strategic framework for the preparation of the policy, programs or development projects, states that poverty reduction and sustainable self-sufficiency of food are the major goals to be accomplished through irrigation and agriculture development. In order to achieve the goals, improvement of agriculture productivity has been targeted and the target figures have been indicated, such as agricultural land of 3.5 million ha, irrigated field area of 0.65 million ha, paddy field area of 2.5 million ha and paddy rice yield of 2.4 ton/ha. In the irrigation and agriculture sector's development policy and programs, the resulting increase in agricultural productivity through the construction and rehabilitation of irrigation facilities and expansion of irrigated field areas have been stressed. In irrigation and agriculture development plans in Cambodia, top priority has been put on the rehabilitation of existing irrigation facilities because of high economic efficiency.

Under such economic and social circumstances, JICA has carried out "the Study on Comprehensive Agricultural Development of Prek Thnot River Basin" and the Study has proposed "The Project for Improvement of Roleang Chrey Headworks" as a top priority urgent project. The irrigation area covered by the regulator has a total of about 10,000 ha in total. According to the Study results, the north main canal covers UNMC, Ou Krang Ambel, and LNMC areas, while the south main canal covers IAIMP and USMC areas. These areas are irrigated by Roleang Chrey regulator. A general layout of present irrigated areas by the regulator is shown below, and the areas shown in dotted lines in the layout are being implemented by the Ministry of Water Resources and Meteorology (MOWRAM).

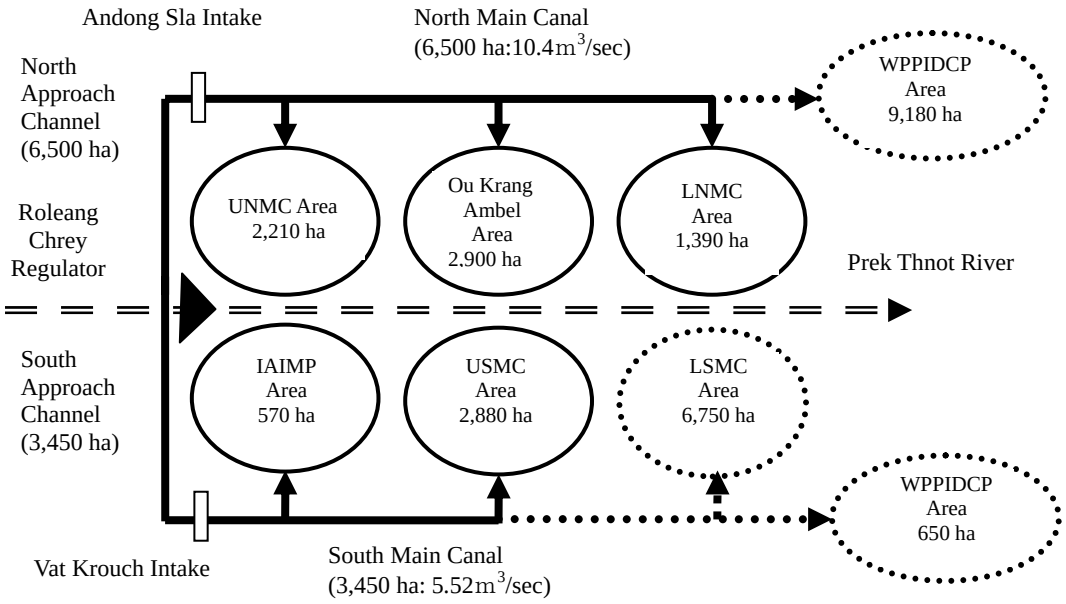


Figure 1-1 General Layout of Present Irrigated Area by the Regulator

The main problems/issues of the proposed Project are as follows:

① Roleang Chrey regulator with five sets of fixed wheel gates was constructed in 1974. The gates need rehabilitation because 33 years have passed since 1974, and the fixed wheels of the gates have not been functioning.

② As the regulator lies on a tuff layer of the river bed, the river bed protection has not been provided for the downstream of the regulator. However, the river bed has been partially scoured.

③ The river bank protection at the downstream area of the regulator is not adequate in terms of length and shape against rapid river flow when the gates are opened.

④ The existing paddy field areas irrigated by the regulator and intakes, 6,500 ha through the north main canal and about 3,500 ha through the south main canal, are facing the risk of being changed into rainfed paddy fields.

⑤ The regulator can not regulate a discharge of 1 m^3/sec to 5 m^3/sec to release it to Kandal Steung Irrigation Area (completed in August 2007), which is located about 40 km downstream of the regulator, since the gate's opening of 4 cm to 5 cm can not be operated. In addition, such gate operation causes mechanical noise and vibration to the gate. One river outlet structure has been required for stable irrigation water supply to Kandal Steung Irrigation Area.

⑥ The Andong Sla Intake with four sets of radial gates was constructed in 1974 when the regulator was constructed. Two out of the four sets of the gates are not functioning, since

the two do not have hoist systems and have been kept closed. The remaining two sets are functioning but much leakage has been caused by the deteriorated rubber seals of the gates, which cause trouble to discharge regulation. In addition, there is danger that flood might enter into the north main canal through the intake gates.

(2) Contents of the Request

In accordance with the JICA Study results, the Royal Government of Cambodia (RGOC) requested grant aid assistance from the Government of Japan for the Project of Improvement of Roleang Chrey Headworks in July 2006. The requested items are as follows:

Table 1-1 Contents of the Requested Items

(1) Rehabilitation of Roleang Chrey Regulator	
	Rehabilitation of all gates and hoist systems
	Improvement of the downstream apron and river side slope protection
	Construction of a river outlet structure at the right side of the regulator
	Construction of an operators hut
(2) Reconstruction of the Intakes with Gates	
	Rehabilitation of the north approach channel to Andong Sla intake
	Reconstruction of Andong Sla intake with gates
	Rehabilitation of the south approach channel to the intake
	Reconstruction of Vat Krouch intake with gates
	Construction of a power transmission line from the regulator to intakes
(3) Engineering Supporting Services	
	Survey, design , preparation of tender documents and construction supervision
	To prepare operation rules and an operation manual for the facilities
	To reinforce the organization for the operation and maintenance of the project facility

1-2 Environmental and Social Considerations

According to MOWRAM's explanation, an Initial Environmental Examination (IEE) was accomplished by the JICA study team on comprehensive agricultural development of Prek Thnot river basin and the results have been approved by the Ministry of Environment, RGOC. Thus, Environmental Impact Assessment (EIA) for the Project is no longer required by RGOC. This explanation is stated in the minutes of discussion of November 21, 2007. However, the JICA study team carried out the IEE in 2005-2006 and the team has presented the following potential negative impacts in Volume III Appendices of its Interim Report (1), though their conclusions are that ① significant negative impacts are not expected with proper management, and that ② mitigation measure proposed will minimize negative impacts much further:

- Air pollution
- Increase of accident
- Water pollution
- Generation of waste (construction and domestic)

- Disturbance of fish and fishery
- Disturbance of wildlife that use river
- Limitation of water usage for domestic use
- Deterioration of sanitation condition, increase of risk diseases
- Change of hydraulic situation

Therefore, the JICA basic design study team has been required to review the IEE results and propose proper measures against the negative impacts. In addition to the IEE results, the following social considerations have also been required to be reflected in the basic design for the successful implementation of the Project:

① Since farmers' income come mainly from irrigated rainy season paddy cultivation, a water cut-off which will be required for the rehabilitation of Roleang Chrey regulator, should not be implemented during the rainy season of May to November. If crop damages are caused by the water cut-off, MOWRAM will have to compensate the farmers for these crop damages.

② The operation bridges of Roleang Chrey regulator and Andong Sla intake are utilized as important crossing structures above the river and the canal. The O&M road of the north approach channel and the north main canal are utilized as main road. Traffic control on the bridges and the road should be minimized.

③ Land acquisition will be required for the rehabilitation of the existing irrigation facilities. Involuntary resettlement should be avoided as much as possible.

Chapter 2 Contents of the Project

Chapter 2 Contents of the Project

2-1 Basic Concept of the Project

2-1-1 Overall Goals and Project Purposes

(1) Overall Goals

The Royal Government of Cambodia (RGOC) has placed top priority on irrigation and agriculture development for poverty alleviation, economic growth and stable supply of rice. In particular, rehabilitation of existing irrigation facilities has been prioritized due to its high economic viability. The requested Project meets the intention of the top policy, and will contribute to the implementation of the RGOC's top policy. The overall goals of the Project are as follows:

① To contribute to poverty alleviation in the rural area

② To contribute to stable supply of rice in Cambodia

(2) Project Purposes

The Project purposes are as follows:

① To maintain present agricultural productivity and farmers' income by stable irrigation water supply to a beneficial area of about 10,000 ha through the improvement of the existing irrigation facilities

② To supply irrigation water to Kandal Steung irrigation area of about 1,950 ha (located at about 40 km downstream) through the construction of the river outlet structure

③ To mitigate inundation and flood damages in both the upstream and downstream areas of the regulator through the rehabilitation of its gates

2-1-2 Outline of the Project

In line with the guideline of Japan's grant aid scheme, the expected goals and Project purposes, the requested items by RGOC have been evaluated and the final contents of Japanese assistance have been concluded as shown in Table 2-1. The final contents have been agreed upon between JICA basic design study team and MOWRAM on November 21, 2007. In order to strengthen operation and maintenance (O&M) capability of MOWRAM for the facilities to be rehabilitated, the soft component plan has been added to the final contents, which will include preparation of O&M guideline and gate operation manual, and rendering guidance on gate operation.

Table 2-1 Final Contents of Japanese Assistance

Requested Items		Final Contents	Evaluation Results/Reasons for the Exclusion from the Japanese Assistance
(1)	Rehabilitation of Roleang Chrey Regulator		
1.1	Rehabilitation of all gates and hoist systems	○	
1.2	Improvement of the downstream river bank protection (river side slope protection)	○	
1.3	Rehabilitation of the downstream river bed protection (river apron protection)	○	
1.4	Construction of a river outlet structure at the right side of the regulator	○	
1.5	Construction of an operator's hut		The existing operator's hut still function and there is enough space for a new control panel.
(2)	Reconstruction of the Intakes with Gates		
2.1	Rehabilitation of the north approach channel to Andong Sla intake		The north approach channel has enough flow capacity and necessity of urgent rehabilitation is not observed.
2.2	Reconstruction of Andong Sla intake with gates	○	
2.3	Rehabilitation of the south approach channel to Vat Krouch intake with gates		The south approach channel has enough flow capacity to serve the present irrigation area. Even though it is rehabilitated, its benefit will not be appreciated since there are no secondary and tertiary canals in the downstream area.
2.4	Reconstruction of Vat Krouch intake with gates		
2.5	Construction of a power transmission line from the regulator to intakes		The power transmission line constructed in 1974 has been destroyed, and no rehabilitation has been carried out for more than 30 years. Under these conditions, a new power transmission line and remote control panel can not be provided. At present, a gate operator operates gates manually without any serious problems. Necessity of urgent rehabilitation has been not observed.
(3)	Engineering Supporting Services		
3.1	To prepare operation rules and operation manual for the facilities	○	

○ : included in the final contents of Japanese assistance.

2-2 Basic Design of the Requested Japanese Assistance

2-2-1 Design Policy

2-2-1-1 Basic Policy

The following are the basic policies on the design for improvement of the existing facilities to achieve the overall goals and Project purposes:

(1) The function of the existing facilities should be recovered to its original design level, implementing the regulator's gates as the top priority.

(2) In due consideration of i) the importance of the regulator's function and ii) the safety of the regulator and its operator, a new control panel for the gates should be installed inside the existing O&M office, and lightning arresters should be installed on the regulator.

(3) The design for improvement of the existing facilities should be carried out with due consideration to facilitating O&M. Based on the fact that lubricant was never before provided to the wheels of the regulator's gates, the existing bushings of the wheels should be replaced with new ones that are maintenance-free.

(4) Materials available in Cambodia should be utilized as much as possible within technically possible extent except for the mechanical and electrical parts/products related to the gate rehabilitation of the regulator. Neither materials nor products including asbestos should be used.

(5) The water cut-off period should be implemented during the dry season of December to April and the period should be the shortest.

(6) For the reconstruction of Andong Sla intake, a temporary diversion channel and temporary coffer dams should be provided for the intake in order to maintain the irrigation water supply to the north main canal, and the water cut-off period for construction of the temporary diversion channel should be the shortest.

(7) All the rehabilitation and construction works should not be carried out in the Prek Thnot river during flood season of July to October to ensure safety of the workers.

(8) During the gate rehabilitation of the regulator and the reconstruction of the intake, traffic control on the operation bridges of the regulator and the intake should be minimized in order not to disrupt public traffic.

(9) The obligations to be taken up by a general contractor on environmental protection should be stipulated in the contract documents (technical specifications), such as sprinkling water on roads, no night works, traffic controller's assignment, water quality tests, etc.

(10) Under the soft component plan, O&M assistance for the improved facilities should be carried out, such as preparation of O&M guideline, irrigation water supply plan and

gate operation manual, and rendering guidance of gate operations. In addition, a communication network among Roleang Chrey regulator and other gated structures located in the downstream of the regulator should be formed in order to mitigate flood damage in the downstream area of the regulator with closely coordinated gate operations.

2-2-1-2 Natural Conditions

(1) Design Flood Discharge of the Prek Thnot River

The Roleang Chrey regulator is located at about 100 km upstream of the Prek Thnot river from its confluence with the Bassac river. The catchment area of the Prek Thnot river is 3,911 km^2 at the regulator, and 5,740 km^2 at the confluence, respectively. According to the results of JICA study on the comprehensive agricultural development of Prek Thnot river basin, monthly average run-off at Peam Khley is shown in Table 2.2.1 and summarized in the following table:

Table 2-2 Monthly Average River Discharge (Unit : m^3/s)

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Average	11.3	5.0	5.7	11.6	36.1	48.2	116.6	155.7	238.2	408.1	158.6	35.0
Max	63.5	34.1	53.3	54.7	345.6	221.6	354.5	373.9	505.8	851.0	614.7	391.5
Min	2.4	0.4	0.4	1.5	3.7	3.0	5.3	12.7	69.8	45.6	12.0	2.4

Note : 80 years from 1901to 2005 (data of 1922, 1973~1996 are not available)
Source : Interim Report(1) Vol.-III, Appendix A、May 2006

The non-uniform hydraulic calculation of floods based on the results of longitudinal survey obtained through the JICA study team shows that the discharge carrying capacity of the Prek Thnot river at the regulator is 1,600 m^3/s, which is a design flood discharge of the regulator. According to the hydrographs of floods shown in Figure 2.2.1, a 2-year probable flood in the river rises within 60 hours, but a 5-year (or more) probable flood rises within a shorter time, say 12 hours. Floods become normal river flow after 120 hours. The rehabilitation works of the regulator will have to be carried out during the dry season in order to avoid flood damage.

(2) Rainfall

There are two seasons in and around the Project area, namely the rainy season from May to November and the dry season from December to April. The averaged annual rainfall is 976 mm with its 87 % occurring during the rainy season. The rainfall data observed at Kampong Speu PDOWRAM are used for the design and construction plan, and are summarized in the following table:

Table 2-3 Monthly Average Rainfall and the Number of Rainy Days Observed at Kampong Speu PDOWRAM

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
Rainfall (mm)	4	4	36	66	104	109	144	123	180	162	31	13	976
Number of Rainy Days	2	1	4	5	6	8	10	11	14	12	6	1	80

Source：Kampong Speu PDOWRAM（2001～2005）

(3) Design Discharge

The design discharge for canals and related structures is estimated using the following equation, which has been used in the JICA study on comprehensive agricultural development of Prek Thnot river basin:

Q= irrigation area x 0.0016

where, Q: design discharge (m^3/sec)

A: irrigation area (ha)

(4) Seismic Coefficient

Since the seismic coefficient to be used for the basic design is not standard in Cambodia, a minimum seismic coefficient of Kh=0.1 is applied to the design in accordance with the Japanese design criteria.

2-2-1-3 Environmental and Social Conditions

According to MOWRAM's explanation, since Initial Environmental Examination (IEE) was accomplished by the JICA study team on comprehensive agricultural development of Prek Thnot river basin and the IEE results have been approved by the Ministry of Environment, Environmental Impact Assessment (EIA) for the Project is no longer required in Cambodia. However, in order to mitigate the potential negative impacts to a possible extent for the successful implementation of the Project, the IEE results and the anticipated social negative impacts have been further reviewed and the possible measures against the impacts have been reflected in the basic design. The measures proposed under the basic design are described in Table 2-4, and environment related laws and regulations in Cambodia are listed in Table 2.2.2 :

Table 2-4 Environmental and Social Considerations

Potential Impacts	Proposed Mitigation Measures	Agency/Organization for Action
Land acquisition	The land required for the construction works is only intended for temporary facilities. Therefore, the land will be rented from land owners during the construction. The land will be returned to the land owners	MOWRAM, IRC

	upon completion of the construction works. MOWRAM will acquire the land in accordance with the conclusions by the Inter-ministerial Resettlement Committee (IRC). MOWRAM is expected to start making arrangements for IRC at the detailed design stage, since the required land will be finalized and demarcated at site. The necessities for land acquisition and the total land area are explained in "2.5.1 Initial Cost Estimation (1) Land Acquisition".	
Limitation of water usage for irrigation due to water cut-off	Since farmers' income comes mainly from irrigated rainy season paddy cultivation, the water cut-off period necessary for the rehabilitation of the regulator's gates should not be implemented during the rainy season of May to November. The water cut-off period should be implemented during the dry season of December to April and it should be kept to a minimum. For the irrigated rainy season paddy cultivation (about 10,000 ha), no limitation of water usage is anticipated. For the irrigated dry season paddy cultivation (about 400 ha to 500 ha), the water usage will not be limited since the water cut-off period is 20 days in total (10 days from December 01 to December 10, 2010 and 10 days from April 21 to April 30, 2011) and the cultivation period could be adjusted to avoid the limitation. In order to continue irrigation water supply to the downstream of the intake, a temporary diversion channel will be constructed even during the reconstruction of the intake in the dry season.	MOWRAM
Limitation of water usage for domestic due to water cut-off	Since there are many residents who depend on water in the canals for domestic use, the negative impact to the residents will occur if the measures for the residents will not be taken by MOWRAM during the water cut-off period. To minimize the negative impact, the JICA basic design study team strongly recommended that MOWRAM take necessary measures against the water cut-off, such as deployment of water supply trucks and construction of temporary coffer dams in the canals. MOWRAM has replied that they will take such actions, in accordance with the conclusions of the IRC. MOWRAM is expected to make arrangements for IRC and secure the conclusions at the detailed design stage.	MOWRAM, IRC
Limitation of water usage for domestic	Apart from the water cut-off as stated above, opening and closing of the regulator's gate in the river will be required for the following purposes: - Gate tests after the installation: consecutive 3 days in May, 2008,	Consultant, Contractor, MOWRAM

use by operating regulator's gates for gate tests and gate operation training	between 8:00 to 16:00 each day - Gate operation guidance under a soft component plan : intermittent 3 days in July and August, 2008 The negative impacts due to the operating regulator's gates is that water level and discharge of canals will be temporarily lowered and decreased, respectively. However, the water usage for domestic use will not be limited, since the decreased canal discharge will be still enough for that use. The water usage for irrigation will be limited, but the limitation due to the operating regulator's gates will be much less than that due to the water cut-off, since the limitation due to the operating regulator's gates is totally different from that due to the water cut-off. Moreover, since the river discharge during the rainy season is much larger than that during the dry season, water level of canals during the rainy season will be recovered to a design water level much faster than that during the dry season.	
Disturbance of fish and fishery	Fish in rivers/canals generally spawn in the rainy season. Disturbance of fish and fishery in the rainy season will be mitigated to a minimum by prohibiting construction works during the rainy season of May to November. On the contrary, fish and fishery in the dry season will be limited, but the limitation will also be minimal. Fish will be able to move between the river and the canal, and fishery could be carried out owing to the temporary diversion works that 1) the north approach channel will be used as temporary diversion channel and 2) another temporary diversion channel will be constructed for the reconstruction of the intake to continue irrigation water supply to the downstream of the intake.	Contractor
Disturbance of wildlife that use river	The river channel between the regulator and two temporary coffer dams in the river will be dried up in the dry season of December to April due to temporary diversion works. However, the disturbance of wildlife is very limited, since the downstream river condition of the downstream temporary coffer dam will remain the same as that during the ordinary dry season. Birds generally dislike high decibel noise which will be produced by driving steel sheet piles or concrete piles. Since such pile-driving works are not included in the construction works, the disturbance of wildlife, such as birds' mating and reproduction is limited.	Contractor

Traffic disturbance during construction	The regulator and the intake are accompanied with operation bridges, which are utilized by the residents as important crossing structures above the river and the canal, respectively. Traffic control on the operation bridges during the construction period will be minimized to avoid disturbance of the local traffic in accordance with cycles of their living. In addition, since the O&M road along the north approach channel and the north main canal is utilized as main road in the area, when the road is temporarily destructed for the reconstruction of the intake, a temporary detour road will be constructed by the contractor to avoid disturbance of their traffic.	Contractor
Increase of accidents	The contractor will assign traffic controller(s) for safety operation of construction equipment. Traffic controller(s) will also be assigned for traffic regulation to avoid traffic accidents at the entrance/ exit of construction sites as well as detour routes. In addition to the above, the contractor will have to hold a regular meeting on safety and sanitary to direct their workers' attention to safety and sanitary.	Contractor
Water pollution of river and canal	The contractor will be prohibited from direct disposing of removed rust and gate leaves, remaining materials of earth works and concrete wastes into rivers and canals. To prevent scattering of removed rust into the river, the contractor will be instructed to use catching nets. In addition to the above, the contractors will have to verify non-contamination of the water even after concerned construction work, by testing water quality in the river and canals before and after the major concrete works and construction/ removal of temporary cofferdams in the river.	Contractor
Air pollution	In order to minimize the impact to air pollution, the contractor will have to minimize scattering of soil dust by utilizing vinyl sheet for dump trucks, as well as sprinkling water over construction site and temporary roads for construction. In order to reduce the emission of CO_2, the contractor and their operators will be instructed to minimize idling of construction equipment/vehicles.	Contractor
Noise and vibration	In order to minimize the impact of noise and vibration, the contractor will have to use construction methods and equipment with less noise and vibration impact to surrounding villages. The contractor will also be prohibited to work on site at night, especially with the work accompanying noise and vibration.	Contractor
Generation	The contractor will be prohibited from disposing construction wastes,	Contractor

of waste (construction and domestic)	such as removed rust of gate leaves, old gate leaves and hoist, demolished soil material and concrete, etc., to river or canal. The contractor will be instructed to dispose such construction wastes to safe space that is approved by MOWRAM/ consultant. Embankment material used for temporary cofferdams will also be disposed to safe space approved by MOWRAM/consultant. If there are local contractors who need it, it will be given to them.	
Deterioration of sanitation condition, increase of risk of diseases	In order to avoid the pollution of surrounding villages, the contractor will have to i) check and manage health condition of their labors, ii) establish health clinic at construction management office, iii) install sanitary facilities, such as toilet, water supply system, etc. Moreover, waste water will have to be purified to water quality that meets water quality standard for health. Also, the contractor will have to hold meeting on safety and sanitary regularly.	Contractor
Change of hydraulic situation	Hydraulic situation of the Prek Thnot River, such as flood condition, will scarcely be affected by the rehabilitation of Roleang Chrey Regulator.	MOWRAM

* The following water quality tests will be carried out by the contractor since they will be stipulated in the contract documents:

- Test items: pH, transparency (turbidity), water temperature, odor, appearance
- Sampling sites: at upstream and downstream of the regulator and the intake (four sites in total)
- Frequency of tests: one time per month during seven months of November 2010 to May 2011

2-2-1-4 Construction Equipment and Materials

The following conditions for the construction equipment and materials have been considered in the basic design:

(1) Construction materials, such as cement, reinforcement bars, forms, concrete pipes, polyvinyl chloride (PVC) pipes which are available in Cambodia, should be used as much as possible after examination of their qualities.

(2) The major materials, such as embankment materials, aggregates for concrete, and ripraps which are available near the site, should be used as much as possible, subject to technical allowable extent.

(3) Construction machinery and equipment by Japanese manufacturers, which are available in Cambodia, should be procured through lease based contract, except for special machine and equipment.

2-2-1-5 Employment of Local Contractors

The following conditions for employment of local contractors have been considered in the basic design:

(1) Local contractors available in Cambodia should be employed as many as possible, if they are determined as qualified in terms of construction capability and financial capacity.

(2) Laborers are generally available in Cambodia. Employed skilled laborers and operators should be sourced from Phnom Penh, while employed common laborers should be sourced within the vicinity of the site.

(3) In accordance with the labor laws of Cambodia, laborers should be provided with overtime allowance, and rest days during Sundays/national holidays.

2-2-1-6 Operation and Maintenance of the Implementation Agency

The following conditions for operation and maintenance (O&M) of the implementation agency have been considered in the basic design:

(1) Roleang Chrey regulator and intakes have been operated and maintained by the regulator and intakes O&M office located at the right bank of Roleang Chrey regulator, under the supervision of Kampong Speu PDOWRAM's director. During improvement works and upon its completion, O&M of the regulator and intakes including existing generators (75 kVA & 23.9 kVA) will remain the responsibility of the same O&M office.

(2) The O&M of the main canals will be carried out by Kampong Speu PDOWRAM, while that of the other irrigation facilities, such as the secondary and tertiary canals and on-farm facilities, will be carried out by FWUCs under the supervision of Kampong Speu PDOWRAM

2-2-1-7 Determination of Grades for Facilities and Materials

The following conditions have been considered in setting a grade for the facilities and materials in the basic design:

(1) The basic policy for the design is that the function of the existing facilities should be recovered to its original design level. Therefore, the specifications of the facilities and materials should be, in principle, the same as that of the original ones.

(2) In order to avoid the replacement of bushings and pins of wheels (40 sets) in the future, which has complex features and technical difficulties, a maintenance-free bushings should be installed in place of the original ones.

(3) The operator climbs up to the operation deck of the regulator to operate control panels of the regulators' gates even at night and in the heavy rain. This is a very dangerous activity. In order to avoid such operation for safety of the operator and to ensure timely gate operation against floods, one remote control panel for the regulator's gates should be installed inside the O&M office.

(4) The hoists and control panels of the regulator's gates have been installed on the top of the regulator. The remote control panel will be installed inside the O&M office. In order to protect such equipment from lightning, lightning arrestors should be fixed on both the regulator and the O&M office.

2-2-1-8 Construction / Procurement Method and Construction Schedule

The following conditions have been considered in determining the procurement method and construction schedule in the basic design:

(1) The implementation schedule should be determined with due consideration to workable days based on weather conditions, work items, work quantities, Japan's fiscal year, Japan's grant aid scheme, and RGOC's tax exemption system.

(2) Since rehabilitation of the regulator's gates includes replacement of bushings and pins, which has complex features and technical difficulties, the rehabilitation of the regulator's gates is identified as the critical path for the entire works.

(3) The work quantities should be distributed evenly over a full working period of the dry season, within a technically possibly extent.

(4) The period of mobilization and demobilization of a contractor should be determined with due consideration to the duration of preparation of necessary procedures for commencement of construction, procurement/lease of construction equipment , removal of site office, and demobilization of equipment.

(5) Since the construction method for rehabilitation/construction works, except that for the replacement of bushings and pins, does not require high technology and engineering works, applied method should be determined with due consideration to safety, least disturbance or damage to residents, shorter period and lower costs.

(6) The work method of temporary diversion work necessary during the replacement of bushing and pins should be determined based on safety, least disturbance or damage to residents, shorter period and lower costs.

(7) The rehabilitation of regulator's gate should be undertaken by a Japanese gate manufacturer, since it requires replacement of bushings and pins, which has peculiar features and technical difficulties.

(8) The gate manufacture should order pins and bushing from a Japanese specialized

maker since they should be of high quality and should be delivered to a site within a limited time.

(9) Slide gates for the river outlet structure and radial gates for Andong Sla intake, sourced from third world country, such as Vietnam and Thailand, should be considered since their quality are of acceptable level.

2-2-2 Basic Plan

2-2-2-1 Outline of Japanese Assistance

(1) Final Contents of Japanese Assistance

The final contents of Japanese assistance to the Project are as follows:

① The Rehabilitation of the Roleang Chrey Headworks

1) Rehabilitation of Roleang Chrey Regulator
- Rehabilitation of all gates and hoist systems
- Rehabilitation of downstream river bank protection
- Construction of downstream river bed protection
- Construction of a river outlet structure at the right bank of the regulator
- Miscellaneous works

2) Reconstruction of Andong Sla Intake
- Replacement of gates
- Reconstruction of the intake

② Soft Component Plan (O&M Assistance for the Improved Facilities)
- Preparation of O&M guideline of the improved facilities, gate operation manuals, etc.
- Guidance on gate operation

(2) Complex Features and Technical Difficulties of Gate Rehabilitation Work of the Regulator

The gate rehabilitation work of the regulator consists of i) replacement of bushings and pins, ii) rust removal and re-painting of gate leaf, iii) replacement of rubber seals, iv) replacement of hoists and related parts, etc. Among these, the replacement of the existing 40 sets of bushings and pins with new ones, has complex features and technical difficulties, and will become the critical path of the entire works.

The details of wheel, bushing and pin are shown in Figure 2.2.2. A bushing is a wide ring-shaped bearing which is pushed into the wheel with strong pressure. A pin is a columnar steel which is inserted into the bushing. Both ends of the pin are fixed to the gate leaf. The wheel with bushing rotates on a pin. One gate has eight wheels. Each wheel is subjected to a

water pressure of about 40 tons considering a total water pressure of about 314 tons acting against one gate leaf. The replacement work sequence is explained in Table 2.2.3 while the standard work flow of the replacement work is shown in Figure 2.2.3. The complex features and technical difficulties of the gate rehabilitation are explained below:

① Necessity of Temporary Diversion Work and Limited Workable Period

The replacement work is carried out while the gates are raised and suspended. The workable period must only be during the dry season of December to April. Since irrigation water supply should be continuous even during the replacement work, a temporary diversion work should be implemented in order to raise the river water surface by 6.7 m. Thus, a water cut-off period is required in order to proceed with the temporary diversion work. However, the water cut-off period must be as short as possible in order to minimize related damage. The workable days of the replacement work including the preparation is therefore very limited.

② Procurement of Bushings and Pins from Makers after Size Measurement

Since as-built drawings of the gates are not available, the contractor has to prepare manufacturing drawings and technical specifications on the bushing and pins prior to procurement from makers. Details of the bushing and pins should be therefore determined by i) removing at least one set of the wheel, bushing and pin from the gate, and ii) measuring the sizes of the removed bushing and pin with a precision of 1/100 mm. A pin may be removed from the wheel on-site, but it is very difficult in Cambodia to remove the bushing from a wheel as discussed in ④ below. It is, therefore, required that the contractor sends the removed wheel with bushing to a factory in a third world country, such as Thailand and Vietnam, where it is possible to remove the bushing from the wheel and measure its size.

③ Drilling of Holes in the Concrete Piers of the Regulator

One of the technical difficulties of the gate rehabilitation is to remove 40 sets of wheels, bushings and pins from the gates, due to restricted available space. For their removal, drilling of ten holes with a diameter of about 40 cm and a length of about 50 cm in the existing concrete piers is necessary. Thus, a drilling machine with diamond bits, which is not available in Cambodia, has to be imported from Japan.

④ Removal of Bushings and Pins

It requires a strong force to remove the existing wheels, bushings and pins from the gates since the bushings and the pins have firmly rusted. Through the drilled hole, hands, a hammer and a jack are inserted and a strong pressure is applied against the pin and bushing within the limited available space. In addition, since the bushing material (brass or bronze) is not as hard as that of pin (steel), the bushing may be broken when

it is removed. In case the bushing is broken, the internal diameter of the wheel has to be measured at a factory in Thailand or Vietnam.

⑤ Mechanical Adjustment of Existing Wheels, New Bushings and New Pins

After the removal of the wheels, bushings and pins from the gates, these are transported to a factory in Thailand or Vietnam. All the existing wheels are mechanically adjusted, including removal of rust and adjustment of hole size using a lathe with a precision of 1/100 mm. After the new pins and new bushings are delivered to the factory, they are processed using a lathe with a precision of 1/100 mm.

⑥ Insertion of New Bushings into the Existing Wheels

All the new bushings have to be inserted to the holes of the existing wheels at the factory in Thailand or Vietnam in accordance with the following JIS provisions (for the case of diameter 120 mm):

- A tolerance of wheel's internal diameter "d2" shown in Figure 2.2.2, shall be from +0.035 mm to -0 mm (H7 of JIS B0401).
- A tolerance of bushing's outer diameter "d2" shown in Figure 2.2.2 shall be from +0.076 mm to +0.054 mm (r6 of JIS B0401).
- The interference shall be from +0.076 mm (= 0.076-0.000 mm) to + 0.019 mm (= 0.054-0.035 mm).

For this work, a lathe with a precision of 1/100 mm, related machinery with tools, and skilled workers are necessary.

⑦ Installation of Existing Wheels with New Bushings and New Pins on the Gate Leaf

After the insertion, the existing wheels with new bushings and new pins are transported from the factory to the regulator site in Cambodia. When the gate is raised to the hole, the existing wheel with new bushing is installed to the gate. Afterwards, a new pin is inserted into the new bushing of the existing wheel. This work is done to both right and left sides of the piers. After the wheels and pins at both sides are fixed, the gate is moved to another hole in order to install another set of wheel. This work has to be repeated until 40 sets of wheels are installed.

⑧ Adjustment by Means of Eccentric Pin

When a new pin is inserted to a new bushing of the wheel, the pin's center has to be deviated from new bushing's center with an eccentric deviation represented as "δ" shown in Figure 2.2.2. When this is done, the eccentric deviation is adjusted so that wheel surface can be fully in contact with the groove of the pier for the gate. Upon adjustment, a dowel pin is driven into the limited space shown in Figure 2.2.2, in order to fix the pin on the gate leaf. Dowel pins of the existing wheels were observed on December 6 and 7, 2007 when the gates were fully opened. The tender drawings of the

gates indicate “Adjustment by Means of Eccentric Pin”. If an eccentric pin is not used, there is a possibility that the gate will deform when subjected to water pressure.

⑨ Fast Transportation

Since the available workable period is very limited, bushings and pins, which are urgently required, are transported by air-cargo. Hoists and control panels, which are not urgently required, are transported by truck and ship. The first one set of wheel with bushing (225 kg) has to be transported by air-cargo from the site to the factory for measurement and procurement of the bushing and pin. The 40 sets of new bushings and new pins which are manufactured in Japan have to be transported by air-cargo to the factory. The details of the transportation is shown in Table 2.2.4.

⑩ Necessity of Management Capability

Before the wheels with new bushings and new pins are delivered to the site, rust removal and re-painting of the gate leaf must be done. At the same time, all the rubber seals have to be replaced with new ones. The duration of works stated in ① to ⑨ will take 3 months and 10 days for the first gate and take 2 months for the second to the fifth gate. When five gates are simultaneously rehabilitated, it will take 3 months and 10 days. When a temporary diversion method is a temporary coffer dam, a total work period of 4 months and 10 days is possible. Thus the contractor has to manage all the necessary works in order to finish the works within the limited period.

(3) Temporary Diversion Plan for Gate Rehabilitation Work of the Regulator

A temporary diversion work is necessary during the rehabilitation of the regulator’s gates. Therefore, the following three temporary diversion plans have been studied:

① River Course Diversion Plan: A temporary coffer dam (L=100 m, Height=8 m) and a temporary diversion channel (L=1,000 m) are constructed at the upstream of the regulator in order to divert the river flow into the newly constructed temporary diversion channel. At the downstream of the regulator, the temporary diversion channel joints the river.

② Temporary Coffer Dam Plan: Instead of the newly constructed temporary diversion channel in the River Course Diversion Plan, the existing north approach channel (with capacity of about 70 m^3/s) is utilized. For the protection of said approach channel, a temporary spillway with related facilities (with capacity of 40 m^3/s) is newly constructed on the north approach channel.

③ Partial Closure Plan: At the immediate upstream of the regulator, the fisrt temporary coffer dam (L=100 m, Height = 8 m) is constructed to enclose a part of the working area (first closure). After the work is finished, a second temporary coffer dam (L=100

m, Height = 8 m) is constructed to enclose the remaining part of the working area (second closure), which is supposed to complete the closure works. However, for Roleang Chrey regulator particularly, a third temporary coffer dam (L=80 m, Height = 8 m) has to be constructed (third closure) since its required dam base length is 40 m based on its height of 8 m, and the side slope of the dam. For this third closure , see Table 2.2.5.

A comparative study of the three plans has been conducted, considering water cut-off period, compensation, cost and work safety. The results of the study are shown in Table 2.2.5. As a result of the comparative study, the temporary coffer dam plan has been selected as the best plan because of the shortest water cut-off period, lesser cost, minimum compensation, and work safety. Typical cross sections of the dam are shown in Figure 2.2.4.

(4) Alternative Study on Gate Rehabilitation Work of the Regulator

A steel stoplog method, as shown in Figure 2.2.5, is generally adopted in Japan as a temporary diversion method suitable for gate rehabilitation works. Adoption of said method is further studied and compared with the temporary coffer dam method. The study has been carried out for the following five alternative plans with due consideration to Japan's grant aid scheme, Japanese fiscal year, detailed design period, and tender period :

① Alternative Plan 1: One set of steel stoplog is used. One set of gate is rehabilitated in the first dry season and four sets of gates are rehabilitated in the second dry season. (The rehabilitation period of the four sets of gates is longer than that of Alternative Plan 2 due to the limited number of stoplog.)

② Alternative Plan 2: Two sets of steel stoplog are used. One set of gate is rehabilitated in the first dry season and four sets of gates are rehabilitated in the 2nd dry season.

③ Alternative Plan 3-1: One temporary coffer dam is constructed in the first dry season. Five sets of gates are rehabilitated in the first dry season.

④ Alternative Plan 3-2: Two temporary coffer dams are constructed. One is in the first dry season and the other is in the second dry season. Three sets of gates are rehabilitated in the first dry season and two sets of gates are rehabilitated in the second dry season.

⑤ Alternative Plan 3-3: One temporary coffer dam is constructed in the second dry season. Five sets of gates are rehabilitated in the second dry season.

The five alternative plans are shown in Figure 2.2.6 to Figure 2.2.10. The study conditions and comparative results are shown in Table 2.2.6, and are summarized in the following table:

Table 2-5 Comparison of 5 Alternative Plans

Items		Alt 1	Alt 2	Alt 3-1	Alt 3-2	Alt 3-3
Method		One set of stoplog	Two sets of stoplog	One coffer dam in 1st dry season	One coffer dam in 1st dry season and the other in 2nd dry season	One coffer dam in 2nd dry season
Main Features of Methods		Water cut-off period of 2 months is necessary for construction of inlet of river outlet.			Water cut-off period of 2 months is not necessary for construction of inlet of river outlet.	
		When construction is being done, river water is flowing. Other coffer dams and dewatering are necessary.			No river water flows. Dewatering is easy.	
		Temporary spillway is not necessary.		Temporary spillway is necessary.		
Gate Rehabilitation Sequence*		No.3→No2→ No.1,5→No.4	No.3→No2,4 → No.1,5	5 gates at one time	No.1,3,5→No.2,4	5 gates at one time
Weight of Air Cargo	1)Site to 3rdWorld country	8 sets of existing wheels and bushings of 1st gate：1.8 tons		1 set of existing wheel and bushing：225 kg		
	2)Japan to 3rd World country	8 sets of new bushing and pins of 1st gate: 240 kg		40 sets of new bushings and pins : 1.2 tons	24 sets of new bushings and pins of 3 gates : 720 kg	40 sets of new bushings and pins : 1.2 tons
	3)3rd World country to site	8 sets of existing wheels, new bushings and new pins：2 tons		zero		
Time Allowance against Delay in Construction Commencement		Very limited		Time allowance of 4 months is available.		
Time Allowance against Long Customs Clearance		Very limited		10 to 15 days of time allowance is available.		
Gate Rehabilitation Period		21 months 20 days	19 months 20 days	20 months 20 days	21 months	21 months 20 days
Water Cut-off Period		2 months 20 days	2 months 20 days	2 months 20 days	40 days	20 days
Direct Cost of Tempo.Diversion**		Yen 48.8 million	Yen 75.1 million	Yen 42.5 million	Yen 85.0 million	Yen 42.5 million
Merits		Low cost	Rehabilitation of plural sets of gates is possible.	・Time allowance against risks is included. ・Air cargo weight of Site ⇔ 3rd world country is minimum.		
		・Air cargo weight from Japan is minimum.		・Lowest cost	・Water cut-off period is short.	・Water cut-off period is the shortest and

	・Temporary spillway is not necessary. ・Skillful staff can be arranged easily since the gate rehabilitation is done at 3 or 4 stages.			・Skillful staff can be arranged easily since the gate rehabilitation is done at 2 stages.	lowest cost.
Demerits	・Time allowance is very limited. ・Air cargo weight of site ⇔ 3rd country is largest.		・Air cargo weight from Japan is largest. ・Temporary spillway is necessary.		
	Water cut-off period is the longest.	・Water cut-off period is the longest and high cost.	・Contractor is hard to arrange plural working groups of skillful workers since 5 gates are rehabilitated at one time.	・2- time construction of coffer dam is necessary.	・Contractor is hard to arrange plural working groups of skillful workers since 5 gates are rehabilitated at one time.
Evaluation	△	△	○	○	◎
	Time allowance against delay and long customs clearance is not included.		Time allowance against delay and long customs clearance (10 to 15 days) is included.		
	Longest water cut-off period and low cost.	Longest water cut-off period and high cost.	Longest water cut-off period and lowest cost.	Short water cut-off period and high cost.	Shortest water cut-off period and lowest cost.

* : The number of gate given as No.1, No.2, No.3, No.4 and No.5 is counted from the right bank to the left bank of the regulator.

** : Cost of temporary spillway is included.

Alternative Plans 3-1, 3-2 and 3-3 have the advantage of a longer gate rehabilitation period of 4 months and 10 days as compared to that of Alternative Plans 1 and 2, which is 3 months and 10 days. Among the identified advantageous three plans, Alternative Plan 3-3 has been selected as the best method since it requires the shortest water cut-off period and is least costly. In addition, Alternative Plan 3-3 allows for a longer time allowance against delay in construction commencement and longer waiting time for customs clearance, and can make construction works in the river much easier than the other Plans.

The water cut-off period of Alternative Plan 3-3 is the shortest, 20 days (10 days x 2 times) and this period does not affect irrigated rainy season paddy cultivation. For residents along the canals who use irrigation water in canals as domestic and drinking use, MOWRAM mentions that they will follow up the conclusions of Inter-Ministerial Resettlement Committee (IRC). The JICA study team strongly recommended that MOWRAM take necessary measures for the residents, such as deployment of water supply trucks, and construction of temporary coffer dams in canals in order to use water in canals, etc. It is noted that MOWRAM's measures are needed for all the alternative plans.

Alternative Plan 3-3 has the disadvantage that new bushings and pins have to be transported from Japan to a third world country by air-cargo. However, since the air-cargo cost is about Yen 1 million and it is less than a difference of Yen 6.3 million when compared to Alternative Plan 1,

Alternative Plan 3-3 remains to be economically advantageous. In addition, gate manufacturer in Alternative Plan 3-3 has to source for higher number of skilled staff since rehabilitation of the gates has to be carried out simultaneously.

After the selection of Alternative Plan 3-3, further reduction of the rehabilitation/construction work period has been studied. As a result, construction period of Alternative Plan 3-3 can be further reduced by five (5) months, considering the following:

① Construction of the downstream river bed protection, rehabilitation of the downstream river bank protection and miscellaneous works, which are scheduled in the first dry season can be postponed to the second dry season.

② Prior to installation of gates, the gate works for Roleang Chrey regulator, Andong Sla intake and the river outlet structure necessitate preparation of manufacturing drawings/technical specifications of mechanical/electrical products, securing approval of the drawings/technical specifications, material procurement, manufacturing and transportation of gates/ gate parts to the site. These works will take the following periods, and that for Andong Sla intake is the critical path for the entire schedule:

- Hoist system and control panels of the regulator's gates: 7 months and 20 days
- Slide gates of river outlet structure: 10 months
- Radial gates of Andong Sla intake : 12 months

Finally the implementation schedule of the Project has been formulated as shown in "2-2-4-2 (8) Implementation Schedule" by postponing the construction commencement date from September 01, 2009 to February 01, 2010, which eventually reduces the construction period and cost. There is no better plan other than the final implementation schedule of the Project in terms of irrigation water cut-off period, time allowance against risk, cost and safety of the work.

2-2-2-2 Rehabilitation Plan of Roleang Chrey Regulator

(1) Rehabilitation of All Gates and Hoist System

① Basic Design Policy

1) All the existing bushings and pins should be replaced with new ones.
2) Since the five sets of gate leaves and wheels are still in good condition, they should be re-used after rust removal and new paining.
3) Since the hoist system with local control panels, such as, the hoists, motors, wire-ropes, etc. have already deteriorated over the past 33 years, these should be completely replaced with new ones.

② Design Features

The present regulator's design features, such as its elevations, dimensions and shapes

of the regulator, will be maintained, such as gate sill elevation of EL 29.00 m and gate crest elevation of EL 35.70 m. However, for the safety of operator(s) and of the regulator, one complete set of remote control panels (self-standing, indoor type panels including main distribution panels and distribution panels for room lighting) will be newly installed inside the existing O&M office.

③ Scale and Dimension of Rehabilitation Work (Mechanical Work)

The scale and dimension of the gate rehabilitation work include the following:

1) Replacement of the existing wheel bushings and pins with new ones (40 sets)
2) Rust removal and re-painting of five gate leaves
3) Replacement of rubber seals fixed on five sets of the gate leaves with new ones
4) Replacement of all five sets of the existing hoist systems with new ones on the operation deck (each set consists of 1 electric motor, 2 drums, wire-rope winch type hoist, 1 local control panel)
5) Installation of 1 set of new control panels at the existing O&M office, as well as connection cables between all remote and local control panels and hoist systems.
6) Installation of lightening arrestors on the regulator (including earthing network)
7) Spare part (rubber seal for one gate, magnetic contactor for control panels 40 units)

(2) Rehabilitation of Downstream River Bank Protection

① Basic Design Policy

The existing river bank protection with riprap does not effectively protect both sides of the river banks due to its insufficient length and improper shape. This should be rehabilitated with a new riprap (boulder 30 to 50 cm diameter) with sufficient length and adequate shape, considering that the main rehabilitation policy is to recover the function to a proper design level.

② Design Features

The river bank protection will be extended up to a 30 m-length, measured from the downstream end of the existing concrete apron. The river bank protection will be curved with an angle of 45 degrees (shaped like a fan), finally connected to the existing river banks.

③ Scale and Dimension of the Rehabilitation Work

The scale and dimension of the downstream river bank protection work are as follows:

1) Toe foundation work : plain concrete, width 2 m x height 2 m x length 110 m (right bank) and 90m (left bank), top elevation EL 28.0 m, geo-textile sheet laid on its bottom and bank side
2) Riprap work: riprap work covering the low water channel of the river bank

with available material at the site and obtained from the rock excavation (rock diameter 30 cm to 50 cm), top elevation of the low water channel set at EL 34.0 m, top width 5 m x maximum height 6 m x thickness 1.5 m (side slope 1:1.5, berm width 1.5 m) x length 89.3 m (right bank) and 78 m (left bank), top elevation EL 34.0 m, geo-textile sheet underneath riprap

3) Embankment work: High water channel of the river bank embanked with excavated material (sandy material) obtained from the site up to the original ground elevation of EL 33.7 m, riprap (thickness 30 cm, boulder 30 to 50 cm diameter) up to ground surface EL 36.5 m

(3) Construction of Downstream River Bed Protection

① Basic Design Policy

The river bed protection should be constructed in order to recover the original river bed with due consideration to the following facts:

1) When a gate of the regulator is opened, river flow at its downstream is hydraulically submersible and the hydraulic force against river bed scouring is not so intense.
2) The downstream river bed of tuff layer has partially caved in.
3) River bed degradation has been scarcely observed over the past 33 years.

② Design Features

At the immediate downstream of the regulator's concrete apron, an additional groundsill with reinforced concrete (width 72.5 m x length 8 m) will be constructed, provided with a cut-off. At the downstream of the groundsill, the dented space (width 40 m x length 40 m) will be filled with sand and gravel up to EL 27.0 m. The surface of the filled sand and gravel will be covered with geo-textile sheet, on which grouted riprap (thickness 0.5 m, boulder 30 cm to 50 cm diameter) will be laid. At the downstream of the grouted riprap, gabions (thickness 0.5 m, boulder 30 cm to 50 cm diameter) will be laid for a length of 10 m in order to connect them to the natural river bed. The tuff projected up from the left river bed area above EL 27.00 m will be removed for smooth river flow, and the river bed will be leveled between EL 27.0 m.

③ Scale and Dimension of the Construction Work

The scale and dimension of the downstream river bed protection are as follows:

1) Additional groundsill work :reinforced concrete, width 72.5 m x drop height (1.25 m for upstream & 1.0 m for downstream) x length 8 m,

	elevations of groundsill set at EL 28.0 m at upstream end and EL 27.0 m at downstream end
2) Backfill work:	backfilled with sand and gravel, width about 40 m x length about 40 m, top elevation of backfilled sand and gravel up to EL 26.5 m
3) Grouted riprap work:	riprap/gravel (30 cm to 50 cm diameter) with plain concrete laid up to top elevation EL 27.0 m, width 40 m x length 42 m x thickness 0.5 m, geo-textile sheet underneath grouted riprap
4) Gabion work:	riprap/gravel (30 cm to 50 cm diameter), gabion (width 80 m x length 10 m x thickness 0.5 m) from top elevation EL 27.0 m to the exiting river bed elevation

(4) Construction of River Outlet Structure

① Basic Design Policy

The river outlet structure with a regulating capacity of about 5 m^3/sec should be constructed at the right bank of the regulator to stabilize irrigation water supply to Kandal Steung irrigation area of 1,950 ha (completed in August 2007 under Japan's grant aid scheme and located at about 40 km downstream of the regulator) without utilizing the regulator's gate. The design discharge of Kandal Steung irrigation area is less than 5 m^3/sec, which is relatively small compared with the gate size. When the gate releases such discharge, the gate opening is only 4 cm to 5 cm and such opening can not be adjusted. In addition, even if the existing gate opening is adjusted to be 4 cm to 5 cm, the gate produces mechanical noise and vibration. This operation should be avoided for safety of the gates.

② Design Features

The river outlet structure will consist of inlet, culvert and outlet. The inlet of said structure will be constructed at the upstream side of the regulator, while the outlet will be at the downstream side of the regulator. At the inlet, four sets of slide gates will be installed; two sets for regulating discharge, and another two sets for repair and maintenance purposes. All the gates will be of clear span 1 m x effective height 1 m, four-edge seal. Since the said gates will be operated manually, the river outlet structure will be constructed at the right bank of the regulator, where the O&M office is closely located. The inlet base elevation at the gate base will be set at EL 31.0 m, 2 m higher than that of the concrete apron of the regulator(EL 29.0 m) , in order to minimize the floating

sand entrance, as well as to accommodate with the low water level during the dry season recorded approximately once in a year. In front of the inlet gates, trash rack will be installed in order to prevent entrance of foreign materials and floating logs. At the outlet, an energy dissipater will be constructed. Grid-bars will also be installed to ensure safety of the local residents.

In due consideration of design discharge, hydraulic characteristics, limited workable period, and easiness of construction, the type of culvert connecting the inlet and the outlet will be a two-barrel pre-cast reinforced concrete pipe with a diameter of 1.0 m covered with in-site reinforced concrete. The centerline of the culvert from the inlet to the outlet will have two curvatures, with a radius of more than 10 m to ease the flow.

③ Scale and Dimension of the Construction Work

The scale and dimension of the river outlet structure (civil works) is as follows:

1) Inlet : reinforced concrete, internal width 2.6 m to 4.6 m x internal height 2.3 m to 4.0 m x length 7.5 m, inlet base elevation EL 30.2 m (29.0 m) to EL 30.7 m, design water level at inlet WL 35.6 m, highest design water level at inlet WL 36.0 m
2) Gate portion at inlet : reinforced concrete, internal width 1.0 m x internal height 6.0 m x length 6.4 m x 2 barrels, gate base elevation EL 31.0 m, gate top elevation EL 37.0 m
3) Culvert : pre-cast reinforced concrete pipe (internal diameter 1.0 m x 2 barrels) , covered up with in-site reinforced concrete (width 3.4 m x total height 1.8 m x length about 83 m), culvert inlet base elevation EL 31.0 m, culvert outlet base elevation EL 30.0 m
4) Outlet : reinforced concrete, internal width 4.0 m x internal height 0.7 m to 4.7 m to 6.0 m x length 10.9 m, outlet base elevation EL 29.3 m to EL 30.0 m, top elevation EL34.0 m

④ Scale and Dimension of the Construction Work (Mechanical Work)

1) Manufacturing and installation of two sets of steel slide gates for discharge regulation (clear span 1.0 m x effective height 1.0 m, four-edge seal)
2) Manufacturing and installation of two sets of steel slide gates for repair and maintenance (clear span 1.0 m x effective height 1.0 m, , four-edge seal)
3) Hoist system: manual rack-pinion / manual screw spindle type
4) Spare part (rubber seal for one gate)

(5) Miscellaneous Works

① Basic Design Policy

The miscellaneous works include three works, namely i) drilling and recovery (filling) of ten holes (diameter = 40 cm and length = about 50 cm per hole) in the existing concrete pier, ii) repair of cracks observed on the existing concrete of the regulator, iii) installation of five staff gauges, and iv) installation of lightning arrestors with earthing network. Drilling a hole should be carried out for replacement of wheel bushings and pins of the regulator's gates.

② Design Features

The drilling is to drill ten holes in total in the existing ten concrete piers with a drilling machine, with a hole of diameter of 40 cm and length of about 50 cm. The drilling machine will be imported from Japan since it is not available in Cambodia. After the related gate replacement works are completed, the holes will be filled with concrete. The repair of cracks will be done to prevent further crack expansion. The method will be combination of i) scraping of the cracked area, ii) filling of epoxy or equivalent, and iii) adding anchor bar or anchor plug in the cracked area, depending on the extent of the cracks. Five staff gauges in total will be installed, namely two each for the existing upstream walls and downstream walls of the regulator, and one for the inlet of the new river outlet structure.

③ Scale of Miscellaneous Works

The scale of the miscellaneous works is as follows:

1) Drilling and filling holes: drilling 10 holes (2 holes x 5 gates, diameter 40 cm, length about 50 cm) , anchor bar welding and concrete filling with non-shrinkage agent
2) Repair of cracks: concrete scraping, anchor bar welding, concrete anchor plug and epoxy injection, etc.
3) Installation of staff gauge: four staff gauges on the existing walls of the regulator (two for upstream and two for downstream) and one staff gauge on the inlet of the river outlet structure.
4) Installation of lightning arrestors: three sets of lightning arrestors on operation deck of the regulator

2-2-2-3 Reconstruction Plan of Andong Sla Intake

(1) Replacement of Gates

① Basic Design Policy

1) The intake gates should be replaced with new ones in order to recover the original

functions and prevent leakage.

2) Since design discharge of the intake gates is 10.4 m^3/sec, four sets of the existing gates should be dismantled and two sets of new radial gates should be installed at the center of the intake. The gates should be operated manually.

3) The elevation of trunnion pins of the existing gates is lower than the design water level. For the new gates, the pins should be installed at an elevation above the design water level.

② Design Features

The base elevation of the new gates will be EL 32.0 m, which is the same as that of the existing gate base. The gate will have design features, such as radius of 5 m, design water head of 4.0 m and hoisting height of 3.0 m.

③ Scale and Dimension of Gate Rehabilitation Work

The scale and dimension of the replacement of the intake gates are as follows:

1) Removal of the existing four sets of gates
2) Replacement of two sets of radial gates with new ones (clear span 4 m x effective height 2.7 m, four-edge seal, manual rack-pinion /manual screw spindle type), Curtain walls with full height constructed at two gate-dismantled opening space
3) Spare part (rubber seal for one gate)

(2) Reconstruction of the Intake

① Basic Design

1) The intake structure should be reconstructed to recover the function of the intake gates.
2) After the four sets of the existing gates and vertical wall at the upstream of the intake gates are dismantled, the side wall, guide wall and base slab should be additionally constructed at the upstream of the intake gates, and the existing operation bridge should be re-used.
3) At the right and left space of the newly installed two gates, reinforced concrete curtain walls should be constructed in place of the dismantled two gates.
4) Since the downstream canal bed has been partially scoured (width about 9 m x length about 5 m x max. depth 0.7 m), the repair with grouted riprap should be carried out for the dented place.

② Design Features

The length of the side wall and base slab will be 5 m. The reinforced concrete wall will be connected to the existing canal banks, using transitional concrete wall and gabions. The scoured canal base at the downstream of the intake gates, will be filled with grouted riprap (thickness 0.5 m, boulder 30 cm to 50 cm diameter) for a length of 12.8 m. At its

downstream, gabions (thickness 0.5 m, boulder 30 cm to 50 cm diameter) will be laid on the canal base of 10 m. The canal base elevation of the gates is EL 32.0 m, which is the same as that of the existing gates.

③ Scale of the Reconstruction Work

The scale of the reconstruction work is as follows:

1) Additional wall & slab : reinforced concrete, internal width 4.0 m x internal height 5.2 m x length 5.0 m x 4 , gate base elevation EL 32.0 m, wall top elevation EL 37.2 m

2) Slab for O&M, operation deck: reinforced concrete, width 2.0 m x clear span 4.0 m x 4, top slab elevation EL 37.5 m, operation deck with steel checkered plate for rack-pinion or screw spindle (width 2.0 m x clear span 4.0 m x 2)

3) Curtain walls for gates: reinforced concrete, span 4.0 m x height 2.5 m x 2, top elevation EL 37.2 m, bottom elevation EL 34.7 m

4) Transition : reinforced concrete, internal width 18.6 m to 43.0 m x internal height 5.2 m x length 5.0 m, top elevation EL 37.2 m

5) Downstream grouted riprap: riprap/gravel (boulder 30 cm to 50 cm diameter) & plain concrete, bottom length 23 m and riprap :bank slope (6 m x both banks) x thickness 0.5 m x length 12.8 m, canal base EL 32.0 m, geo-textile sheet underneath and bank slope

6) Downstream gabion : riprap/gravel (boulder 30 cm to 50 cm diameter), gabion, bottom length 23 m and bank slope (6 m x both banks) x thickness 0.5 m x length 10.0 m, canal bed from EL 32.0 m to the original canal bed, geo-textile sheet underneath and bank slope

7) Upstream gabion : riprap/gravel (boulder 30 cm to 50 cm diameter), gabion, bottom length 23 m and bank slope (11.2 m x both banks) x thickness 0.5 m x length 5.0 m, canal bed from EL 32.0 to the original canal bed, geo-textile sheet underneath and bank slope

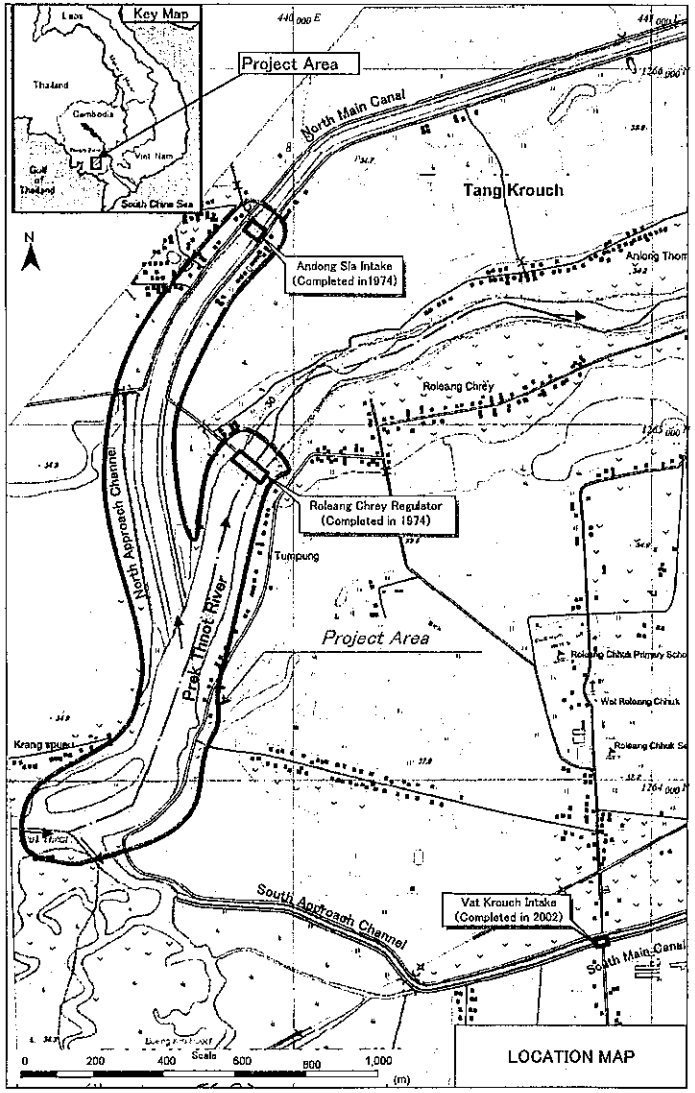
2-2-3 Basic Design Drawings

A list of the basic design drawings is shown below:

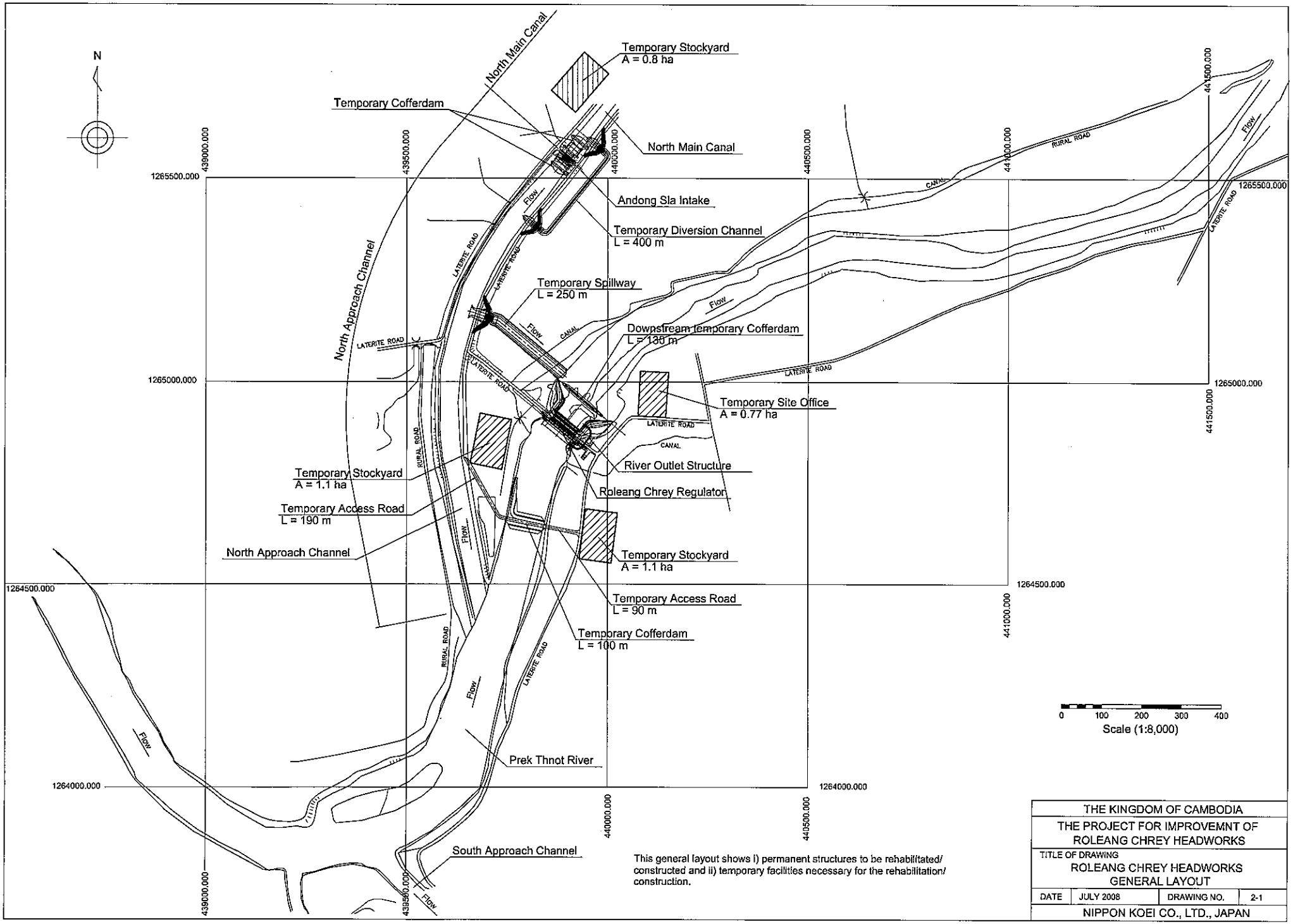
Table 2-6 List of Basic Design Drawings

NO.	DRAWING NO.	TITLE OF DRAWINGS
	GENERAL	
1	1 - 1	Location Map
	ROLEANG CHREY REGULATOR	
2	2 - 1	Roleang Chrey Headworks General Layout
3	2 - 2	General Plan of River Protection and Outlet Structure
4	2 - 3	Plan of River Protection and Outlet Structure
5	2 - 4	River Bed and River Bank Protection
6	2 - 5	River Outlet Structure (1/4)
7	2 - 6	River Outlet Structure (2/4)
8	2 - 7	River Outlet Structure (3/4)
9	2 - 8	River Outlet Structure (4/4)
10	2 - 9	Miscellaneous Works (1/3)
11	2 - 10	Miscellaneous Works (2/3)
12	2 - 11	Miscellaneous Works (3/3)
13	2 - 12	Elevation and Sections (Regulator's Gates)
14	2 - 13	Main Wheel General (Regulator's Gates)
15	2 - 14	Electirc System (Regulator's Gates)
16	2 - 15	River Outlet Structure Gate
17	2 - 16	Temporary Coffer Dam and Approach Road
18	2 - 17	Temporary Spillway (1/2)
19	2 - 18	Temporary Spillway (2/2)
20	2 - 19	Temporary Road for River Outlet Structure (1/2)
21	2 - 20	Temporary Road for River Outlet Structure (2/2)
	ANDONG SLA INTAKE	
22	3 - 1	General Plan of Intake Structure
23	3 - 2	Intake Structure (1/4)
24	3 - 3	Intake Structure (2/4)
25	3 - 4	Intake Structure (3/4)
26	3 - 5	Intake Structure (4/4)
27	3 - 6	Intake Gate
28	3 - 7	Temporary Coffer Dam and Diversion Channel (1/2)
29	3 - 8	Temporary Coffer Dam and Diversion Channel (2/2)

LOCATION MAP

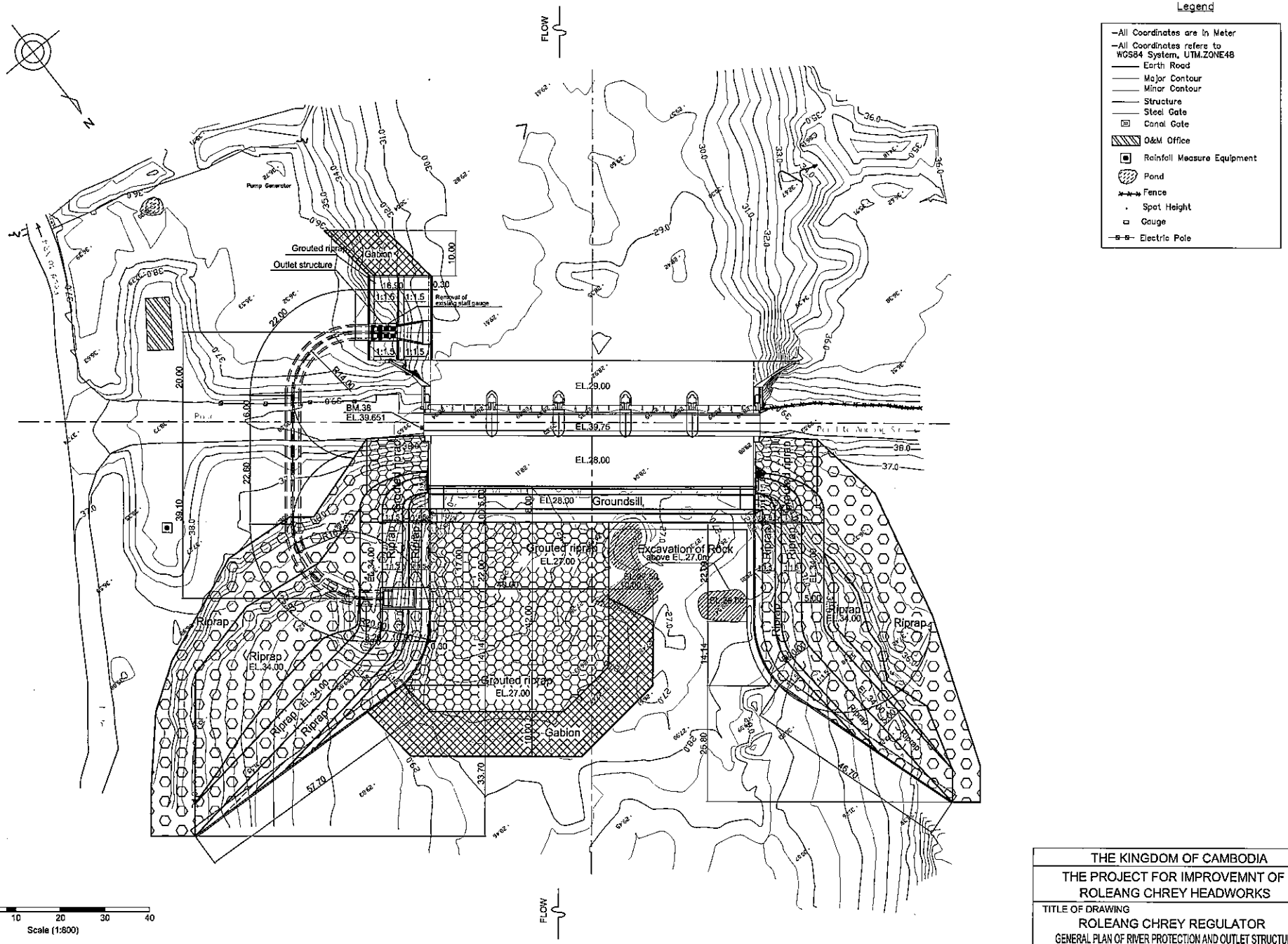


THE KINGDOM OF CAMBODIA			
THE PROJECT FOR IMPROVEMNT OF ROLEANG CHREY HEADWORKS			
TITLE OF DRAWING LOCATION MAP			
DATE	JULY 2008	DRAWING NO.	1-1
NIPPON KOEI CO., LTD., JAPAN			

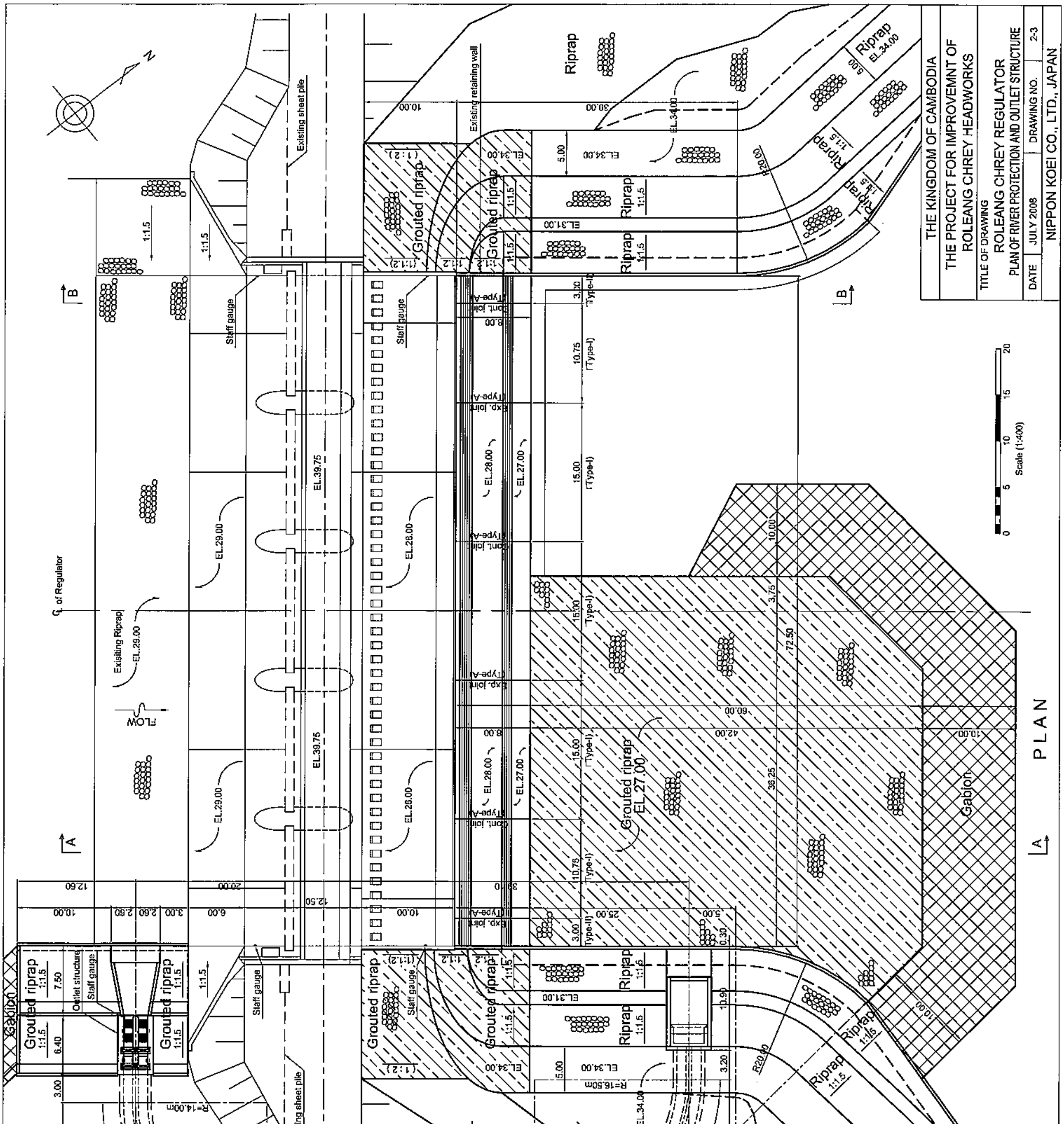


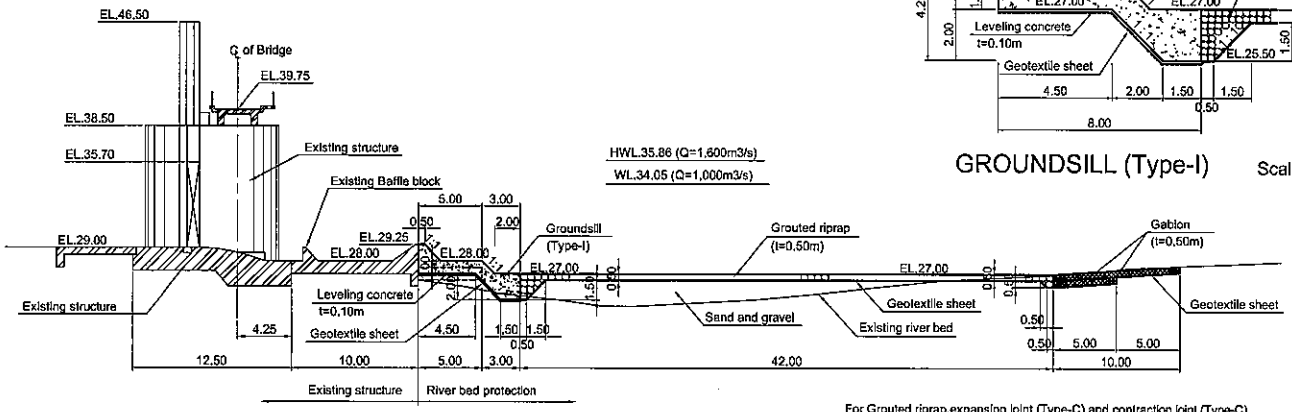
This general layout shows i) permanent structures to be rehabilitated/ constructed and ii) temporary facilities necessary for the rehabilitation/ construction.

THE KINGDOM OF CAMBODIA	
THE PROJECT FOR IMPROVEMNT OF ROLEANG CHREY HEADWORKS	
TITLE OF DRAWING: ROLEANG CHREY HEADWORKS GENERAL LAYOUT	
DATE: JULY 2008	DRAWING NO.: 2-1
NIPPON KOEI CO., LTD., JAPAN	



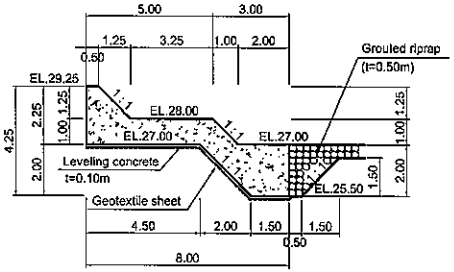
THE KINGDOM OF CAMBODIA			
THE PROJECT FOR IMPROVEMNT OF ROLEANG CHREY HEADWORKS			
TITLE OF DRAWING ROLEANG CHREY REGULATOR GENERAL PLAN OF RIVER PROTECTION AND OUTLET STRUCTURE			
DATE	JULY 2008	DRAWING NO.	2-2
NIPPON KOEI CO., LTD., JAPAN			


THE KINGDOM OF CAMBODIA
THE PROJECT FOR IMPROVEMNT OF ROLEANG CHREY HEADWORKS
TITLE OF DRAWING
ROLEANG CHREY REGULATOR
PLAN OF RIVER PROTECTION AND OUTLET STRUCTURE
DATE
JULY 2008
DRAWING NO.
2-3
NIPPON KOEI CO., LTD., JAPAN
PLAN
Scale (1:400)
Grouted riprap
EL.27.00
Gabion
Riprap
EL.34.00
Existing Riprap
EL.29.00
FLOW
℄ of Regulator
℄ of Bridge
Existing sheet pile
Existing retaining wall
Staff gauge
Outlet structure
Concrete pipe
O&M office
EL.39.75
EL.28.00
EL.31.00
EL.36.50

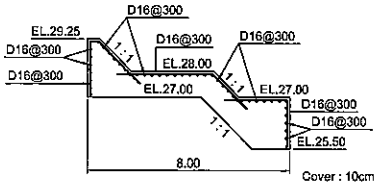


SECTION A - A Scale A

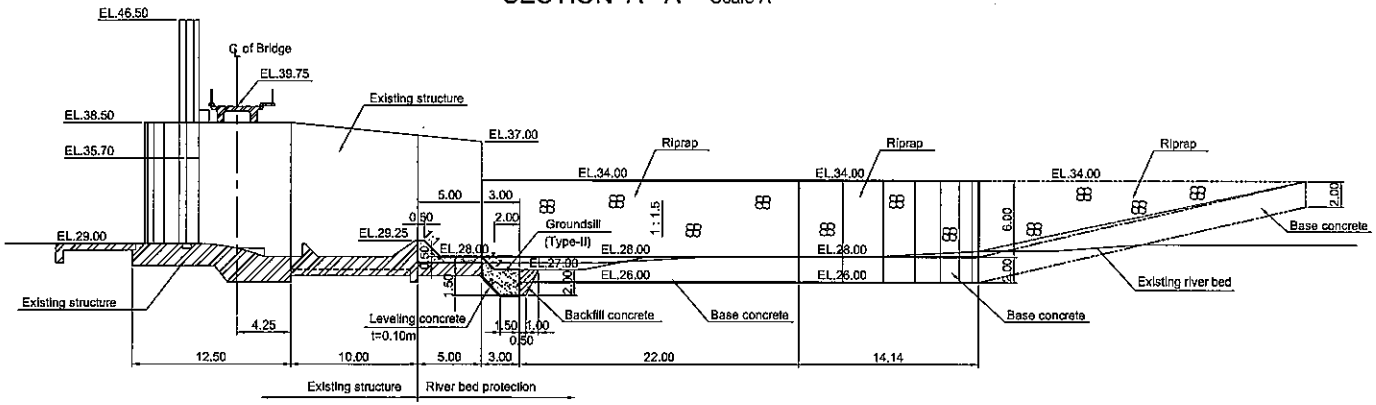
For Grouted riprap,expansion joint (Type-C) and contraction joint (Type-C) shall be installed every 10m /10.5m inturn cross sectionally / longitudinally.



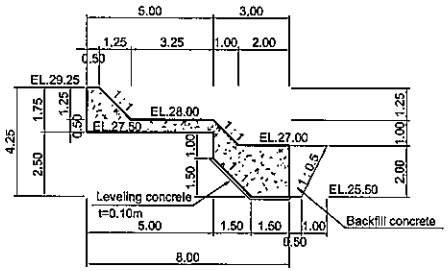
GROUNDSILL (Type-I) Scale B



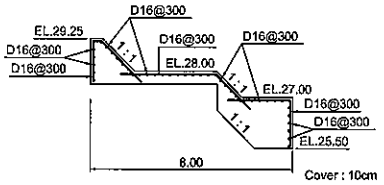
BAR ARRANGEMENT Scale B
GROUNDSILL (Type-I)



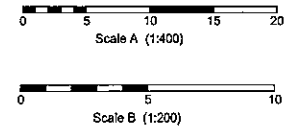
SECTION B - B Scale A

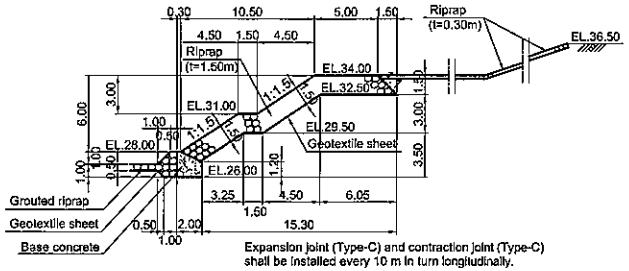


GROUNDSILL (Type-II) Scale B



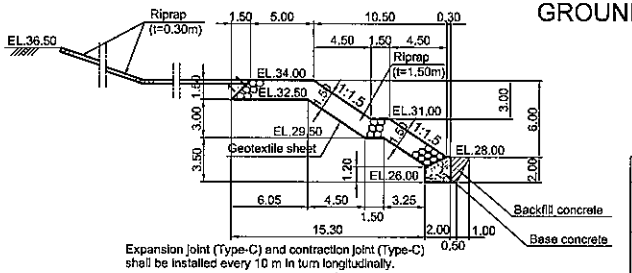
BAR ARRANGEMENT Scale B
GROUNDSILL (Type-II)





Expansion joint (Type-C) and contraction joint (Type-C) shall be installed every 10 m in turn longitudinally.

RIGHT BANK PROTECTION Scale A

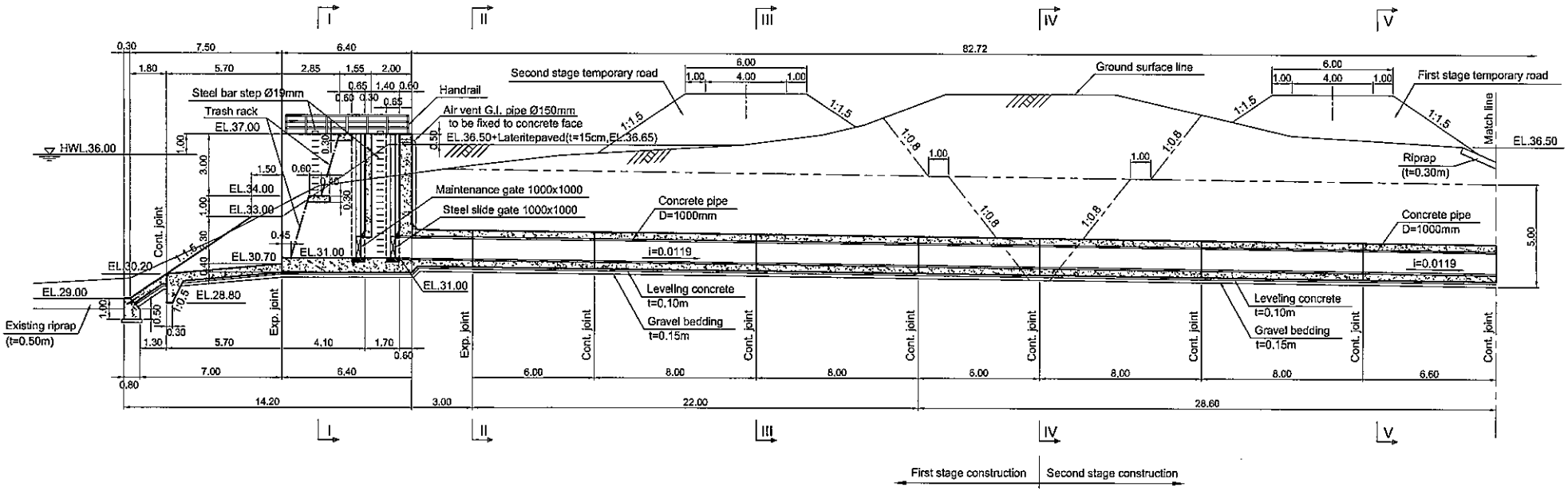


Expansion joint (Type-C) and contraction joint (Type-C) shall be installed every 10 m in turn longitudinally.

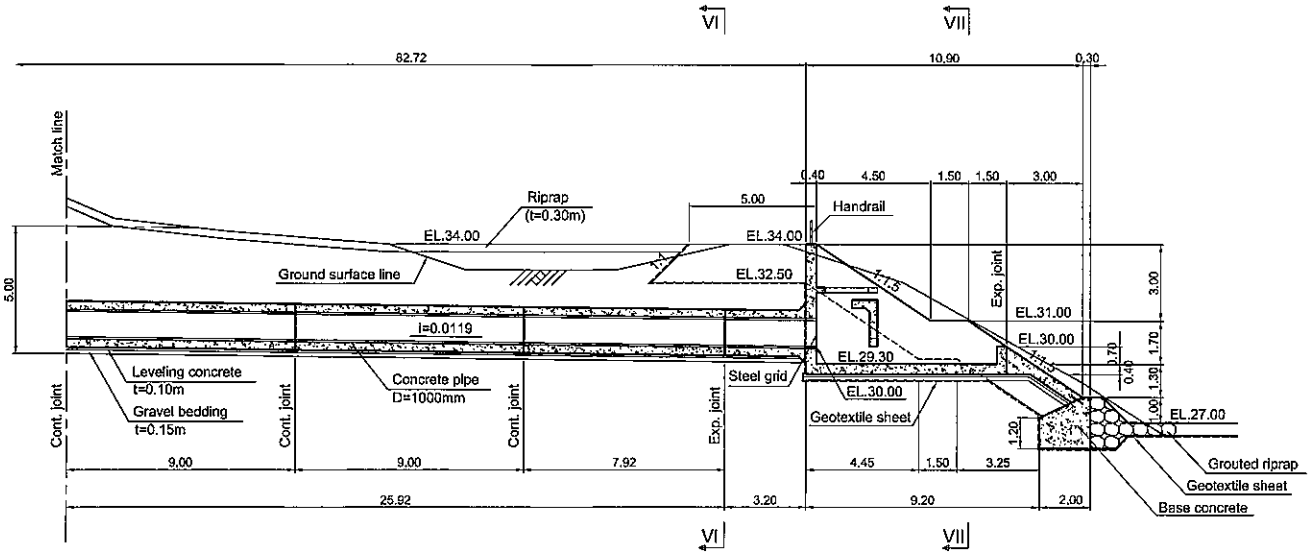
LEFT BANK PROTECTION Scale A

For Grouted riprap,Riprap and Gabion, boulder with a size of 30cm - 50cm shall be used.

THE KINGDOM OF CAMBODIA			
THE PROJECT FOR IMPROVEMNT OF ROLEANG CHREY HEADWORKS			
TITLE OF DRAWING ROLEANG CHREY REGULATOR RIVER BED AND RIVER BANK PROTECTION			
DATE	JULY 2008	DRAWING NO.	2-4
NIPPON KOEI CO., LTD., JAPAN			



LONGITUDINAL SECTION

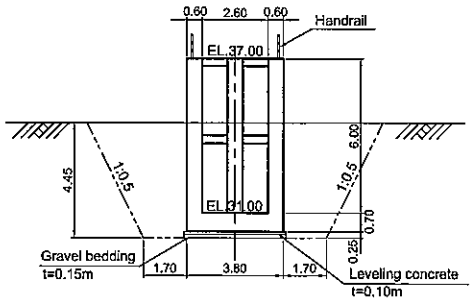


For Grouted riprap and Riprap, boulder with a size of 30cm - 50cm shall be used.

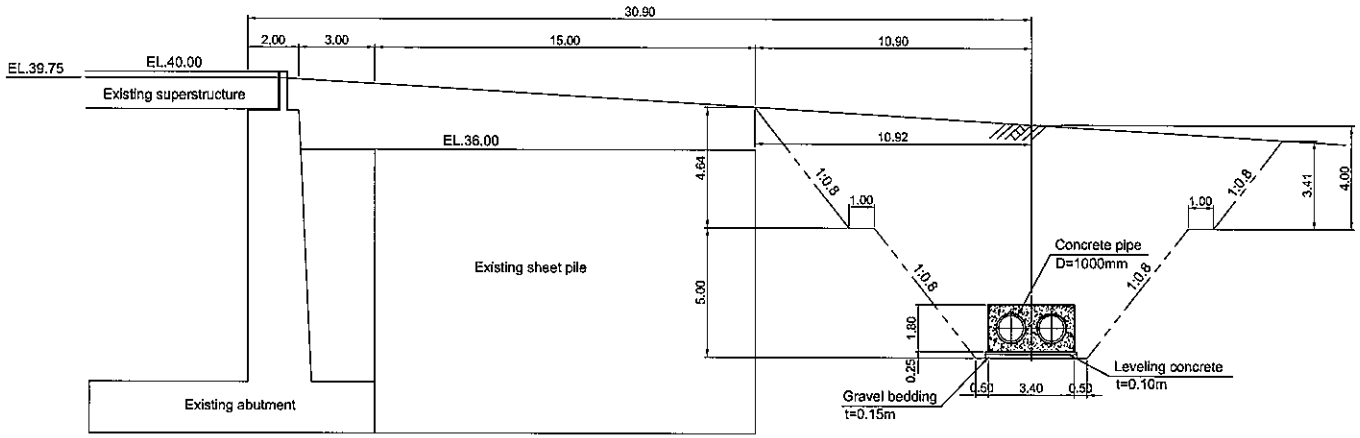
0 5 10
Scale (1:200)

LONGITUDINAL SECTION

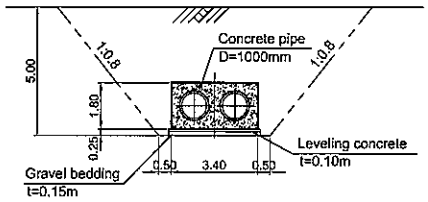
THE KINGDOM OF CAMBODIA			
THE PROJECT FOR IMPROVEMNT OF ROLEANG CHREY HEADWORKS			
TITLE OF DRAWING ROLEANG CHREY REGULATOR RIVER OUTLET STRUCTURE (1/4)			
DATE	JULY 2008	DRAWING NO.	2-5
NIPPON KOEI CO., LTD., JAPAN			



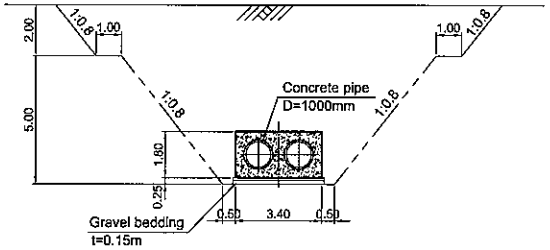
SECTION I - I



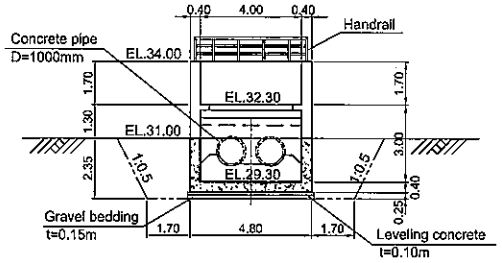
SECTION IV - IV



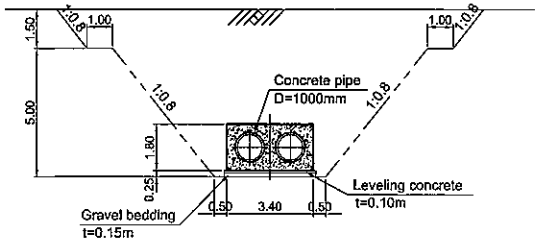
SECTION II - II



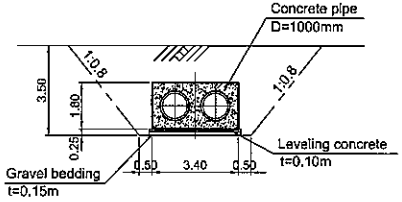
SECTION V - V



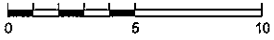
SECTION VII - VII



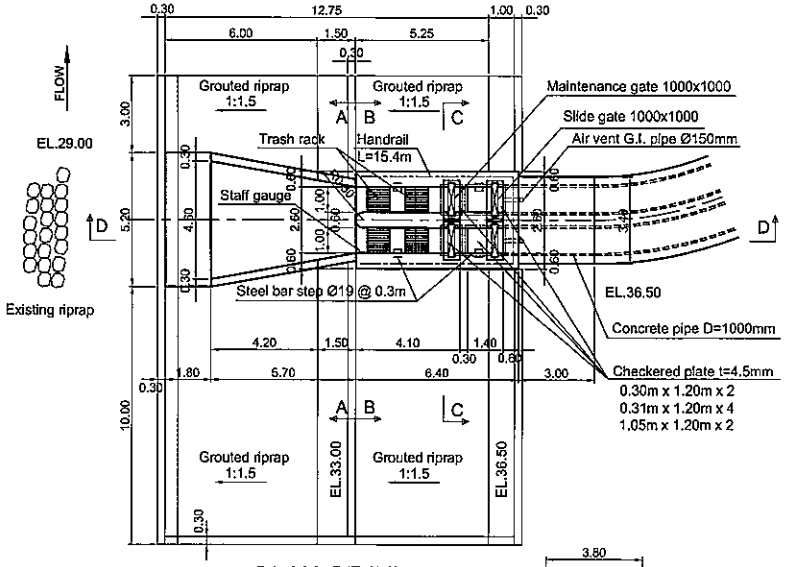
SECTION III - III



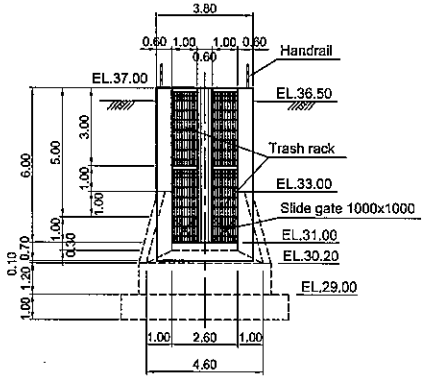
SECTION VI - VI



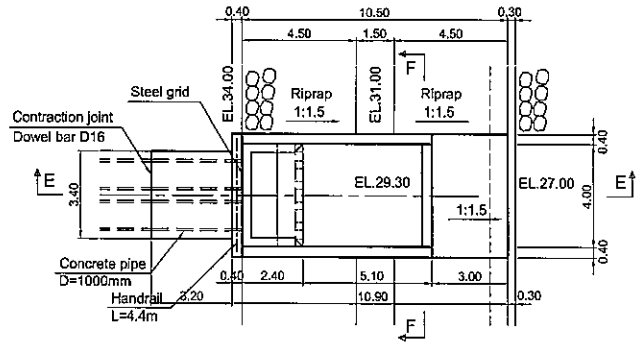
THE KINGDOM OF CAMBODIA			
THE PROJECT FOR IMPROVEMNT OF ROLEANG CHREY HEADWORKS			
TITLE OF DRAWING ROLEANG CHREY REGULATOR RIVER OUTLET STRUCTURE (2/4)			
DATE	JULY 2008	DRAWING NO.	2-6
NIPPON KOEI CO., LTD., JAPAN			



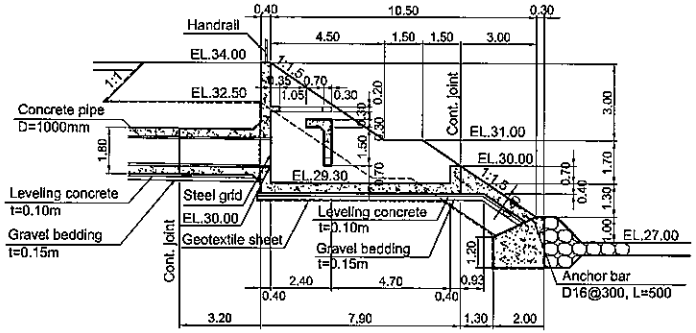
PLAN OF INLET



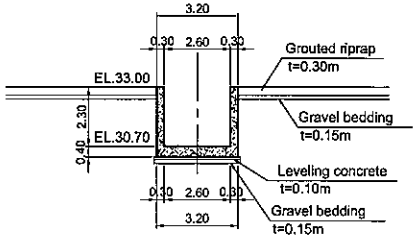
ELEVATION OF INLET



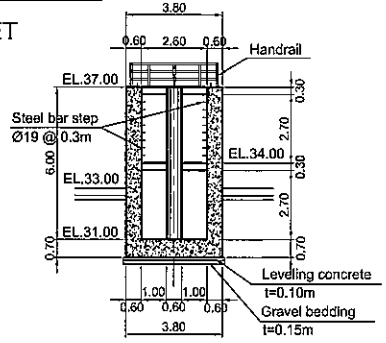
PLAN OF OUTLET



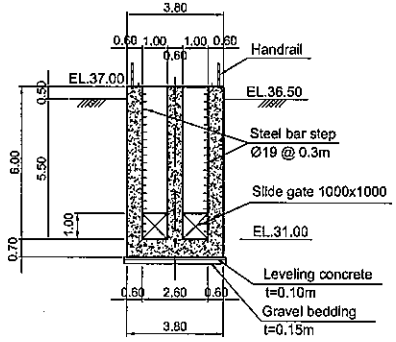
SECTION E - E



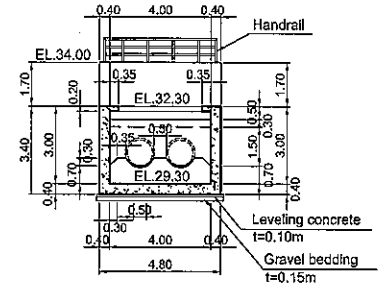
SECTION A - A



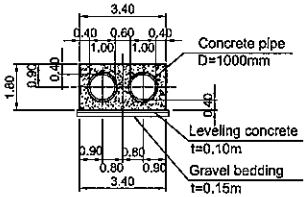
SECTION B - B



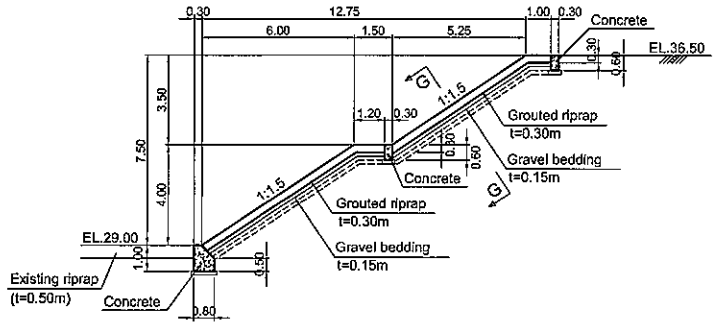
SECTION C - C



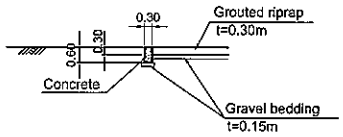
SECTION F - F



PIPE CONDUIT



UPSTREAM RIVER BANK PROTECTION

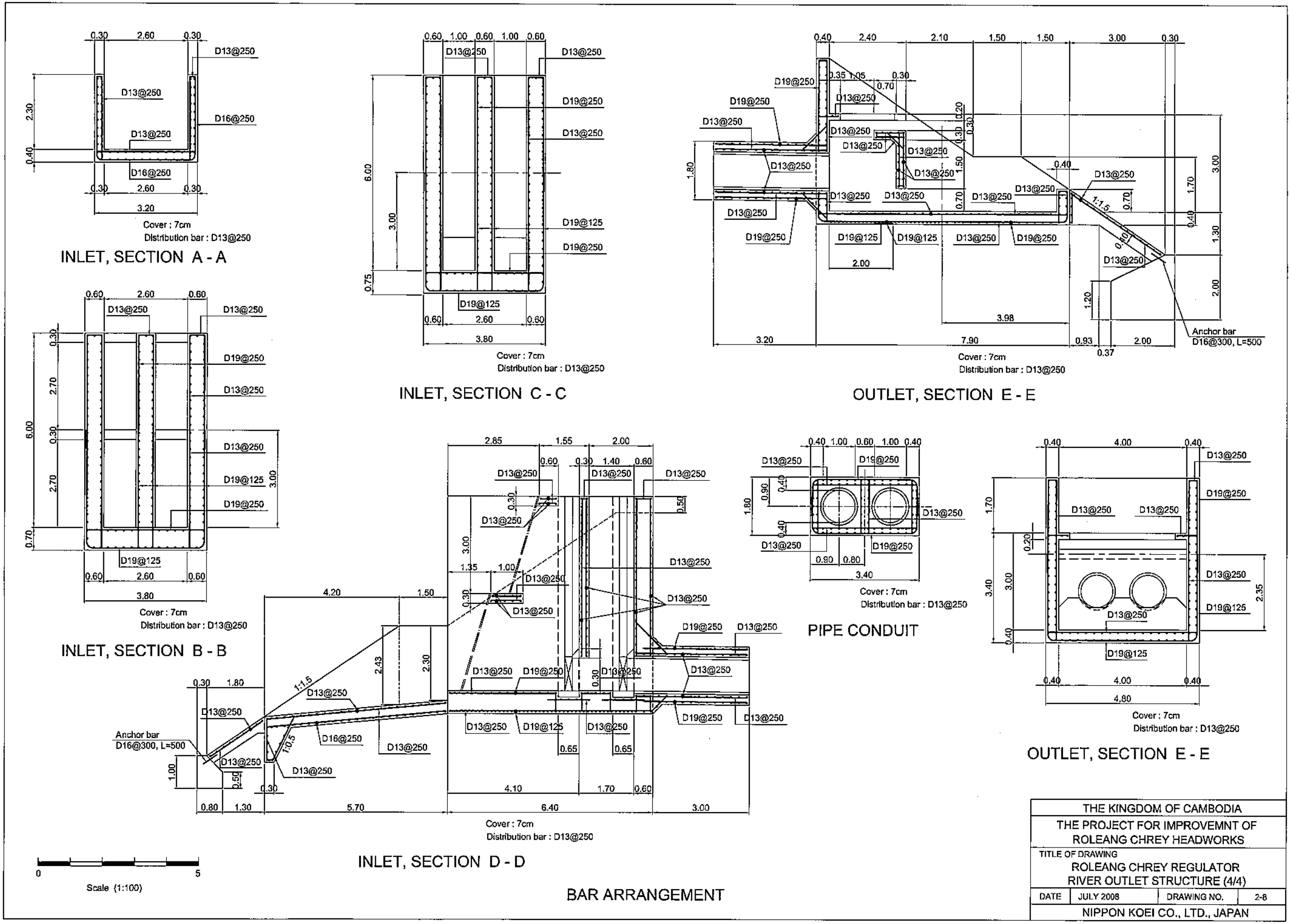


SECTION G - G

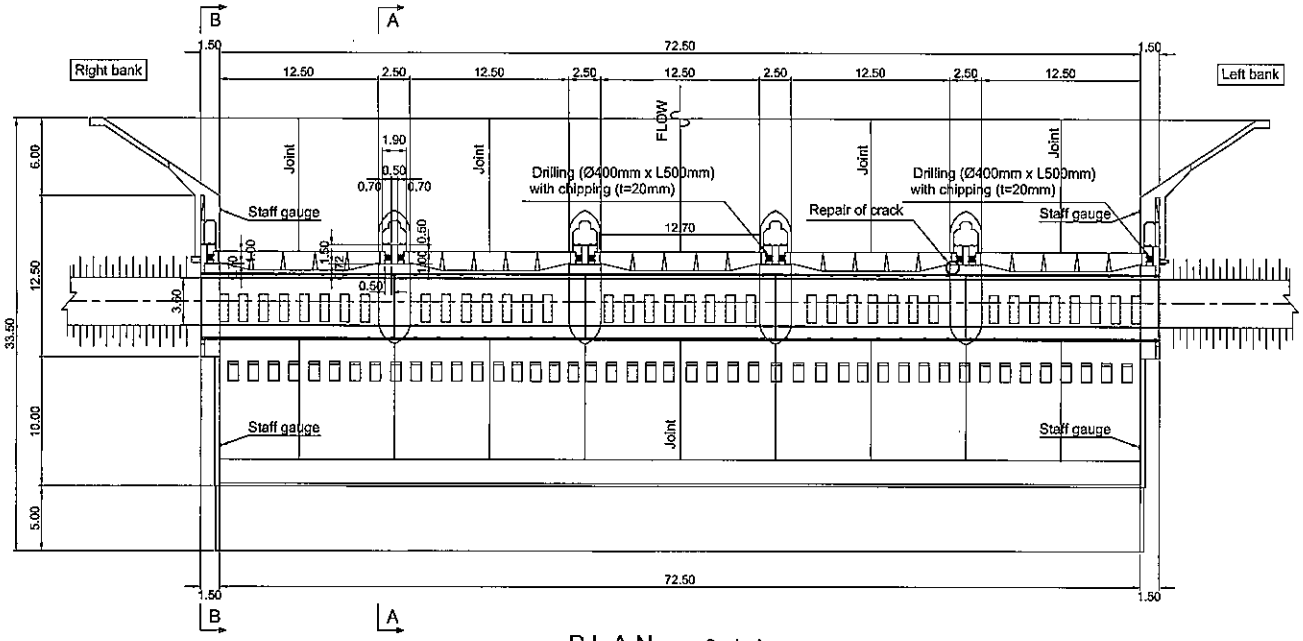
0 5 10
Scale (1:200)

For Grouted riprap and Riprap, boulder with a size of 30cm - 50cm shall be used.

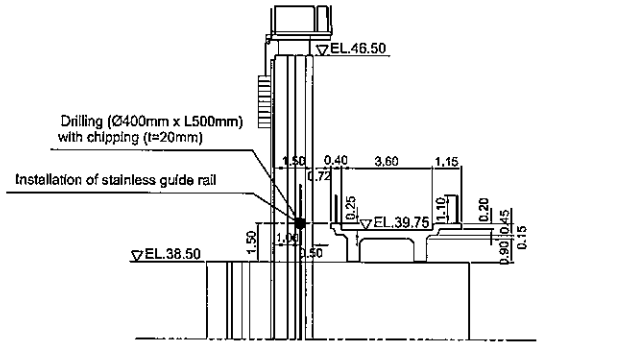
THE KINGDOM OF CAMBODIA			
THE PROJECT FOR IMPROVEMNT OF ROLEANG CHREY HEADWORKS			
TITLE OF DRAWING ROLEANG CHREY REGULATOR RIVER OUTLET STRUCTURE (3/4)			
DATE	JULY 2008	DRAWING NO.	2-7
NIPPON KOEI CO., LTD., JAPAN			



INLET, SECTION A - A
Cover : 7cm
Distribution bar : D13@250
INLET, SECTION B - B
Cover : 7cm
Distribution bar : D13@250
INLET, SECTION C - C
Cover : 7cm
Distribution bar : D13@250
OUTLET, SECTION E - E
Cover : 7cm
Distribution bar : D13@250
Anchor bar
D16@300, L=500
INLET, SECTION D - D
Cover : 7cm
Distribution bar : D13@250
PIPE CONDUIT
Cover : 7cm
Distribution bar : D13@250
OUTLET, SECTION E - E
Cover : 7cm
Distribution bar : D13@250
Scale (1:100)
BAR ARRANGEMENT
THE KINGDOM OF CAMBODIA
THE PROJECT FOR IMPROVEMNT OF
ROLEANG CHREY HEADWORKS
TITLE OF DRAWING
ROLEANG CHREY REGULATOR
RIVER OUTLET STRUCTURE (4/4)
DATE
JULY 2008
DRAWING NO.
2-8
NIPPON KOEI CO., LTD., JAPAN

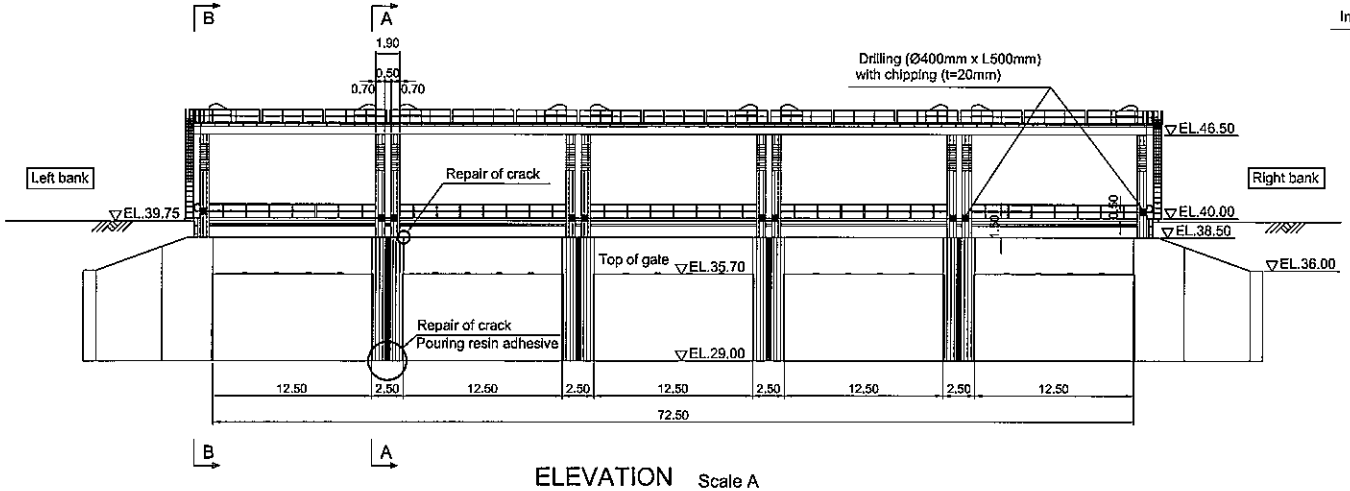


PLAN Scale A



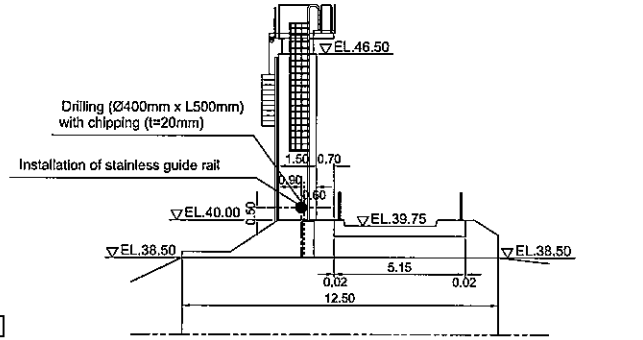
Note: Drilled pier shall be filled with non-shrinkage concrete with 8 anchor bars (D16 x 200mm).

SECTION A - A Scale B



ELEVATION Scale A

Note:Joint shall be filled with bitumen for damaged sections.



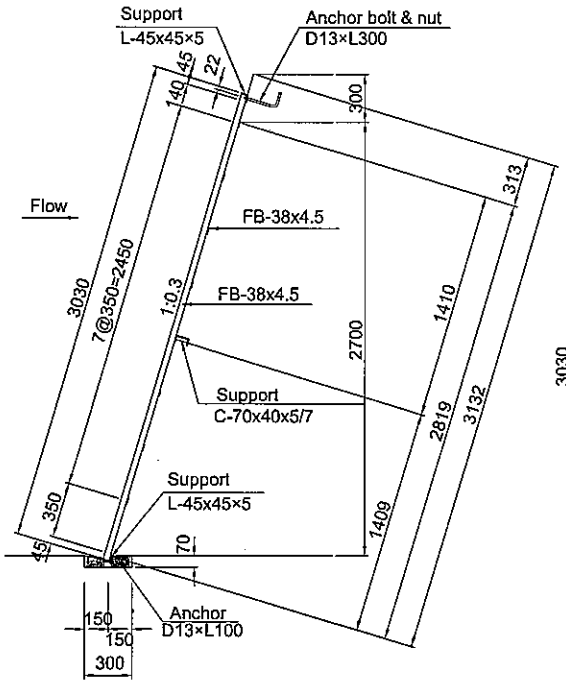
Note: Drilled pier shall be filled with non-shrinkage concrete with 8 anchor bars (D16 x 200mm).

SECTION B - B Scale B

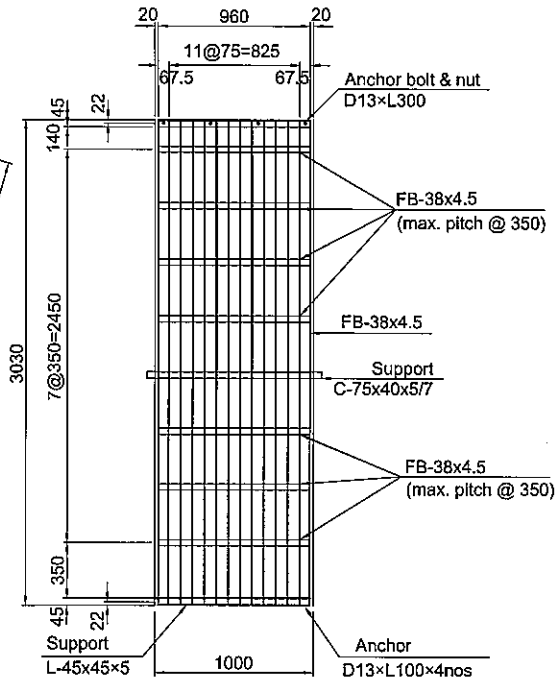
0 5 10 15 20
Scale A (1:400)

0 5 10
Scale B (1:200)

THE KINGDOM OF CAMBODIA			
THE PROJECT FOR IMPROVEMNT OF ROLEANG CHREY HEADWORKS			
TITLE OF DRAWING ROLEANG CHREY REGULATOR MISCELLANEOUS WORKS (1/3)			
DATE	JULY 2008	DRAWING NO.	2-9
NIPPON KOEI CO., LTD., JAPAN			

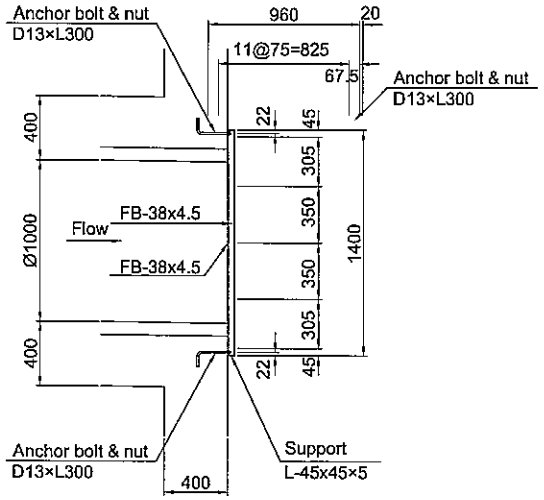


SECTION

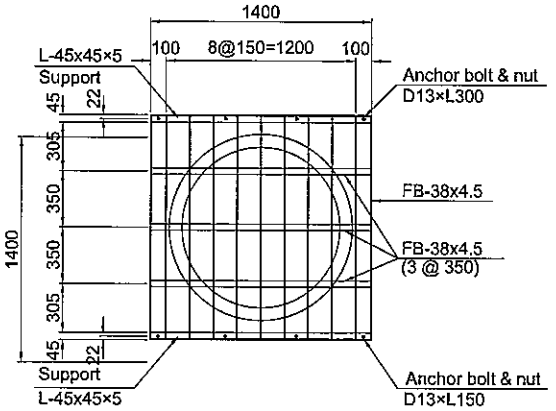


FRONT VIEW

TRASH RACK

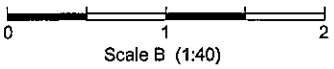


SECTION

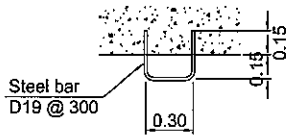


FRONT VIEW

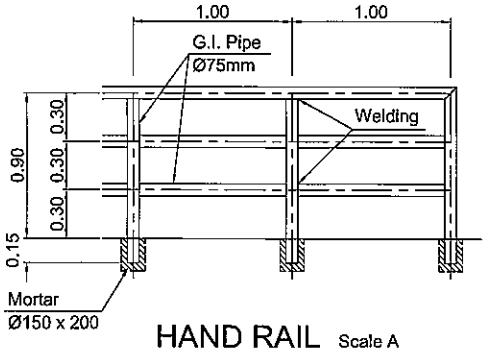
GRID



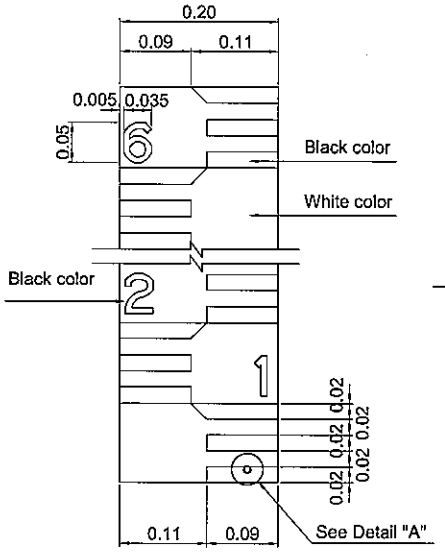
THE KINGDOM OF CAMBODIA			
THE PROJECT FOR IMPROVEMNT OF ROLEANG CHREY HEADWORKS			
TITLE OF DRAWING ROLEANG CHREY REGULATOR MISCELLANEOUS WORKS (2/3)			
DATE	JULY 2008	DRAWING NO.	2-10
NIPPON KOEI CO., LTD., JAPAN			



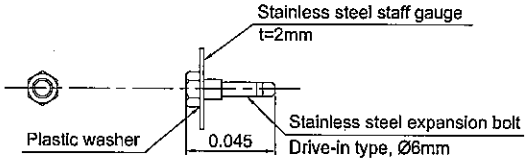
STEP Scale A



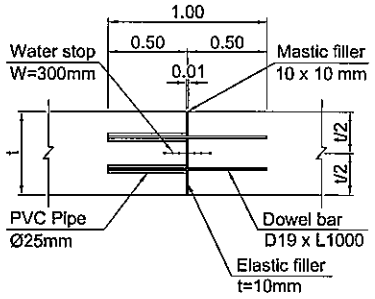
HAND RAIL Scale A



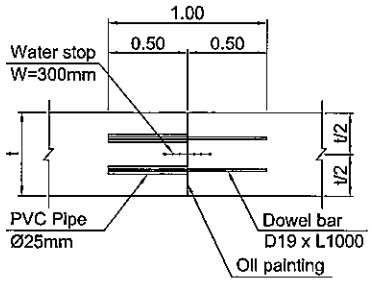
STAFF GAUGE Not to scale



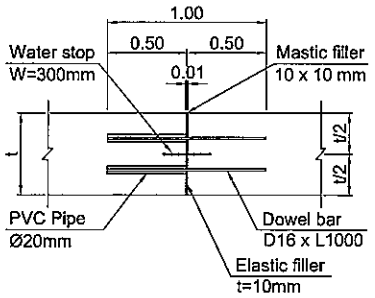
DETAIL "A" Not to scale



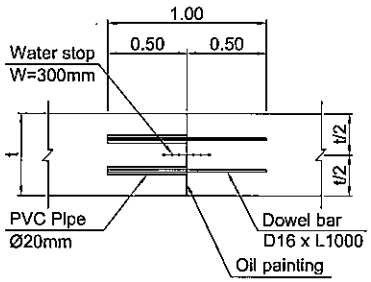
EXPANTION JOINT Type-A
Not to scale



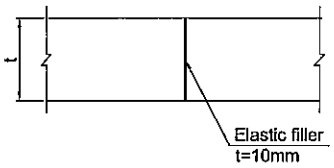
CONTRACTION JOINT Type-A
Not to scale



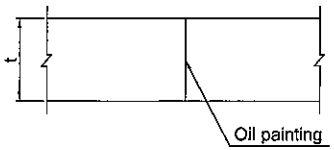
EXPANTION JOINT Type-B
Not to scale



CONTRACTION JOINT Type-B
Not to scale

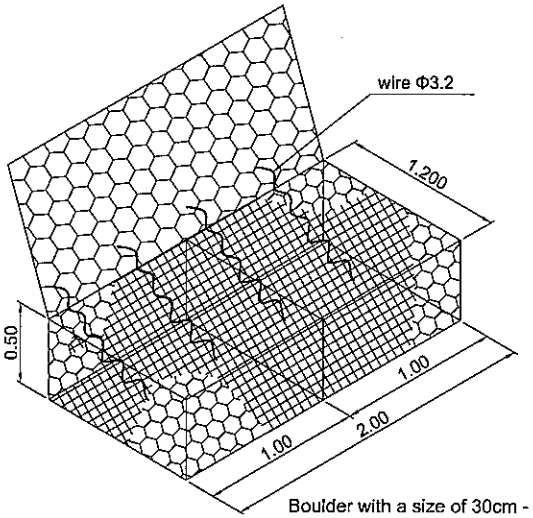


EXPANTION JOINT Type-C
Not to scale



CONTRACTION JOINT Type-C
Not to scale

Note: Type-B joint shall be applied unless otherwise specified.

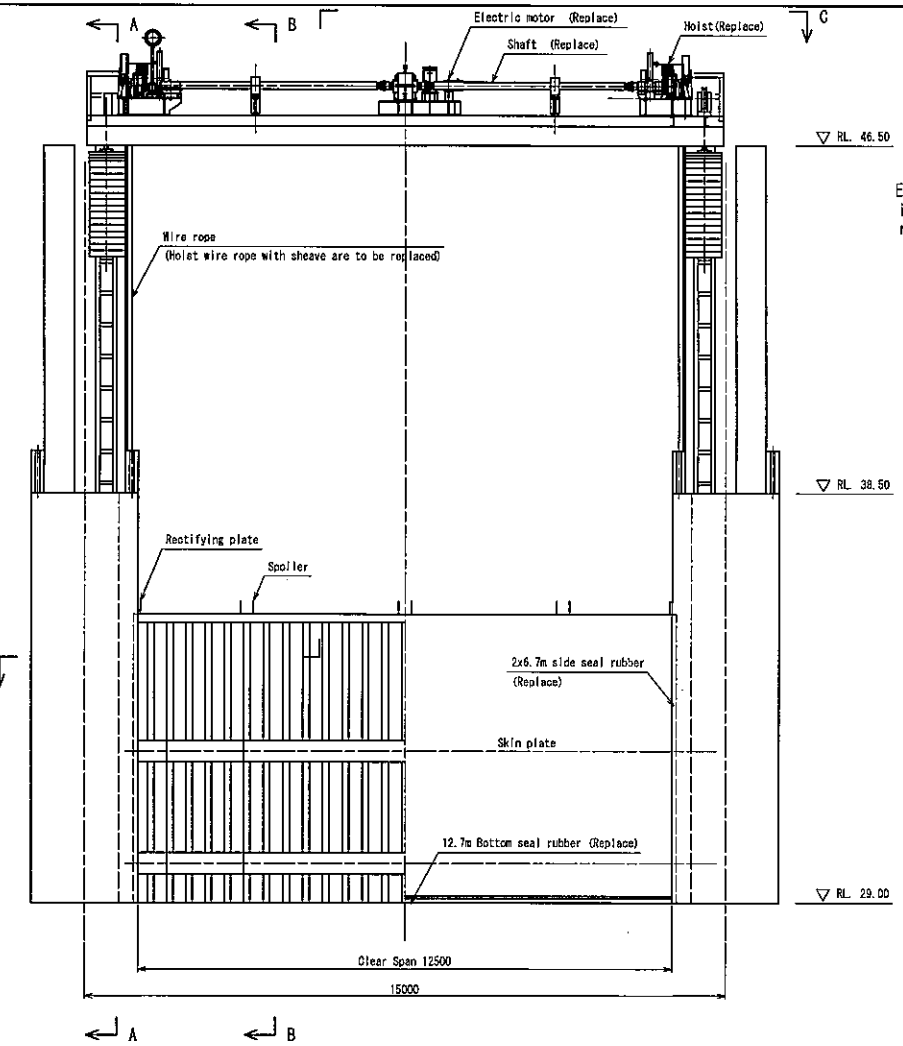


Boulder with a size of 30cm - 50cm shall be used.

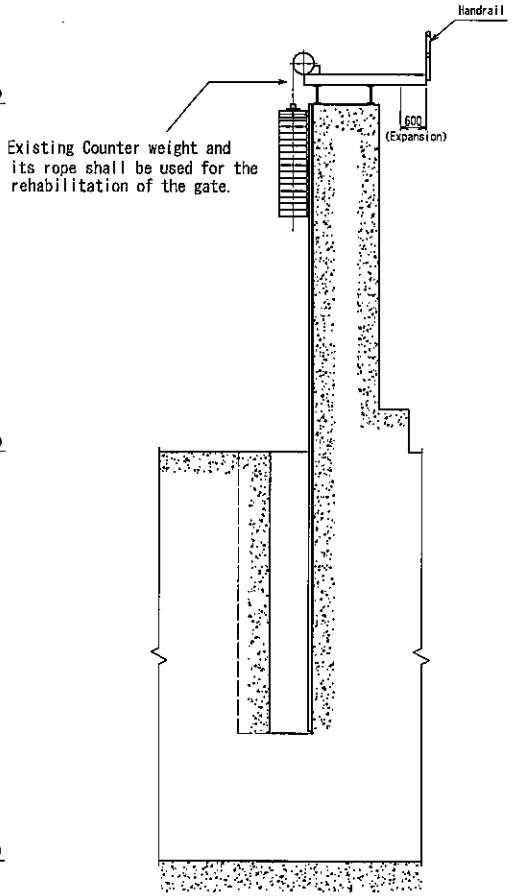
GABION Not to scale

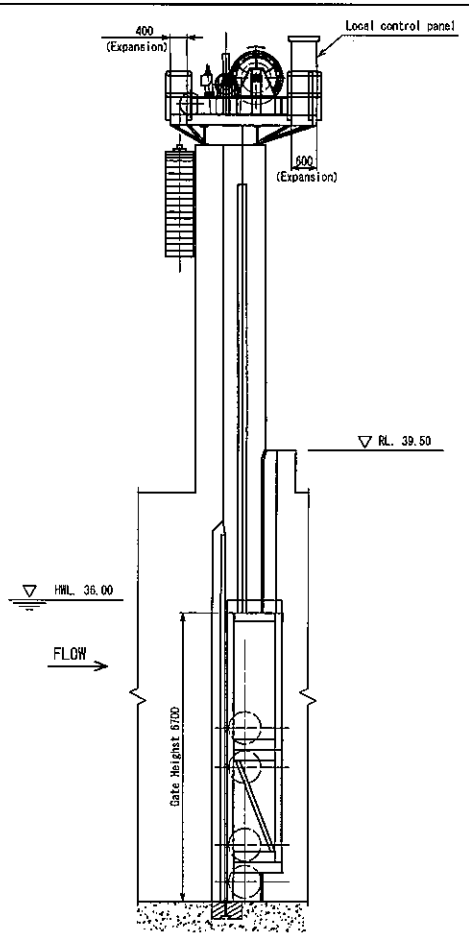
0 1 2
Scale B (1:40)

THE KINGDOM OF CAMBODIA			
THE PROJECT FOR IMPROVEMNT OF ROLEANG CHREY HEADWORKS			
TITLE OF DRAWING ROLEANG CHREY REGULATOR MISCELLANEOUS WORKS (3/3)			
DATE	JULY 2008	DRAWING NO.	2-11
NIPPON KOEI CO., LTD., JAPAN			



SECTION A-A

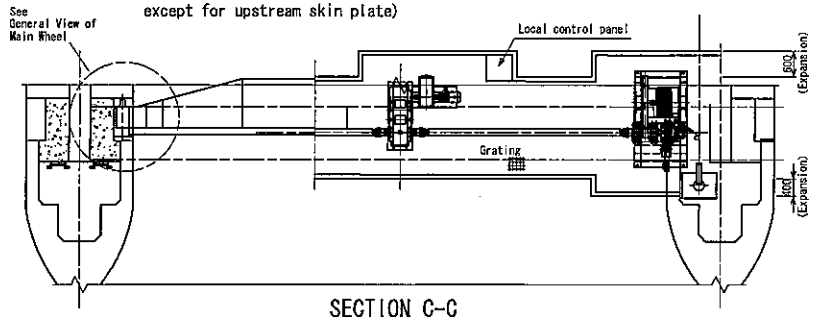




SECTION B-B

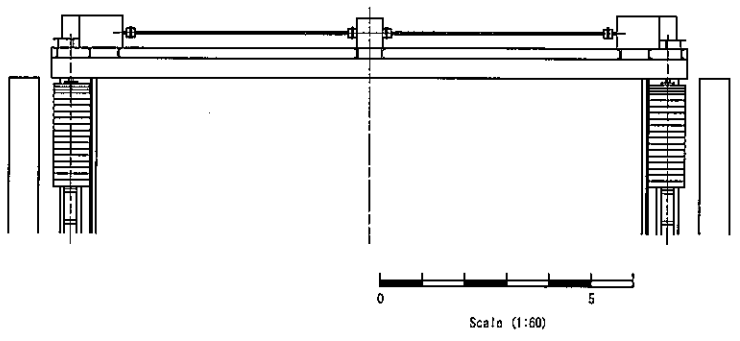
DOWNSTREAM VIEW
(Painting area : 436.3m²
except for upstream skin plate)

UPSTREAM VIEW
(Painting area : 85.8m²)

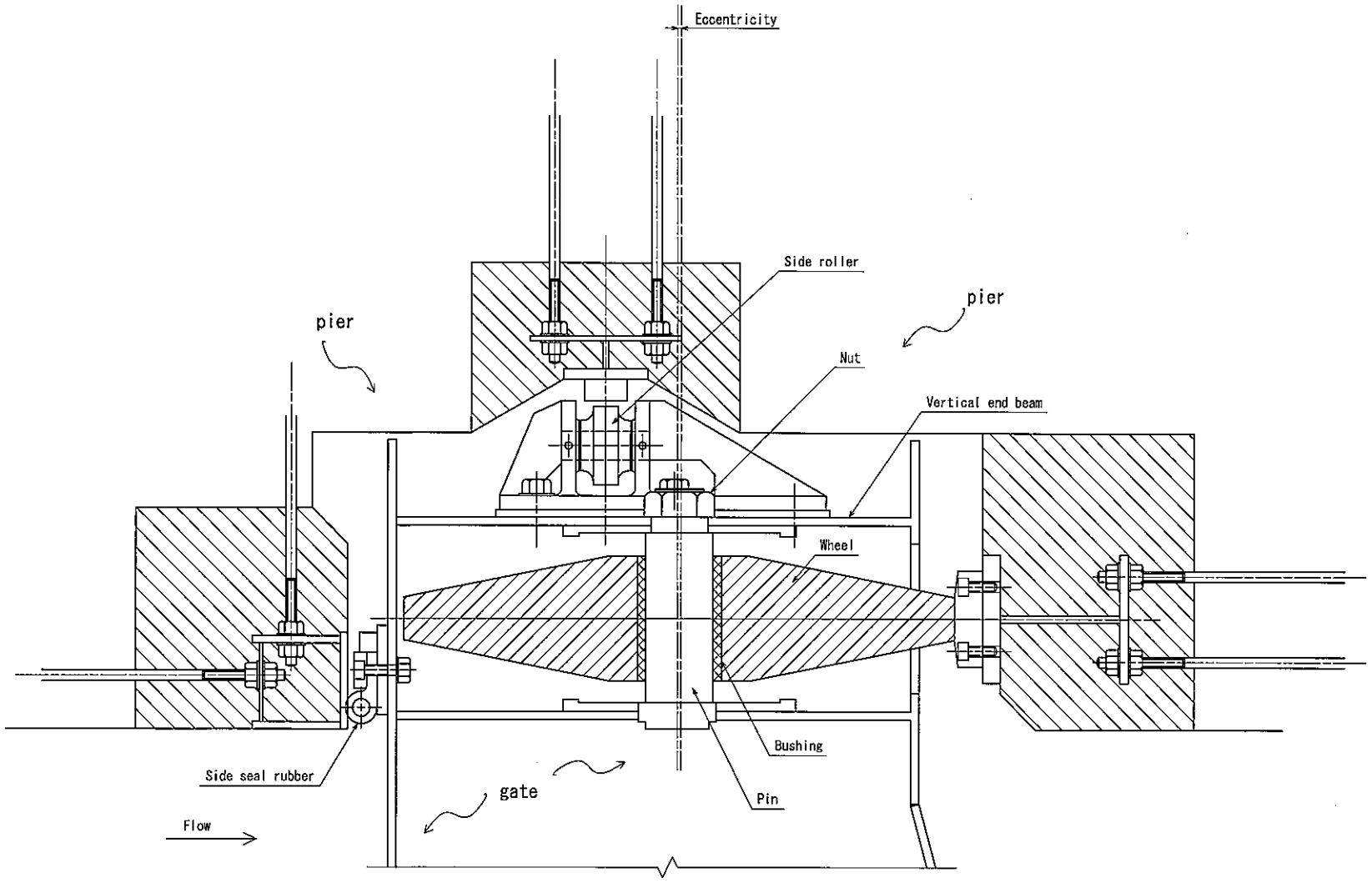


SECTION C-C

Existing hoist shown below shall be removed.



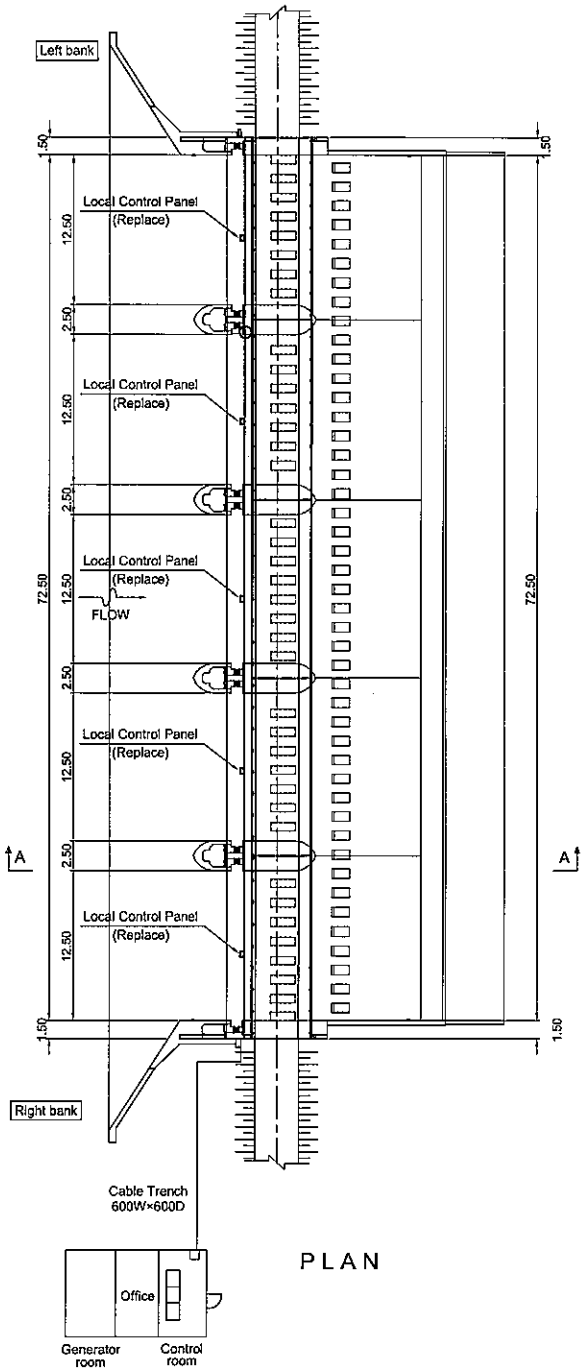
THE KINGDOM OF CAMBODIA			
THE PROJECT FOR IMPROVEMNT OF ROLEANG CHREY HEADWORKS			
TITLE OF DRAWING ROLEANG CHREY REGULATOR ELEVATIONS AND SECTIONS			
DATE	JULY 2008	DRAWING NO.	2-12
NIPPON KOEI CO., LTD., JAPAN			



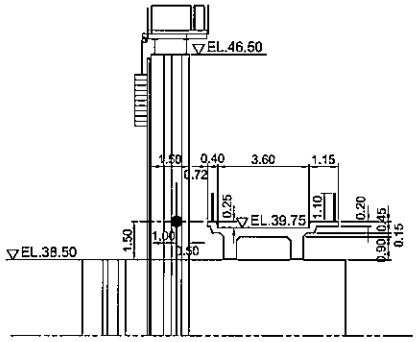
General View of Main Wheel

No Scale

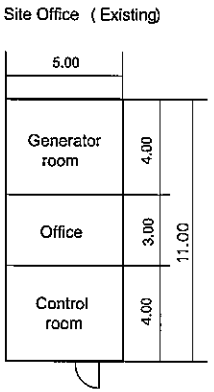
THE KINGDOM OF CAMBODIA			
THE PROJECT FOR IMPROVEMNT OF ROLEANG CHREY HEADWORKS			
TITLE OF DRAWING ROLEANG CHREY REGULATOR MAIN WHEEL GENERAL			
DATE	JULY 2008	DRAWING NO.	2-13
NIPPON KOEI CO., LTD., JAPAN			

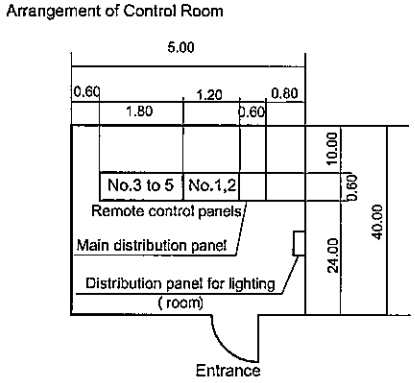


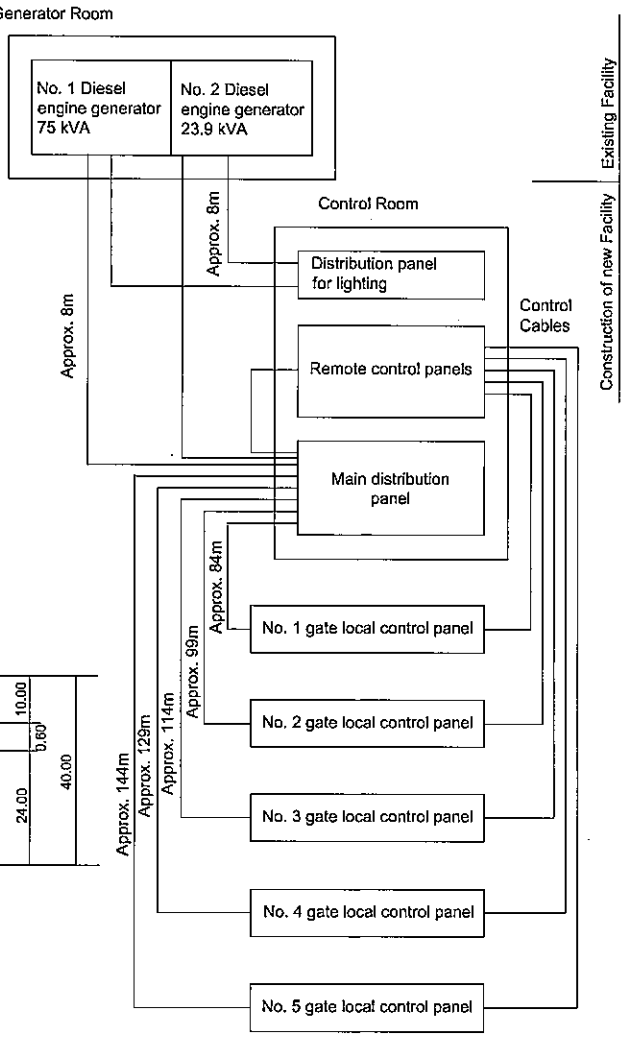
PLAN



SECTION A - A



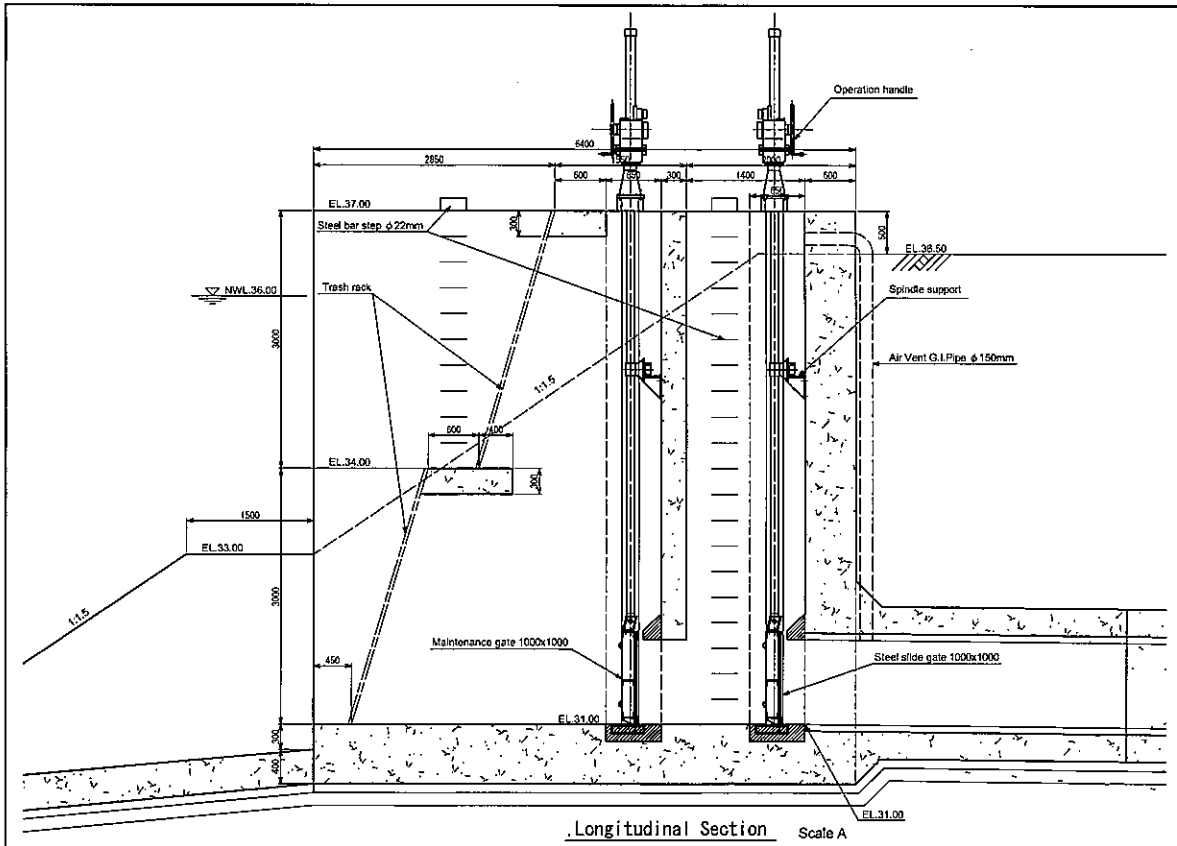




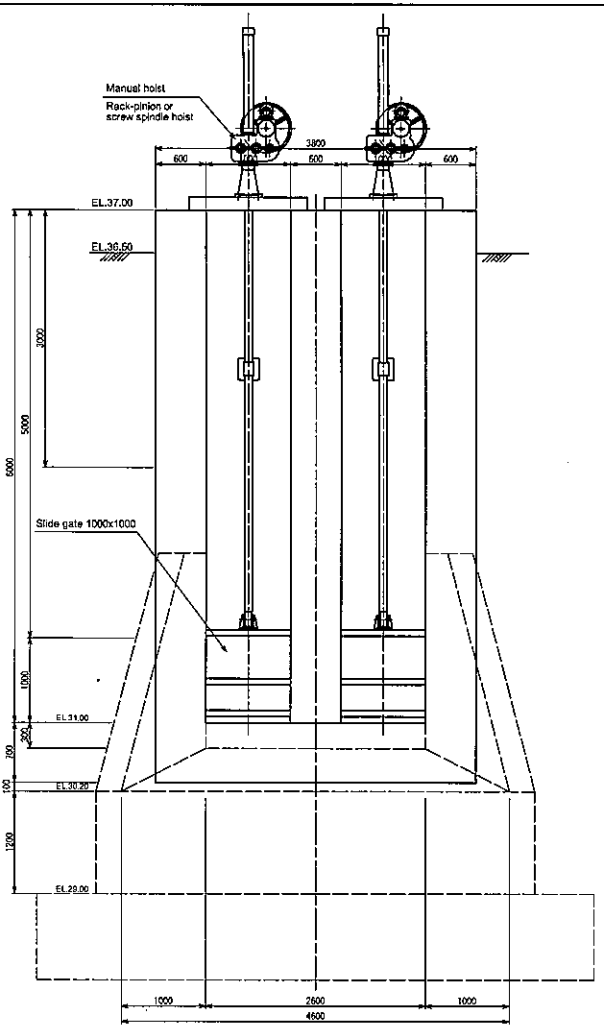
Electric Power Supply System

Installation of three lightning rods with earthing network shall be carried out according to instruction of the Engineer.

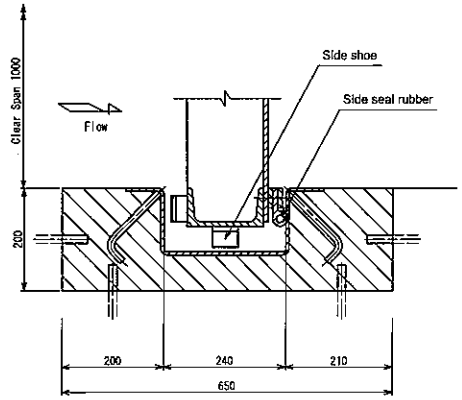
THE KINGDOM OF CAMBODIA			
THE PROJECT FOR IMPROVEMNT OF ROLEANG CHREY HEADWORKS			
TITLE OF DRAWING ROLEANG CHREY REGULATOR Electric System (Regulator's Gates)			
DATE	JULY 2008	DRAWING NO.	2-14
NIPPON KOEI CO., LTD., JAPAN			



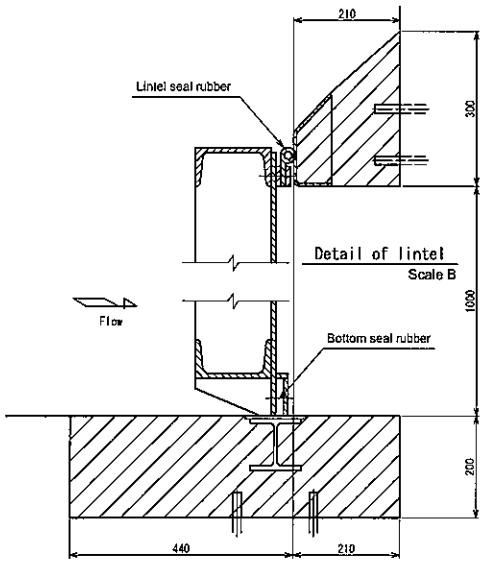
.Longitudinal Section Scale A



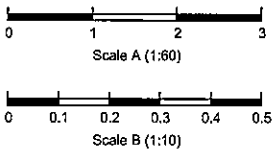
Elevation of Inlet Scale A



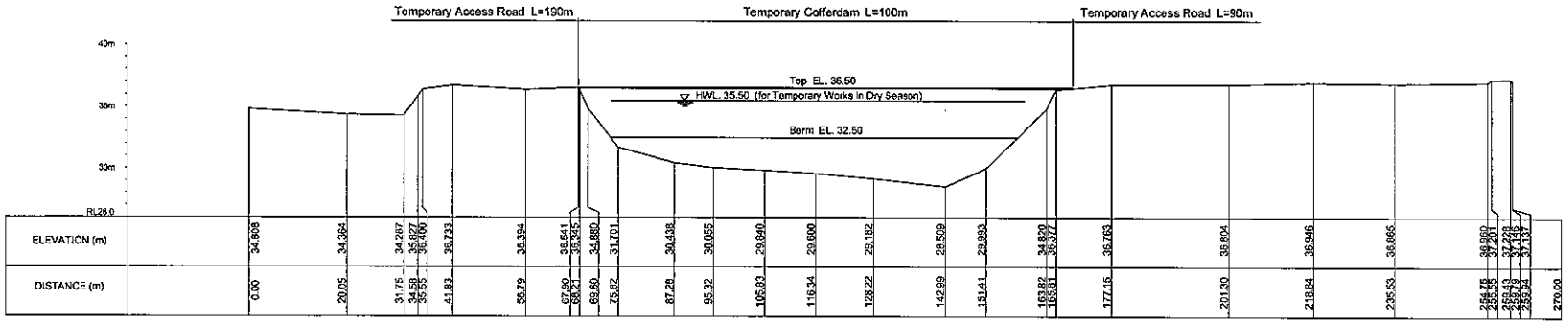
Detail of side seal and side shoe Scale B



Detail of sill Scale B



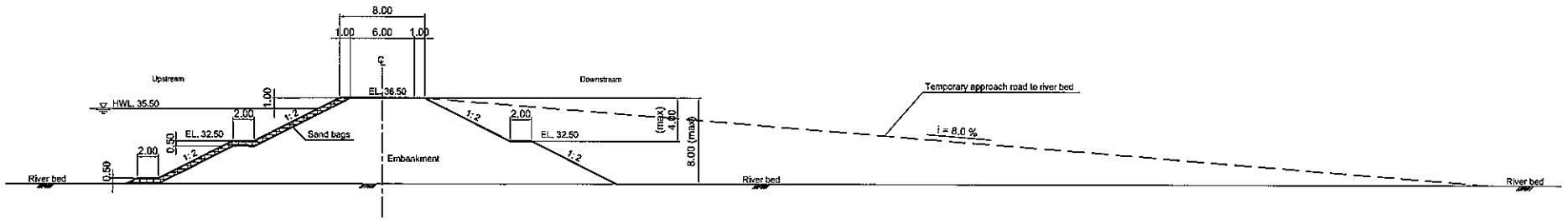
THE KINGDOM OF CAMBODIA			
THE PROJECT FOR IMPROVEMNT OF ROLEANG CHREY HEADWORKS			
TITLE OF DRAWING ROLEANG CHREY REGULATOR RIVER OUTLET STRUCTURE GATE			
DATE	JULY 2008	DRAWING NO.	2-15
NIPPON KOEI CO., LTD., JAPAN			



Note: River cross section survey was done in the fesibility study of Prek Thnot River basin in 2008.

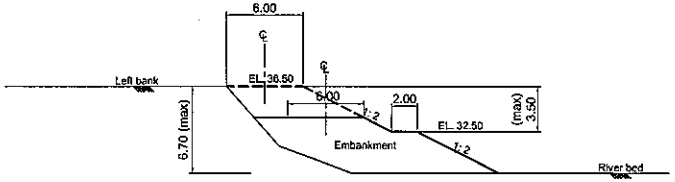
Elevation
of Temporary Cofferdam

Vertical Scale B
Horizontal Scale A



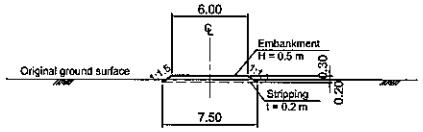
Typical Cross Section
of Temporary Cofferdam

Scale B



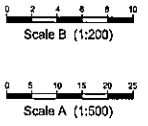
Typical Cross Section
of Temporary Approach Road to River Bed

Scale B

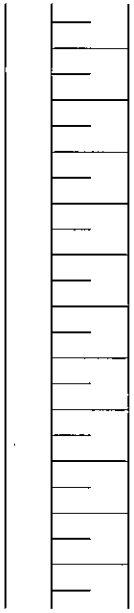


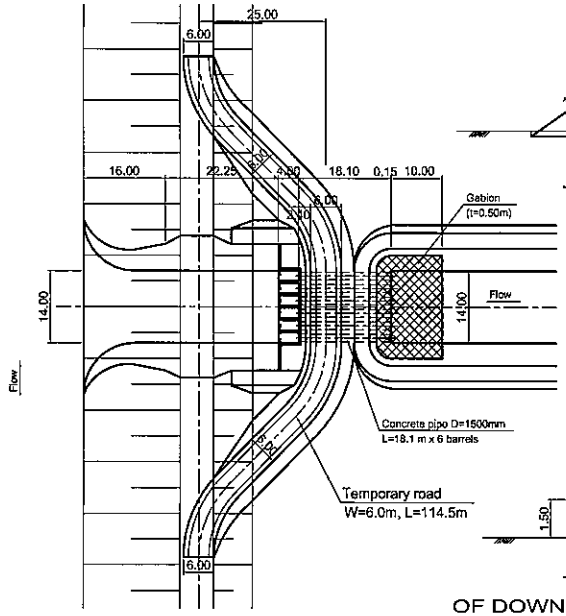
Typical Cross Section
of Temporary Access Road

Scale B

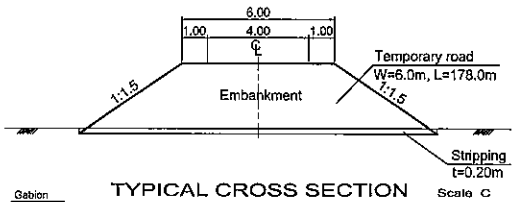


THE KINGDOM OF CAMBODIA			
THE PROJECT FOR IMPROVEMNT OF ROLEANG CHREY HEADWORKS			
TITLE OF DRAWING ROLEANG CHREY REGULATOR TEMPORARY COFFERDAM AND APPROACH ROAD			
DATE	JULY 2008	DRAWING NO.	2-16
NIPPON KOEI CO., LTD., JAPAN			

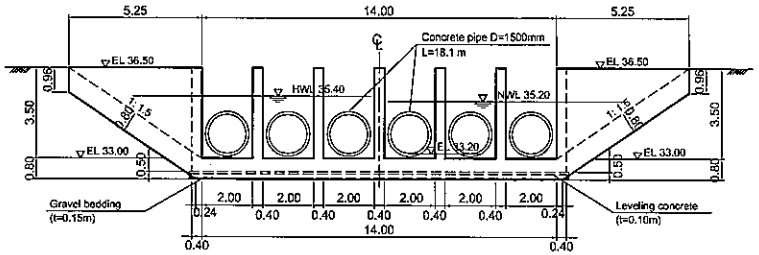




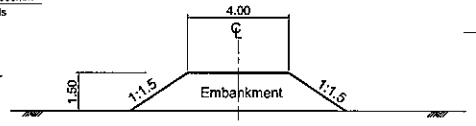
PLAN Scale A



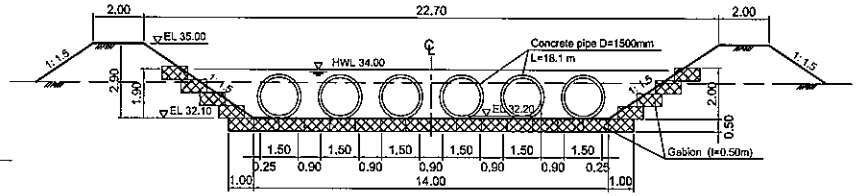
TYPICAL CROSS SECTION OF TEMPORARY ROAD Scale C



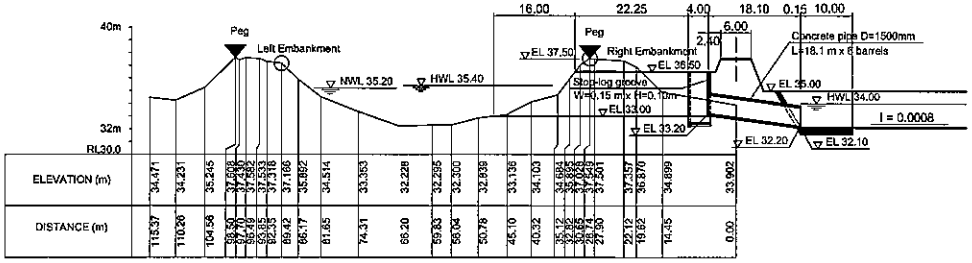
CROSS SECTION AT INLET Scale C
(UPSTREAM OF CONDUIT)



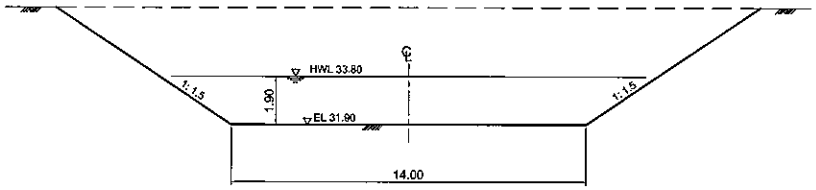
TYPICAL CROSS SECTION
OF DOWNSTREAM TEMPORARY COFFERDAM Scale C



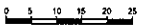
CROSS SECTION AT INLET Scale C
(DOWNSTREAM OF CONDUIT)



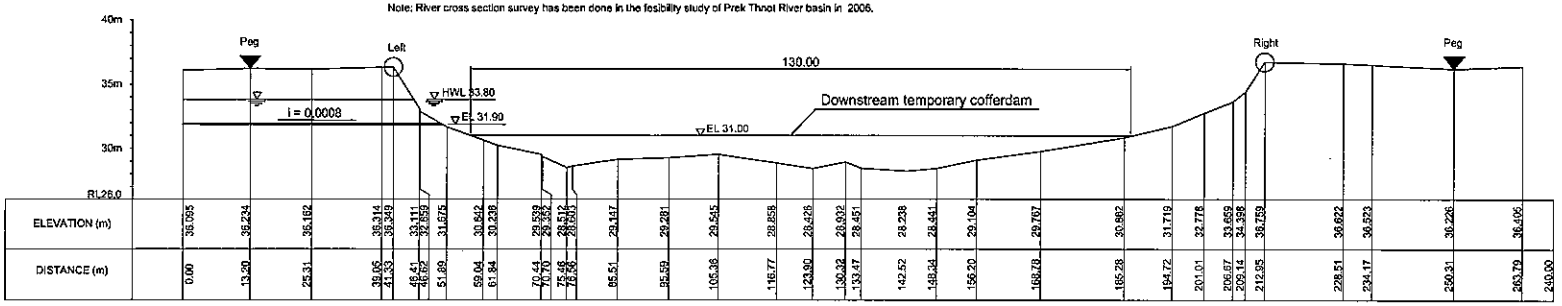
LONGITUDINAL SECTION AT INLET Vertical Scale B
Horizontal Scale A



CROSS SECTION AT OUTLET Scale C



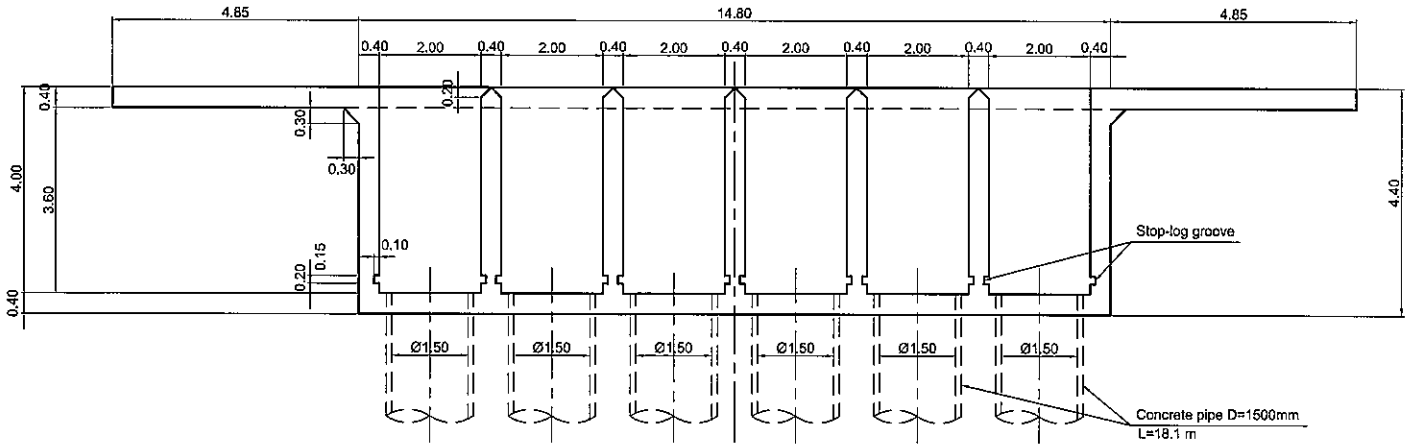
Note: River cross section survey has been done in the fesibility study of Prek Thnot River basin in 2006.



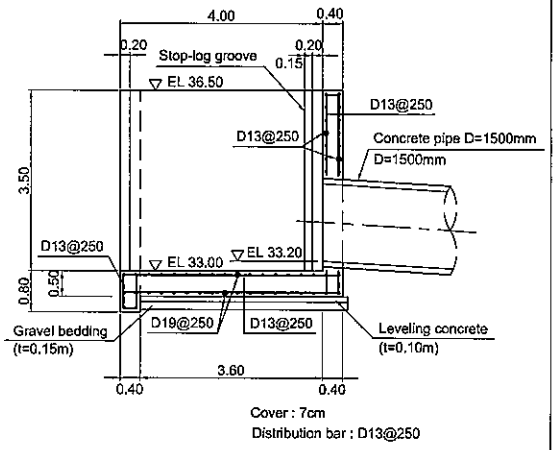
LONGITUDINAL SECTION AT OUTLET Vertical Scale B
Horizontal Scale A

Note: River cross section survey has been done in the fesibility study of Prek Thnot River basin in 2006.

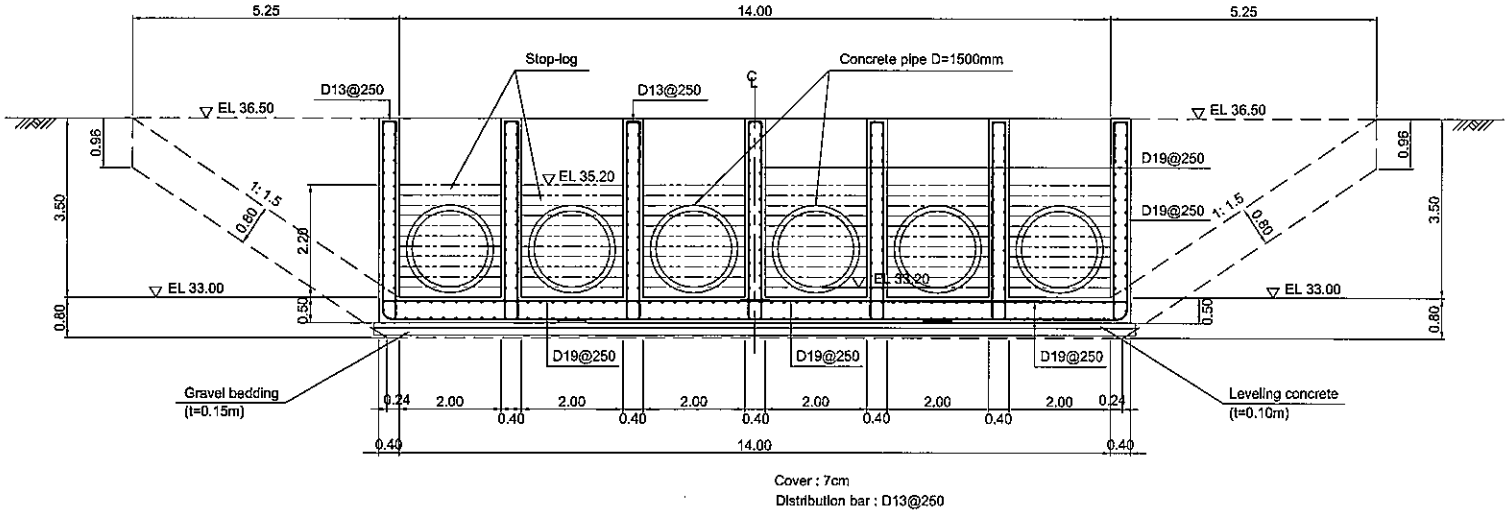
THE KINGDOM OF CAMBODIA	
THE PROJECT FOR IMPROVEMNT OF ROLEANG CHREY HEADWORKS	
TITLE OF DRAWING ROLEANG CHREY REGULATOR TEMPORARY SPILLWAY (1/2)	
DATE: JULY 2008	DRAWING NO.: 2-17
NIPPON KOEI CO., LTD., JAPAN	



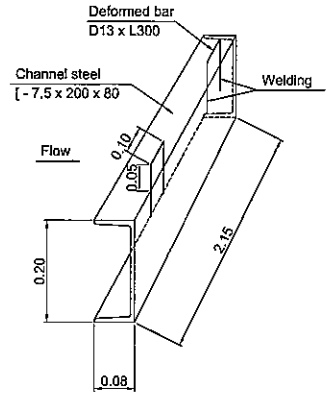
INLET, P L A N



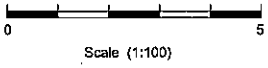
INLET, LONGITUDINAL SECTION



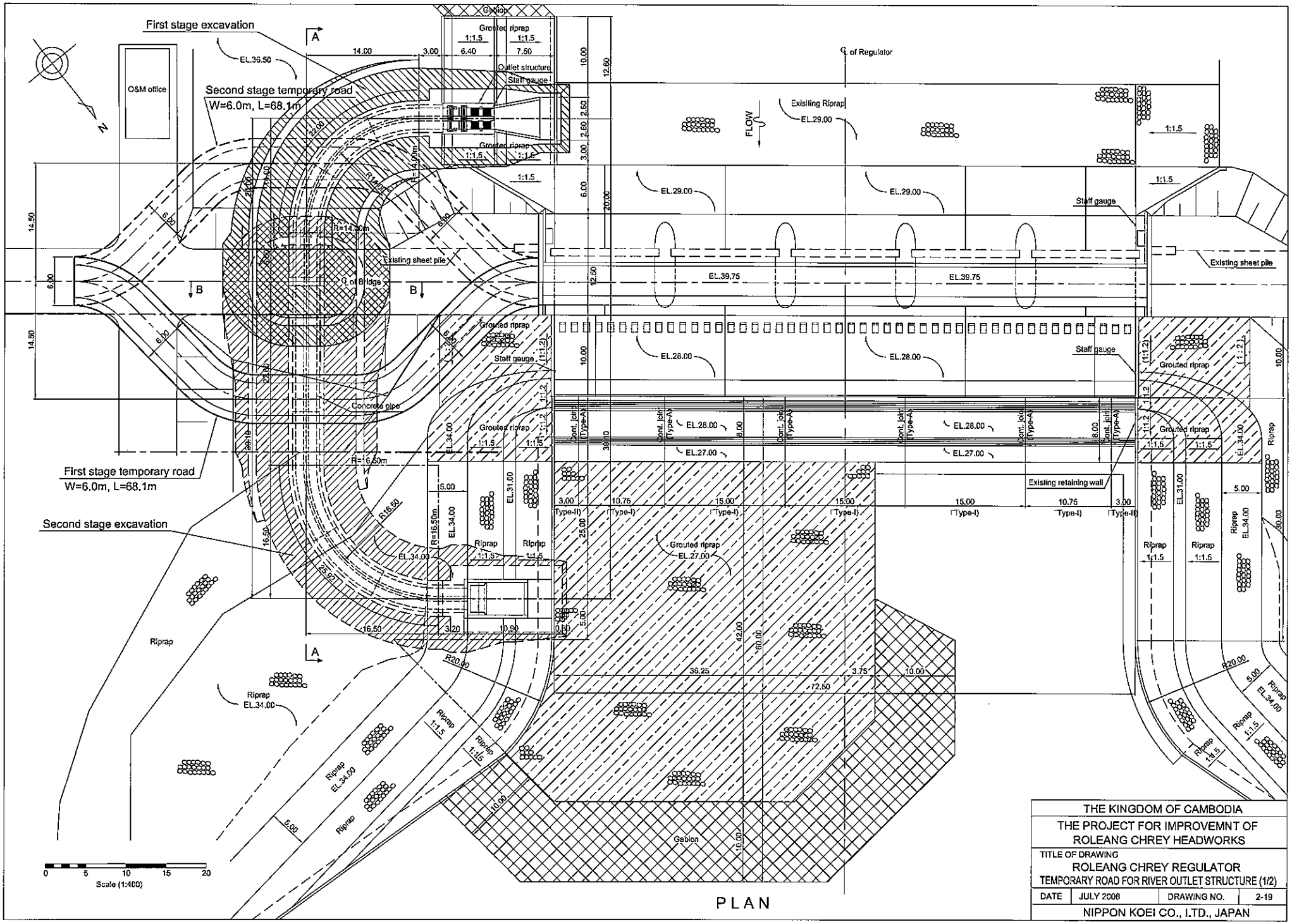
INLET, CROSS SECTION



STOP-LOG Not to scale

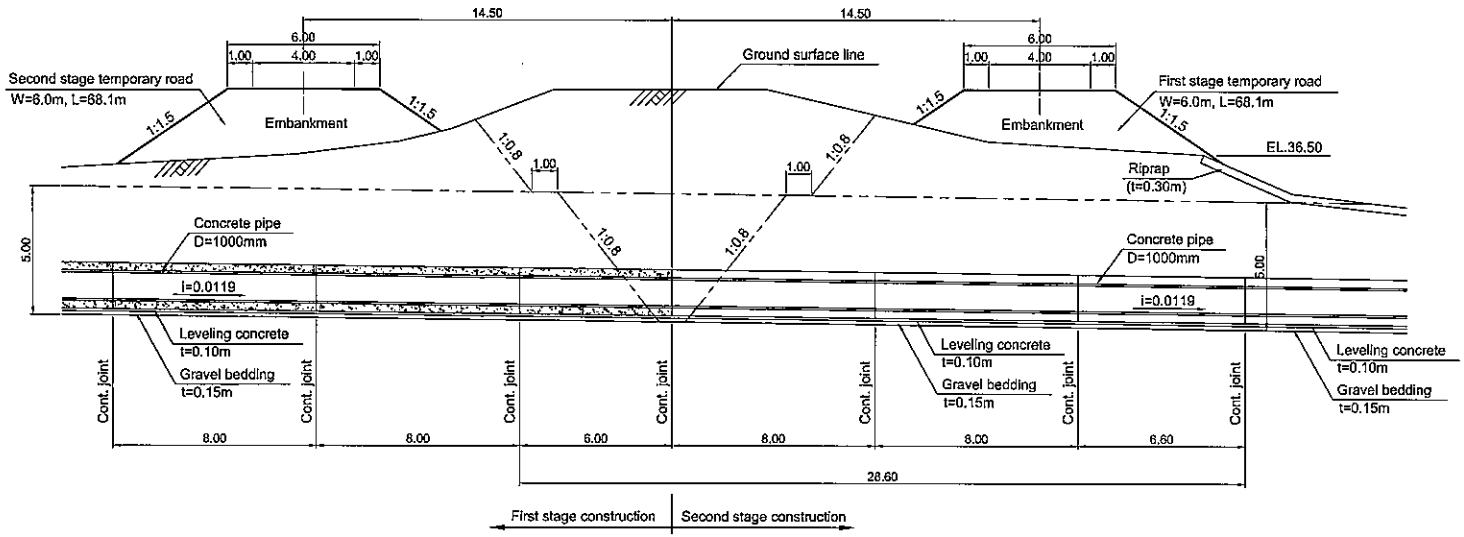


THE KINGDOM OF CAMBODIA			
THE PROJECT FOR IMPROVEMNT OF ROLEANG CHREY HEADWORKS			
TITLE OF DRAWING ROLEANG CHREY REGULATOR TEMPORARY SPILLWAY (2/2)			
DATE	JULY 2008	DRAWING NO.	2-18
NIPPON KOEI CO., LTD., JAPAN			

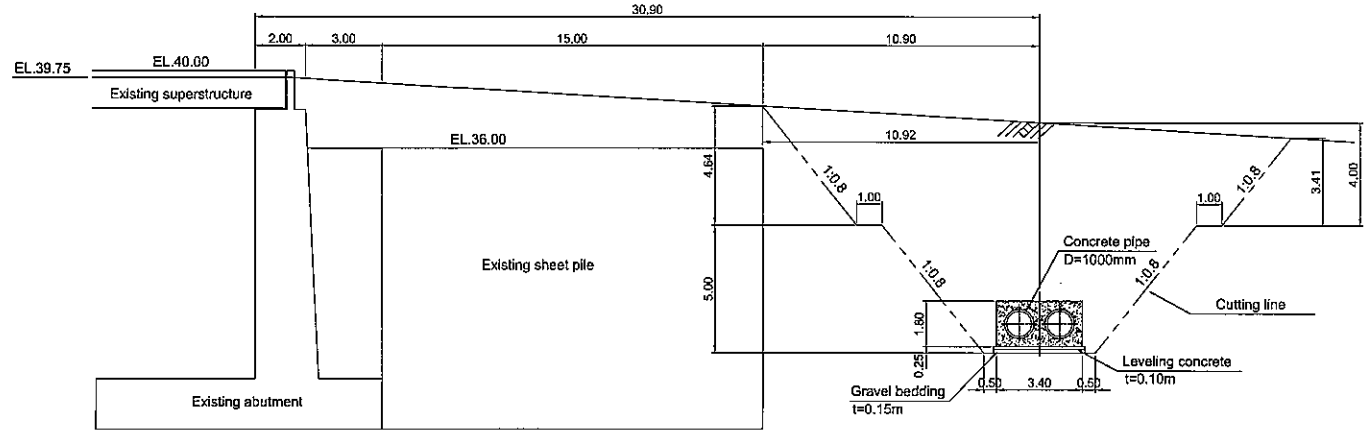


PLAN

THE KINGDOM OF CAMBODIA	
THE PROJECT FOR IMPROVEMNT OF ROLEANG CHREY HEADWORKS	
TITLE OF DRAWING	
ROLEANG CHREY REGULATOR TEMPORARY ROAD FOR RIVER OUTLET STRUCTURE (1/2)	
DATE: JULY 2008	DRAWING NO.: 2-19
NIPPON KOEI CO., LTD., JAPAN	



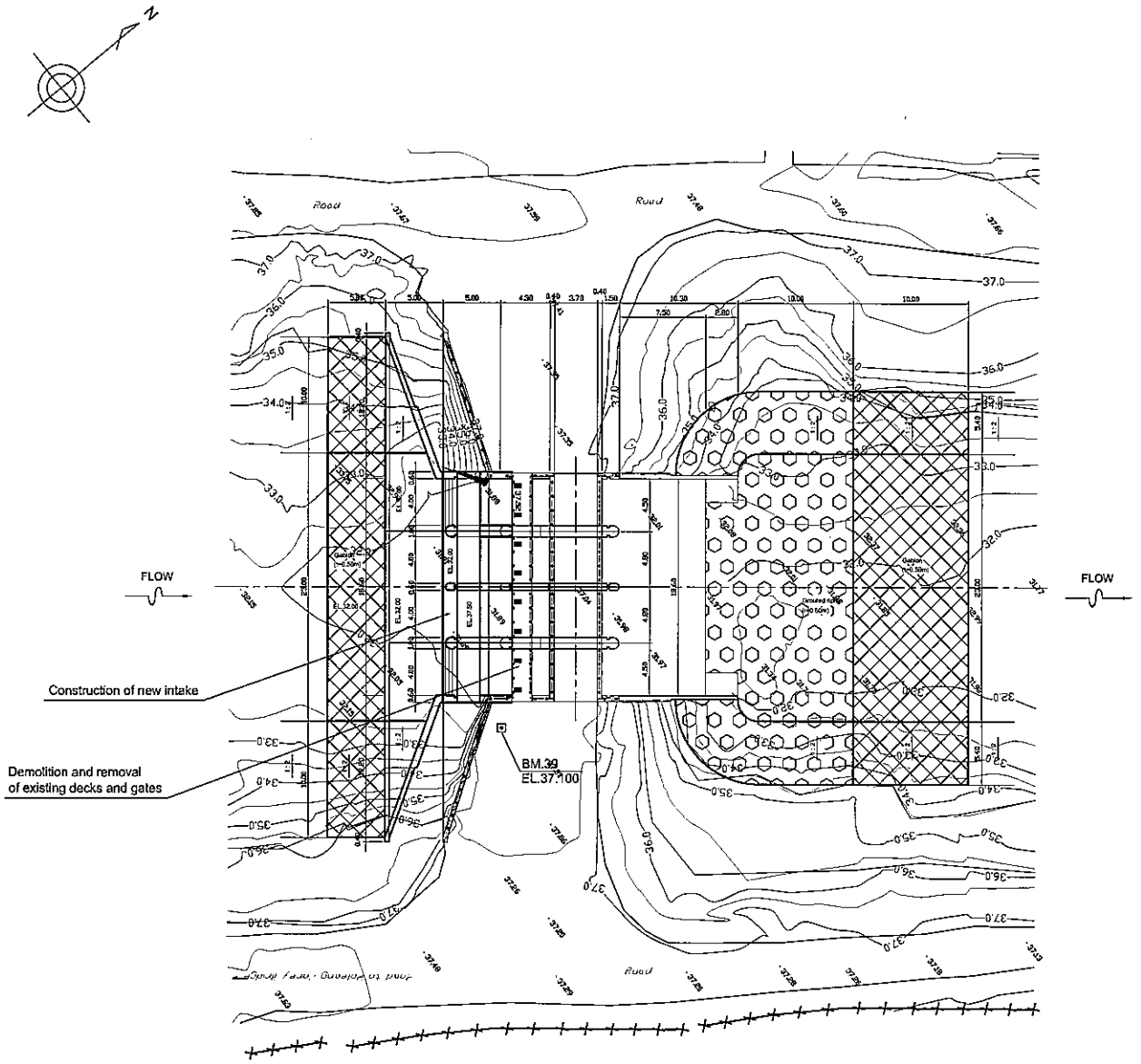
SECTION A - A



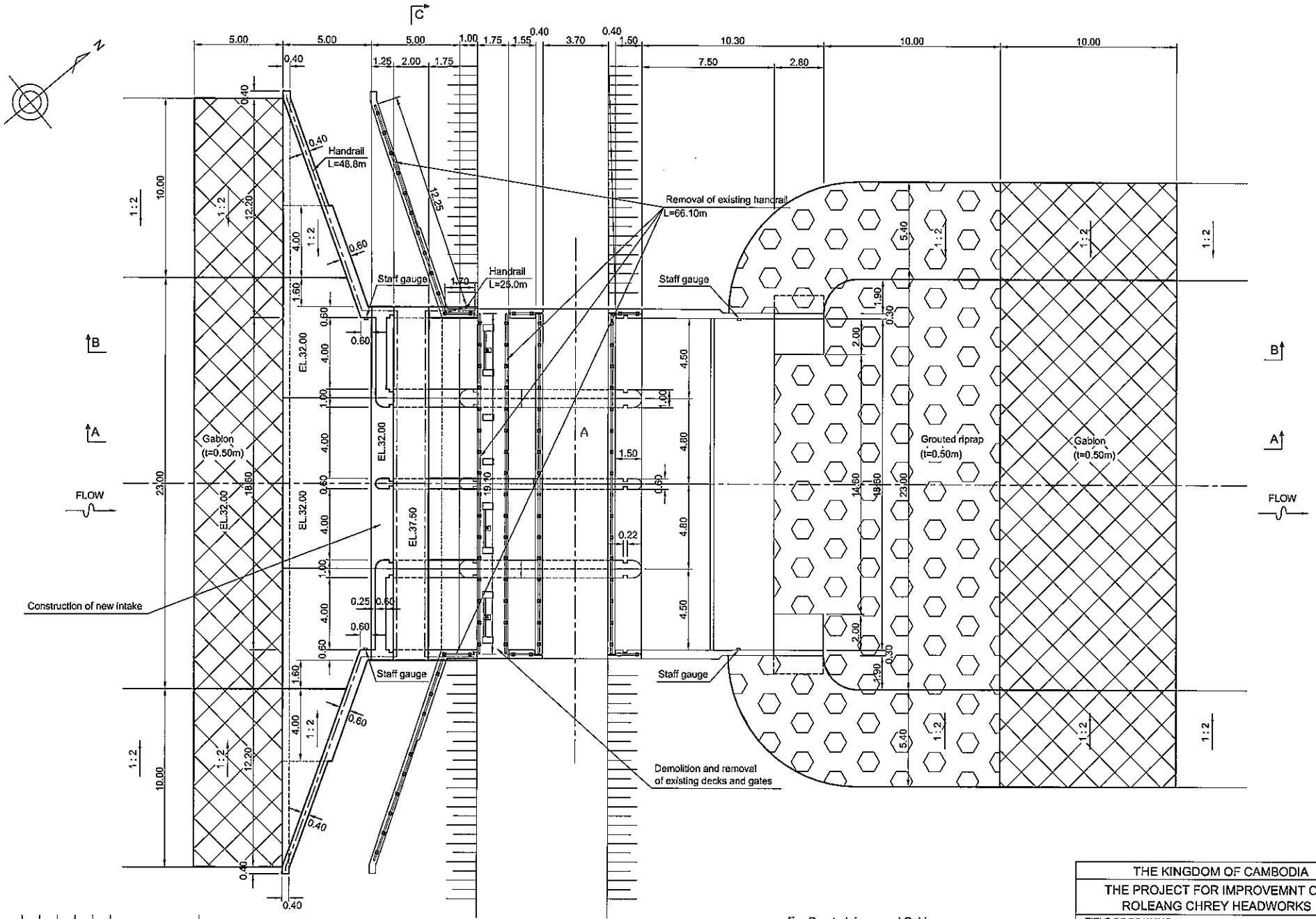
SECTION B - B

0 5 10
Scale (1:200)

THE KINGDOM OF CAMBODIA			
THE PROJECT FOR IMPROVEMNT OF ROLEANG CHREY HEADWORKS			
TITLE OF DRAWING ROLEANG CHREY REGULATOR TEMPORARY ROAD FOR RIVER OUTLET STRUCTURE (2/2)			
DATE	JULY 2008	DRAWING NO.	2-20
NIPPON KOEI CO., LTD., JAPAN			



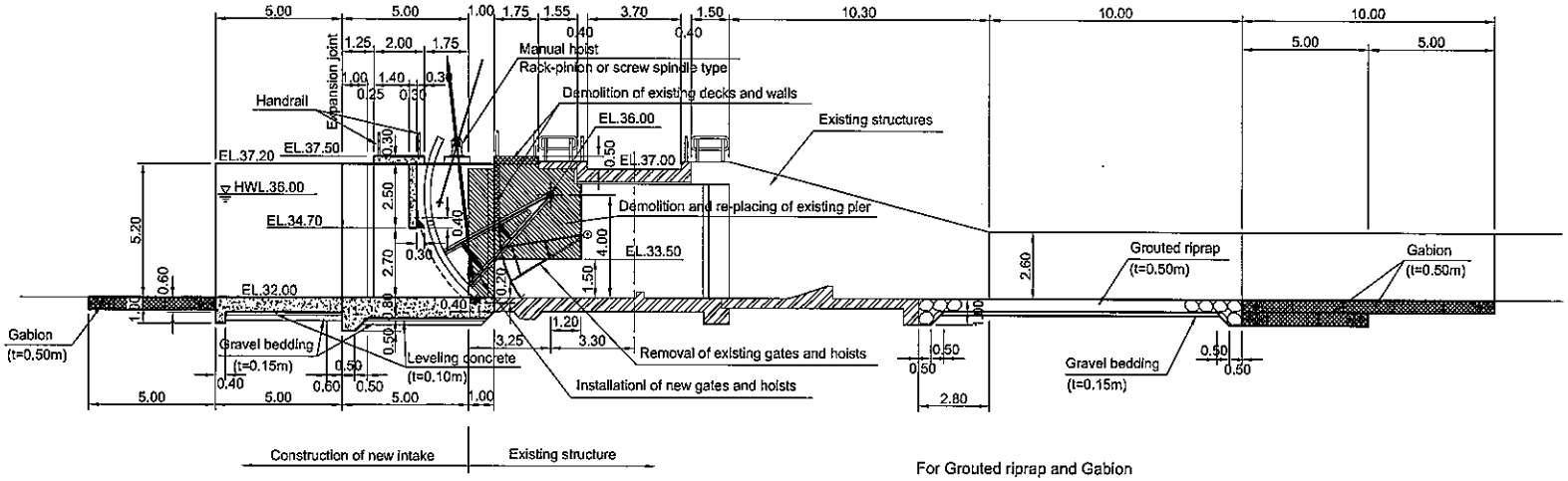
THE KINGDOM OF CAMBODIA			
THE PROJECT FOR IMPROVEMNT OF ROLEANG CHREY HEADWORKS			
TITLE OF DRAWING ANDONG SLA INTAKE GENERAL PLAN OF INTAKE STRUCTURE			
DATE	JULY 2008	DRAWING NO.	3-1
NIPPON KOEI CO., LTD., JAPAN			



PLAN

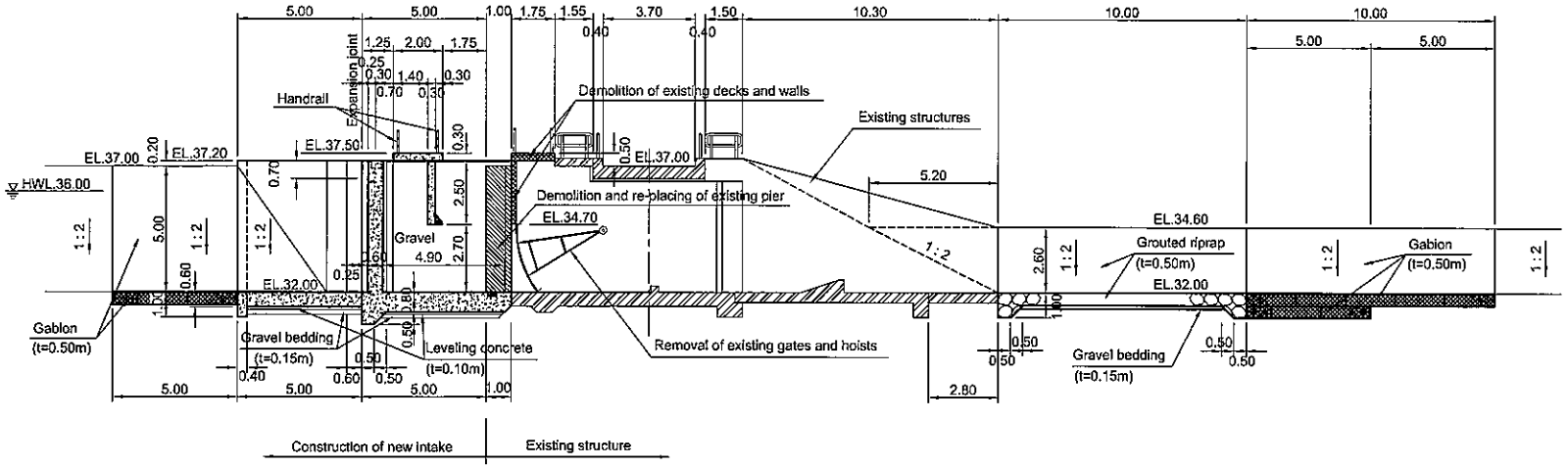
For Grouted riprap and Gabion
boulder with a size of 30cm - 50cm shall be used.

THE KINGDOM OF CAMBODIA			
THE PROJECT FOR IMPROVEMNT OF ROLEANG CHREY HEADWORKS			
TITLE OF DRAWING ANDONG SLA INTAKE INTAKE STRUCTURE (1/4)			
DATE	JULY 2008	DRAWING NO.	3-2
NIPPON KOEI CO., LTD., JAPAN			



For Grouted riprap and Gabion
boulder with a size of 30cm - 50cm shall be used.

SECTION A - A

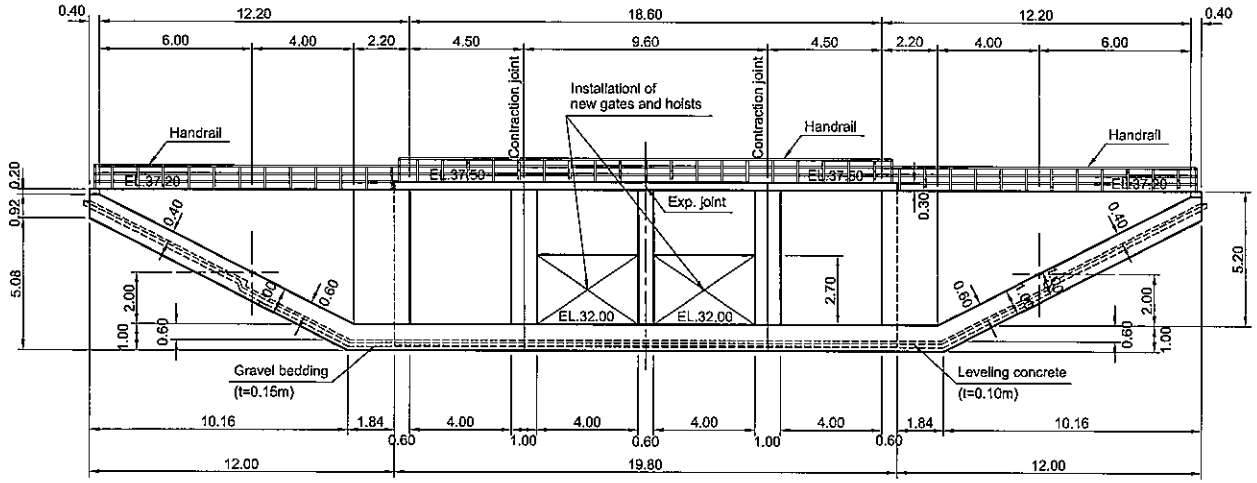


For Grouted riprap and Gabion
boulder with a size of 30cm - 50cm shall be used.

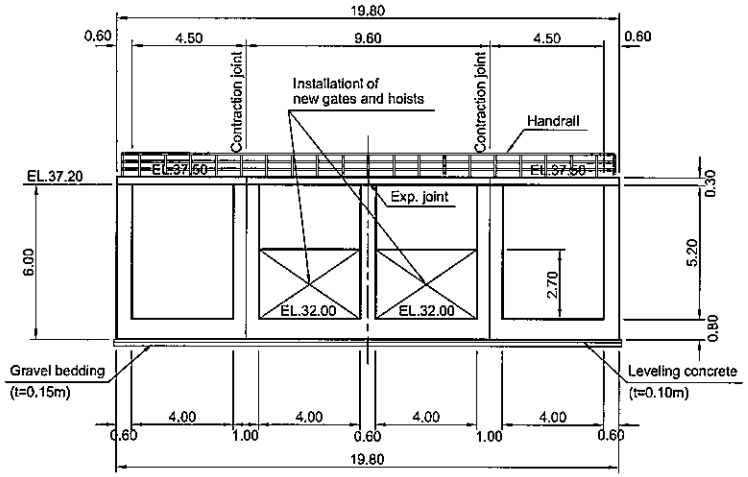
SECTION B - B

0 5 10
Scale A (1:200)

THE KINGDOM OF CAMBODIA			
THE PROJECT FOR IMPROVEMNT OF ROLEANG CHREY HEADWORKS			
TITLE OF DRAWING ANDONG SLA INTAKE INTAKE STRUCTURE (2/4)			
DATE	JULY 2008	DRAWING NO.	3-3
NIPPON KOEI CO., LTD., JAPAN			



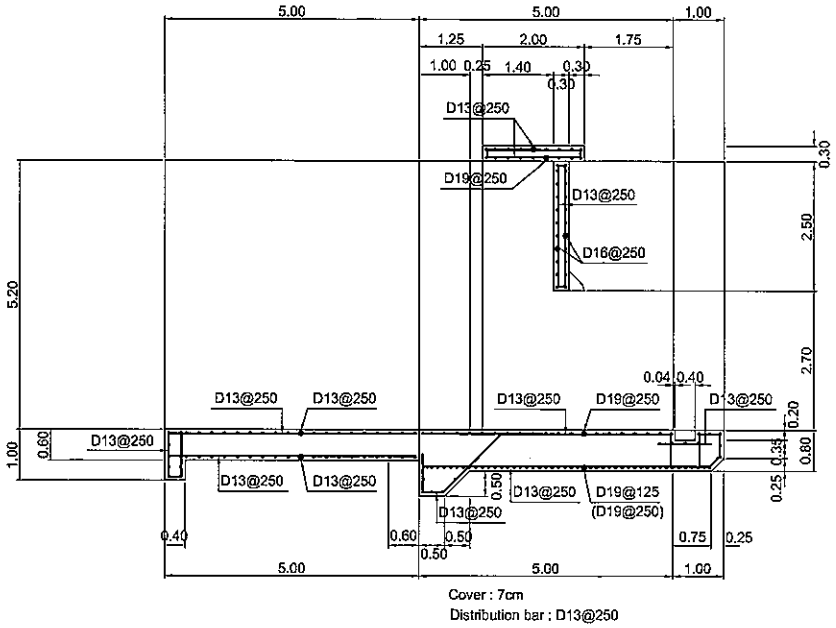
FRONT ELEVATION



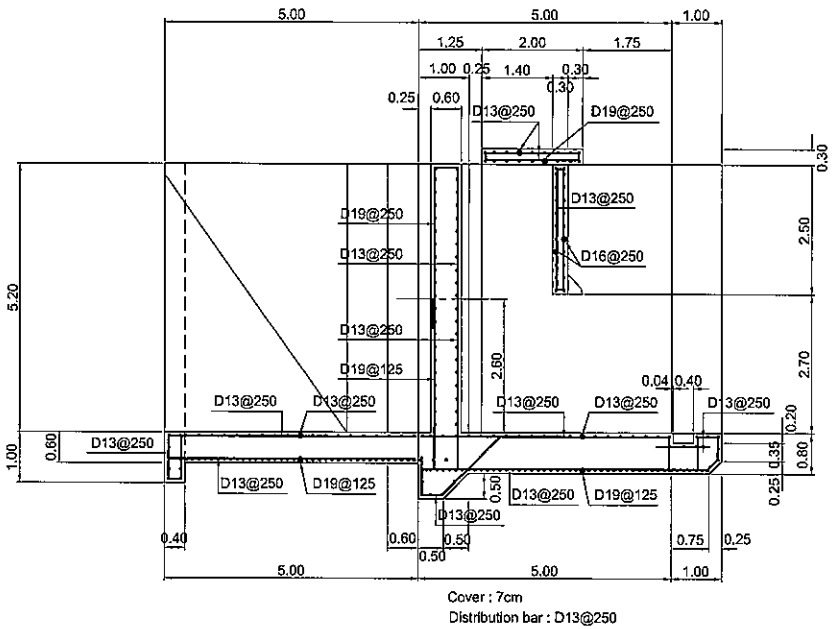
SECTION C - C

0 5 10
Scale A (1:200)

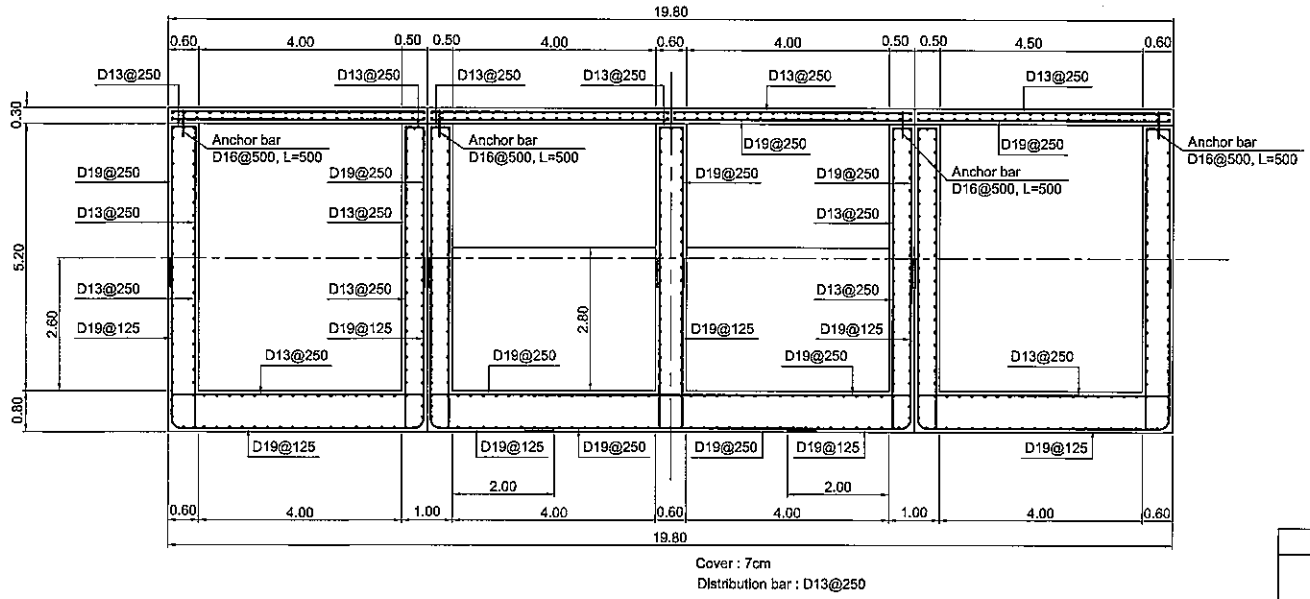
THE KINGDOM OF CAMBODIA			
THE PROJECT FOR IMPROVEMNT OF ROLEANG CHREY HEADWORKS			
TITLE OF DRAWING ANDONG SLA INTAKE INTAKE STRUCTURE (3/4)			
DATE	JULY 2008	DRAWING NO.	3-4
NIPPON KOEI CO., LTD., JAPAN			



SECTION A - A



SECTION B - B



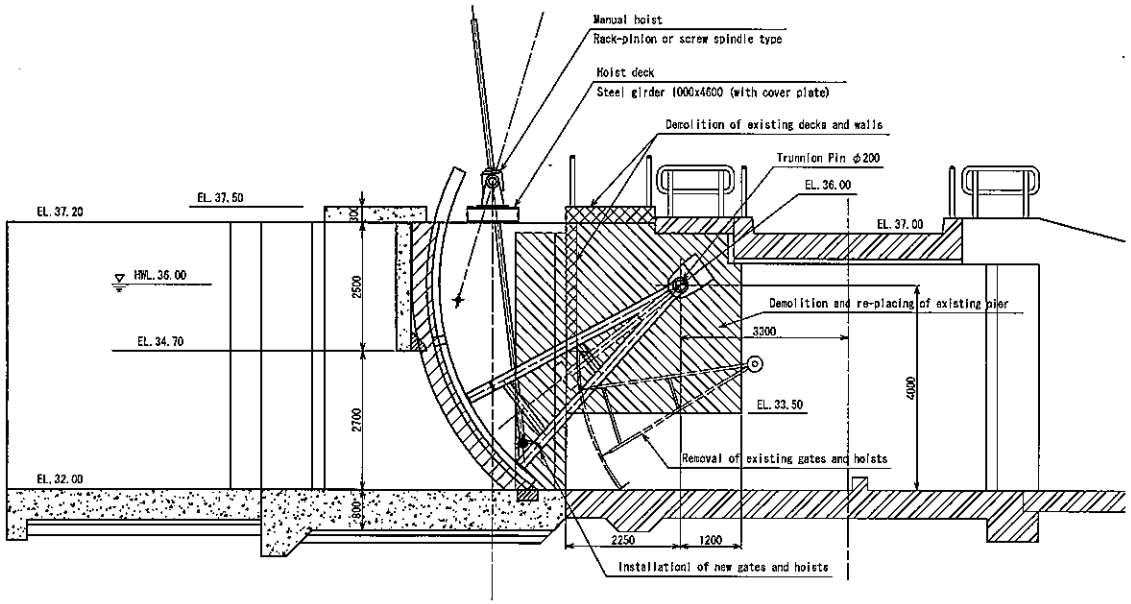
SECTION C - C

BAR ARRANGEMENT

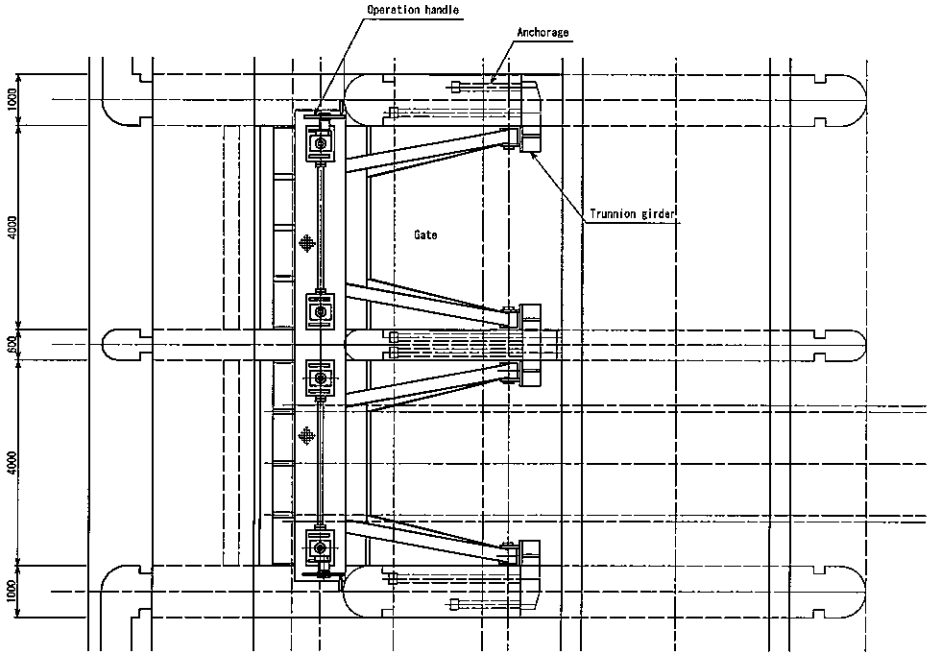
0 5

Scale (1:100)

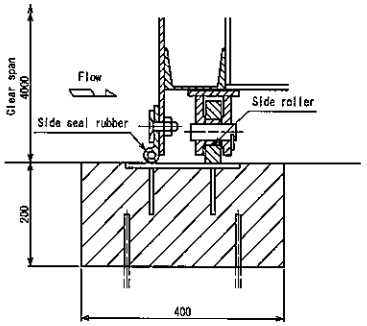
THE KINGDOM OF CAMBODIA			
THE PROJECT FOR IMPROVEMNT OF ROLEANG CHREY HEADWORKS			
TITLE OF DRAWING ANDONG SLA INTAKE INTAKE STRUCTURE (4/4)			
DATE	JULY 2008	DRAWING NO.	3-5
NIPPON KOEI CO., LTD., JAPAN			



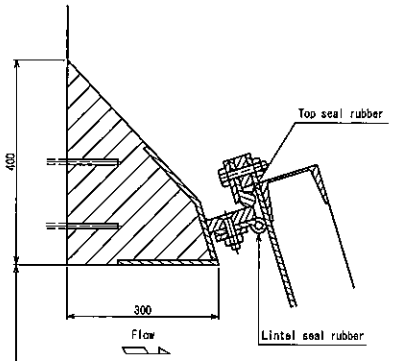
Longitudinal Section Scale A



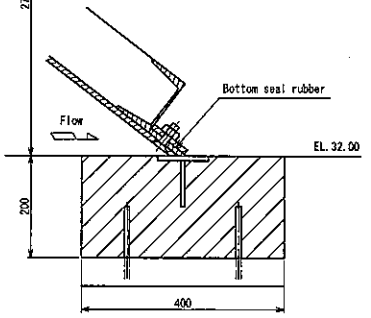
Plan Scale A



Detail of side seal and side roller Scale B



Detail of lintel Scale B

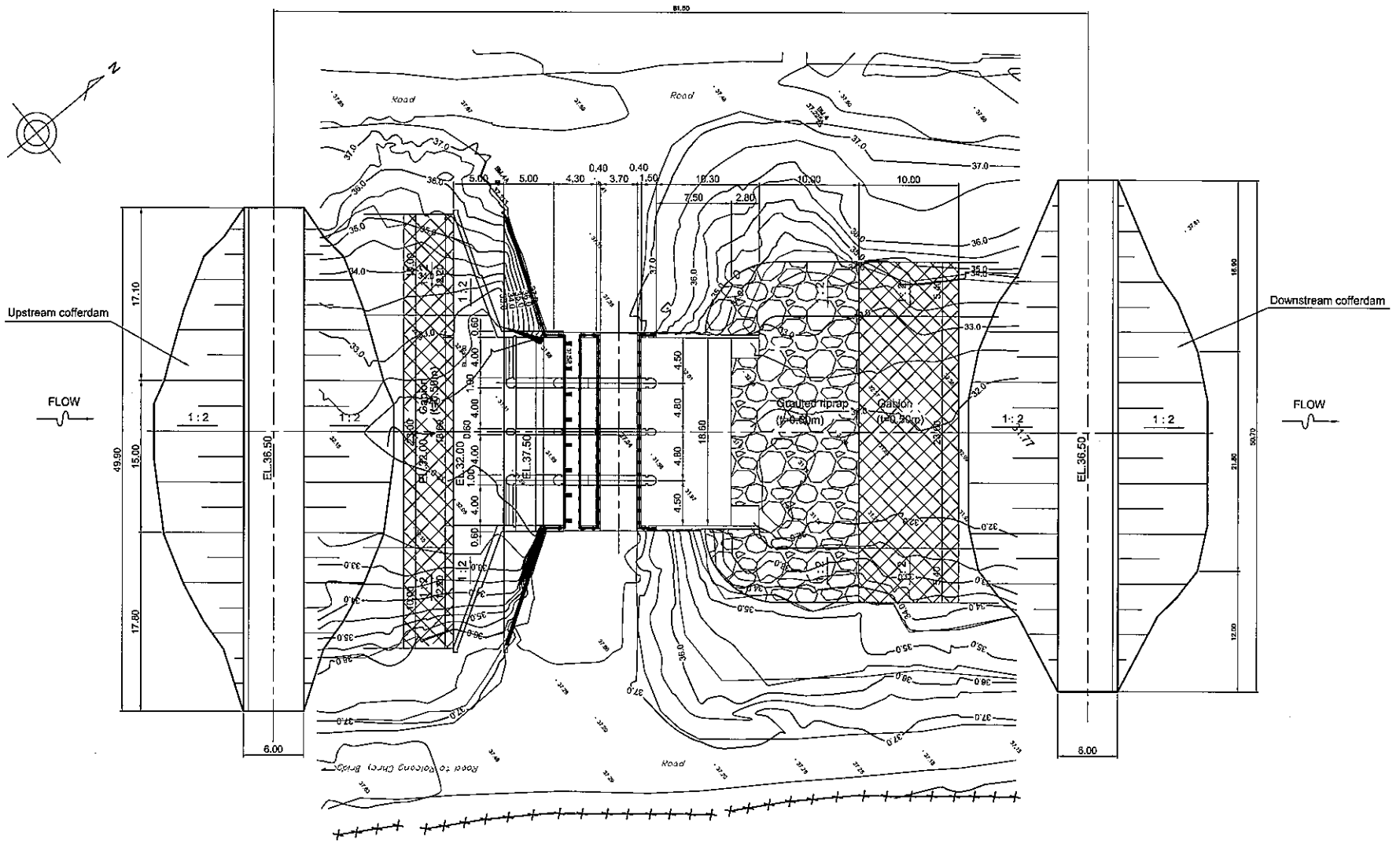


Detail of Sill Scale B

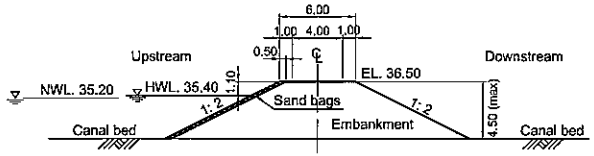
0 1 2 3 4 5
Scale A (1:100)

0 0.1 0.2 0.3 0.4 0.5
Scale B (1:10)

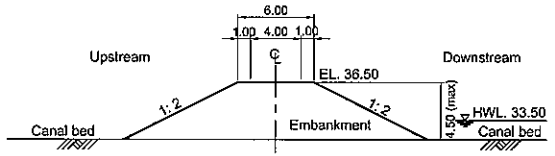
THE KINGDOM OF CAMBODIA			
THE PROJECT FOR IMPROVEMNT OF ROLEANG CHREY HEADWORKS			
TITLE OF DRAWING ANDONG SLA INTAKE INTAKE GATE			
DATE	JULY 2008	DRAWING NO.	3-6
NIPPON KOEI CO., LTD., JAPAN			



PLAN



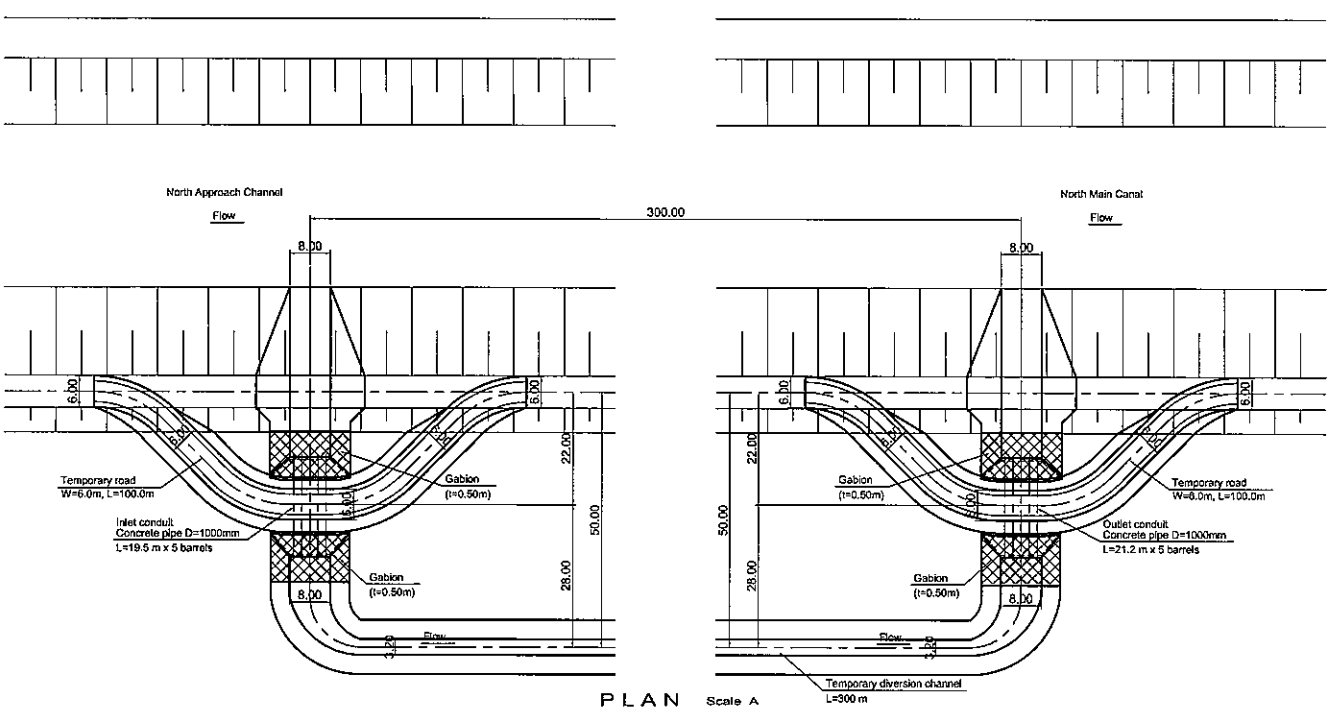
TYPICAL CROSS SECTION
OF UPSTREAM COFFERDAM



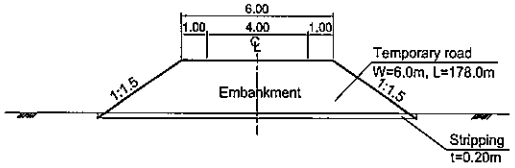
TYPICAL CROSS SECTION
OF DOWNSTREAM COFFERDAM

0 5 10 15 20
Scale (1:400)

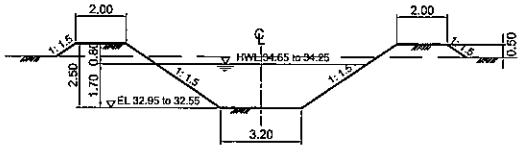
THE KINGDOM OF CAMBODIA			
THE PROJECT FOR IMPROVEMNT OF ROLEANG CHREY HEADWORKS			
TITLE OF DRAWING ANDONG SLA INTAKE TEMPORARY COFFERDAM AND DIVERSION CHANNEL (1/2)			
DATE	JULY 2008	DRAWING NO.	3-7
NIPPON KOEI CO., LTD., JAPAN			



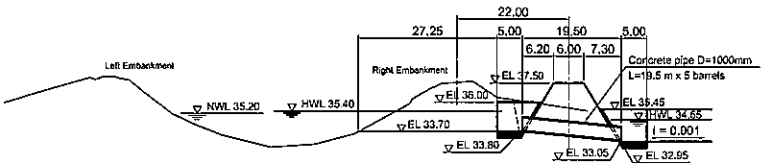
PLAN Scale A



TYPICAL CROSS SECTION OF TEMPORARY ROAD Scale C

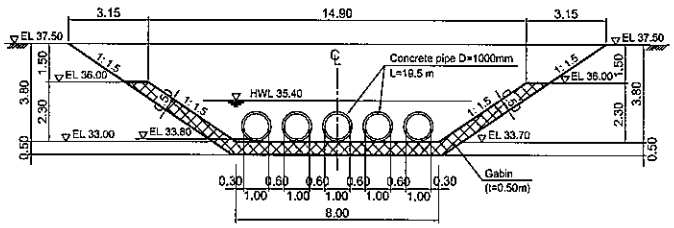


TYPICAL CROSS SECTION OF DIVERSION CHANNEL Scale C

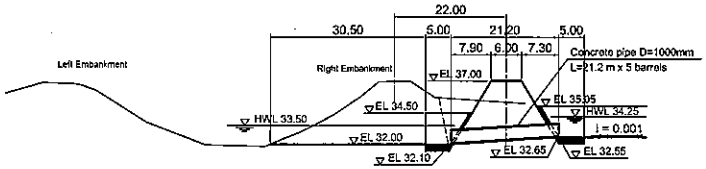


LONGITUDINAL SECTION AT INLET

Vertical Scale B
Horizontal Scale A

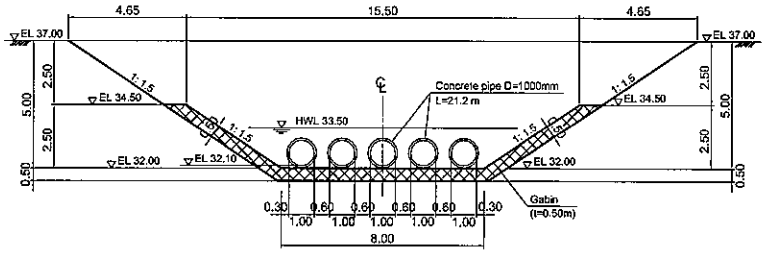


CROSS SECTION AT INLET Scale C
(UPSTREAM OF CONDUIT)

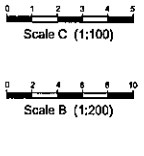


LONGITUDINAL SECTION AT OUTLET

Vertical Scale B
Horizontal Scale A



CROSS SECTION AT OUTLET Scale C
(DOWNSTREAM OF CONDUIT)



THE KINGDOM OF CAMBODIA			
THE PROJECT FOR IMPROVEMNT OF ROLEANG CHREY HEADWORKS			
TITLE OF DRAWING ANDONG SLA INTAKE TEMPORARY COFFERDAM AND DIVERSION CHANNEL (2/2)			
DATE	JULY 2008	DRAWING NO.	3-8
NIPPON KOEI CO., LTD., JAPAN			

2-2-4 Implementation Plan

2-2-4-1 Implementation Policy

The improvement works of the Project will be implemented based on the following conditions in consideration of Japanese Grant Aid Scheme.

① MOWRAM will be responsible for the Project implementation and the implementing agency will be the National Project Management Office (NPMO) including the Project Management Unit (PMU) for North Western Area.

② When the Exchange of Notes (E/N) between GOJ and RGOC regarding the detailed design is signed, MOWRAM will take care of overall procedures necessary for the implementation of the Project. A Japanese consulting firm, recommended by Japan International Cooperation Agency (JICA) and entrusted by MOWRAM will sign a detailed design contract with MOWRAM, and will accordingly prepare the detailed design and tender documents.

③ NPMO will start facilitating the land acquisition in parallel with the detailed design. At the same time, NPMO will make arrangements to the Inter-ministerial Resettlement Committee (IRC) to get necessary measures against the water cut-off.

④ When the Exchange of Notes (E/N) between GOJ and RGOC regarding the construction works is signed, the Japanese consultant together with NPMO will commence the tendering procedures .

⑤ A Japanese contractor, after signing the contract with MOWRAM for the construction works, will undertake the construction works, while the consultant will perform the construction supervision.

⑥ Upon completion of the construction works, the responsibility of O&M of the improved irrigation facilities will be handed over to Kampong Speu PDOWRAM. The O&M of the regulator and intakes will be executed by the Regulator & Intakes O&M Office, which has been operated under the supervision of Director of Kampong Speu PDOWRAM since 1974.

The construction works will be carried out, considering that the Japanese contractor will source and/or procure construction equipment and materials by himself, and utilize manpower supplied by local sub-contractors in Cambodia. For the rehabilitation of regulator’s gates, a Japanese gate manufacturer will undertake the work, since the replacement of the existing pins and bushings of the gates has complex features and technical difficulties. New pins and bushings will have to be by a Japanese maker. Said gate manufacturer will have to utilize a mechanical factory in a third world country, such as Thailand and Vietnam in order to carry out the technically difficult works in Cambodia related to the replacement of bushings and pins. The main contractor will be a Japanese general contractor, while the Japanese gate manufacturer

may be a Joint Venture partner or a nominated sub-contractor of the general contractor. Therefore, the general contractor will be responsible for all the works including the gate rehabilitation. The general contractor will procure the slide gates of the river outlet structure of the regulator, and radial gates of Andong Sla intake from gate manufacturers in a third world country.

The assignment schedule of the contractor's experts has been prepared according to the following considerations:

① The improvement works will consist of two types of the works, namely civil works and mechanical works inclusive of electrical works.

② The mechanical works inclusive of electrical works will include preparation of i) manufacturing drawings, ii) technical specifications of products to be procured, and iii) work schedule of the mechanical works including securing approval from consultant/client prior to procurement and manufacturing.

③ The improvement works will need quality control of the civil works and mechanical works inclusive of electrical work.

④ A contractor will execute the improvement works, considering the required quantities of the construction materials, construction period, and site conditions (rainy and dry seasons).

The Japanese experts of contractor's team are as follows:

① Site Manager (1 person)

② Civil Engineer (Regulator and Intake: 1 person)

③ Mechanical Engineer (Gates: 1 person)

④ Electrical Engineer (Control panel and electrical work for gates: 1 person)

2-2-4-2 Implementation Conditions

(1) Negative Environment Impacts during Construction

The anticipated negative environment impacts during the construction will be noise/vibration, air pollution, increase of accident, water pollution, generation of waste (construction and domestic), deterioration of sanitation condition / increase of risk diseases, traffic disturbance, etc. The contractor will have to take proper actions as proposed in "2-2-1-3 Environmental and social conditions" in order to minimize the impacts.

(2) Water Cut-Off

Although two-time water cut-off periods are required for the rehabilitation of the regulator's gates, no limitation for irrigation will be expected. However, since the residents who depend on water in canals will be limited as described in "2-2-1-3 Environmental and social

conditions", MOWRAM will have to take necessary measures for them in accordance with the IRC's conclusions prior to the commencement of the rehabilitation of the regulator's gates.

(3) Scope of Works

① Scope of Works to Be Executed by GOJ

1) Detailed design and preparation of tender documents
2) Construction/rehabilitation works

② Undertakings by RGOC

1) Land acquisition required for implementation of the Project
2) Compensation due to water cut-off (such as deployment of water supply trucks, construction of temporary coffer dams in canals, etc.)
3) Permission for operating regulator's gates required for i) gate tests and ii) gate operation training under the soft component plan
4) Holding stakeholders meetings to secure residents' cooperation and understanding for the implementation of the Project
5) Undertaking of budgeting and settlement for customs, inland duty imposed on the procured machinery and materials, and others
6) Coordination with other relevant agencies and issuance of necessary permission (s) required for the implementation of the Project
7) O&M of the improved facilities, namely Roleang Chrey regulator and Andong Sla intake
8) Assistance to FWUCs in O&M of canals and on-farm facilities
9) Maintaining the security in and around the Project area
10) Assignment of counterpart personnel

(4) Construction Supervision

① Preparation of Detailed Design and Tender Documents

Immediately after signing the E/N about the detailed design between GOJ and RGOC, the contract for the consulting services will be concluded between MOWRAM and a Japanese consultant, and the detailed design will be started. At the detailed design stage, the following works will be done.

1) Preparation of detailed design
   - Detailed design based on the basic design and field investigation results
   - Review of the Project cost through the detailed design
2) Preparation of the tender documents
   - Preparation of the tender drawings

- Preparation of the tender documents for the construction works

② Tender and Construction Supervision

Immediately after the signing of E/N about the construction works between GOJ and RGOC, the contract for construction supervision will be concluded between MOWRAM and the Japanese consultant. The Japanese consultant will start tendering procedures with MOWRAM and select a contractor. After a contractor is selected, the construction supervision will commence. The scope of construction supervision is summarized as follows:

1) Evaluation and approval of the following documents and drawings submitted by the contractor:
   - Construction drawings
   - Mechanical & electrical drawings for manufacturing and procurement
   - Technical specifications of mechanical & electrical products
   - Application for commencement of the works
   - Construction schedule and plan including mechanical & electrical works
   - Samples of construction materials
2) Progress and quality control
   - Checking and rendering guidance on the construction plan and construction schedule
   - Quality control
   - Progress monitoring of the construction works
   - Inspection of the construction works
3) Approval for the payment to the contractor
   Checking and evaluation of the performance of the works necessary for issuance of payment certificates and completion certificates to the contractor

(5) Quality Control Plan

The quality control of the works will be undertaken by the contractor under the supervision of the consultant based on the Japanese standards, since there is no statutory standard for quality control presently adopted in Cambodia. Through periodic inspections, concrete quality will be checked from results of slump tests and compressive strength tests, while embankment quality will be checked from results of soil density tests by sand replacement method. Concrete aggregates' test, design mix test, etc. shown in the following table will also be carried out. Necessary test items and corresponding test frequencies are also presented in the following table. All the tests will be conducted either in Phnom Penh or site:

Table 2-7 Test Items

	Test Items	Frequency
Concrete Test	Design mix	One time
	Resistance to abrasion	One time
	Organic impurities in fine aggregates	One time
	Soundness of aggregates by use of sodium sulfate	One time
	Alkali reaction	One time
	Water quality (pH, turbidity)	One time

(6) Procurement Plan

Major construction materials for the construction works are cement, pre-cast concrete products, forms, reinforcing bars, concrete pipes, polyvinyl chloride (PVC) pipes, etc. These materials are available in Cambodia, and there is no problem about their quality and availability. Embankment materials, concrete aggregates and stones are available in and around the regulator will be used as much as possible. Other products, such as pins and bushings of wheels, hoist systems of regulator's gates and rubber seals required for rehabilitation of the regulator's gates will be procured in Japan since such items should be of high quality and its procurement period is very limited. Radial gates of the intake and slide gates of the river outlet structure can be manufactured by gate manufacturers in a third world country, such as Thailand and Vietnam. Regarding construction equipment, these can be leased from several companies in Cambodia. It is, however, noted that a drilling machine with 40 cm diameter and of diamond bits is not available in Cambodia. This is intended for drilling 10 holes through the existing piers, in order to remove pins and bushings of the wheels from the gates. Thus, this should be procured in Japan and transported to Cambodia.

Materials and products procured in Phnom Penh will be transported to the site through National Road No.4. Those procured in Japan will be transported by sea from Yokohama to Sihanoukville, and they will finally be transported to the site by land. The pins and bushings procured in Japan will be transported by plane from Narita to an airport of a third world country where a gate factory is located, and processed pins and bushings will be transported by land from the gate factory to the site. The in-land transportation route and distance are shown in the following table.

Table 2-8 In-land Transportation Route and Distance

Route	Transportation Distance	Road Conditions
Sihanoukville seaport to the site	About 170 km	good
Thailand's border to the site (by land)	About 470 km (National Road No.5: 410 km, and National Road No.4: 60 km)	good
Vietnam's border to the site (by land)	About 220 km (National Road No.1: 160 km, and National Road No.4: 60 km)	A part of National Road No.1 is under rehabilitation as of December 2007
Phnom Penh airport to the site	About 50 km (National Road No.4)	good

(7) Soft Component Plan

At the final stage of construction, technical assistance to the O&M of the rehabilitated and constructed facilities will be rendered to Cambodian gate operators as soft component plan in order to sustain the functions for stable irrigation water supply. The objectives of the soft component plan are as follows :

① The gate operation of the regulator and intake will be conducted smoothly and adequately.

② The gate operation of river outlet structure for Kandal Steung irrigation facilities will be conducted smoothly and adequately.

③ A communication network among the Roleang Chrey regulator and the gate structures in the downstream of the regulator, such as Kandal Steung Weir, Teuk Thla Weir, and etc. will be formulated for closely coordinated gate operation.

④ Closely coordinated gate operation of Roleang Chrey regulator and Andong Sla intake will possibly prevent flood entrance to the north approach channel and regulate irrigation water to the north main canal in accordance with irrigation water supply schedule.

⑤ The gate operators will recognize importance and necessity of O&M of the facilities.

The activities of the soft component plan are as follows:

① Preparation of O&M guideline of the improved facilities, irrigation water supply schedule and gate operation manual of the regulator, river outlet structure and Andong Sla intake.

② Seminar based on the above documents

③ Technical guidance on gate operation against flood, utilizing the communication network of Roleang Chrey regulator, Kandal Steung Weir, Teuk Thla Weir, etc. as shown in Figure 2.2.11.

For the soft component plan, one O&M expert of the consultant will be assigned for four months at the final stage of the construction. The participating trainees will consist of 10 gate operators who are or will be involved in O&M of irrigation facilities and gates, such as those from Kampong Speu PDOWRAM, Kandal PDOWRAM, Roleang Chrey and Intakes O&M Office, Kandal Steung weir O&M Office and Teuk Thla Weir O&M Office.

(8) Implementation Schedule

The Project will be implemented under the following stages:

① Detailed Design Stage

1) Detailed design 3 months

2) Preparation of tender documents 1.83 months

② Construction Stage

1) PQ and Tender works 3 months

2) Construction works 19 months

③ Soft Component Plan 4 months

The implementation schedule is shown below.

Stage	Works		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Preparation	Cabinet Meeting of GOJ	▼						▼											
	E/N		▼						▼										
Detailed Design	Detailed Design																		
	Tender Documents																		
Construction	Tender and Contract																		
	Construction																		
Soft Component Plan /Assistance of O&M of the Improved Facilities																			

Stage	Works	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34
Preparation	E/N																	
Detailed Design	Detailed Design																	
	Tender Documents																	
Construction	Tender and Contract																	
	Construction																	
Soft Component Plan /Assistance of O&M of the Improved Facilities																		

Rainy Season Dry Season

Figure 2-1 Implementation Schedule

2-3 Obligations of Recipient Country

2-3-1 Items to Be Undertaken by Recipient Country

MOWRAM will be responsible for the implementation of the Project and the implementing agency will be the National Project Management Office (NPMO) including the Project Management Unit (PMU) for North Western Area, should undertake the following activities:

(1) To provide necessary documents and information for implementation of the Project

(2) To provide the land necessary for construction of temporary site office, temporary stock yards of construction materials and equipment, temporary spillway, temporary diversion channel for Andong Sla intake, and temporary access road

(3) To compensate farmers/residents for crop damage and loss of domestic and drinking water available in canal, due to the water cut-off necessary for the construction activities during the dry season in accordance with IRC's conclusions.

(4) To permit opening and closing of the regulator's gates required for i) gate test and ii) guidance of gate operation under soft component plan

(5) To secure residents' cooperation for the construction through stakeholders meeting

(6) To secure MOWRAM's budget and staff for the Project implementation including assignment of necessary counterpart personnel

(7) To open a bank account in Japan including bearing the banking cost and handling charge

(8) To arrange for tax exemption for machinery/equipment and materials procured in accordance with the authorized contract and proceed with a necessary formality for custom clearance

(9) To arrange for tax exemption for any taxes, such as custom tax, inland duty and other financial surcharge imposed to the Japanese experts assigned to the Project in accordance with the authorized contract

(10) To support Japanese Nationals' entry and stay for fulfillment of the authorized contract

(11) To authorize approval, permission, authorization, etc. for the Project implementation

(12) To implement an effective O&M work for the improved irrigation facilities under the Japan's Grant Aid Scheme

(13) To take timely action for coordinating any claims to the Project implementation from the third persons or non beneficiaries concerned

(14) To ensure the safety for the Japanese Nationals against any conflict, riot, trouble, insurrection, mines, etc.

2-3-2 Practicability of RGOC's Obligations

(1) Official Procedures Required for the Project Implementation

MOWRAM has experienced the implementation and management of i) Project for Improvement of Facilities of Colmatage Systems in Kandal Province along the Mekong River (December 1999 to March 2001), and ii) Project for Rehabilitation of the Kandal Steung Irrigation System in the Lower Prek Thnot River Basin (February 2005 to August 2007). MOWRAM will be able to manage the proceedings necessary for the official formalities for the Project to be carried out under the Japan's Grant Aid Scheme. In addition, MOWRAM agreed upon in minutes of discussions of November 21, 2007 that MOWRAM would undertake land acquisition, compensation/measures due to water cut-off, and O&M activities of the facilities with necessary stakeholders meetings.

(2) Land Acquisition

The Project does not require land for permanent facilities since it is an improvement project. The required land is only intended for temporary site office of contractor and consultant, temporary stock yards of equipment/machinery and materials, temporary spillway, temporary diversion channel, and limited access road. The required land will be rented from land owners and after the construction works, such land will be returned to the land owners. MOWRAM has experience of land acquisition for other projects under Japan's grant aid scheme. MOWRAM would not have any serious problem acquiring the required land.

(3) Water Cut-Off and Compensation / Measures due to Water Cut-Off

For the rehabilitation of the Roleang Chrey regulator's gates, MOWRAM will have to carry out two-time water cut-off during 20 days in total during the dry season. Since the water cut-off period is scheduled in the beginning and the end of the dry season, paddy cultivation will not be affected, since farmers can adjust their cultivation period. However, since there are many residents who depend on water in canals for domestic use, the JICA basic design study team on the Project strongly recommended that MOWRAM take necessary measures at his own expense against the water cut-off for them in order to reserve water in canals as shown in attached minutes of discussions of June 12, 2008. MOWRAM has replied that the necessary measures will be concluded by IRC and MOWRAM will accept the conclusions of IRC. Since MOWRAM has experience of coordinating with IRC and understands necessity and timing of the measures, they will be able to secure the conclusions from IRC and take necessary measures prior to the water cut-off.

(4) Permission for Operating Regulator's Gates

In order to carry out a test of opening and closing of the regulator's gates and gate

operation training or guidance under the soft component plan, MOWRAM will have to permit opening and closing of the regulator's gates. If the gate opening and closing are done, water surface of irrigation canals will be lowered and the irrigation will be influenced. However, the influence by the gate opening and closing will be very limited because of the following:

- The opening and closing will be done only from 8:00 to 16:00.
- The opening and closing will be done one gate by one gate.
- The opening and closing period will be shorter than the water cut-off period.
- Water level in canal during the rainy season will recover much faster than that during the dry season.

For the residents who depend on water in canal for domestic use, no limitation is expected since water for domestic use will be available in canal though the water level in canal will go down. Considering this and necessity of the operating the gates, MOWRAM will permit it. Prior to the permission, MOWRAM will secure the residents' cooperation and understanding through stakeholders meetings. (It is noted that such permission was agreed upon between JICA basic design study team on the Project and MOWRAM on June 12, 2008 as shown in the minutes of discussions.)

(5) O&M of the Improved Facilities

Roleang Chrey regulator and two intakes, namely Andong Sla intake and Vat Krouch intake have been operated by one (1) gate operator of the regulator and intakes O&M office under the supervision of Kampong Speu PDOWRAM since 1974. He has long experience and knowledge obtained through the experience. In addition, at the final stage of the construction, gate operators' O&M capability of the improved facilities will be strengthened as soft component plan which will include i) preparation of O&M guideline, gate operation manual, and etc. of the improved facilities, and ii) guidance of gate operation based on a new gate operation network formed among Roleang Chrey regulator, and gated structures located in the downstream area of the regulator. Because of these reasons, the improved regulator and intake will be operated adequately. However, since the present gate operator is now 69 years old, the JICA basic design study team has recommended that MOWRAM should train new gate operator as his successor and assign him urgently.

2-4 Project Operation Plan

The O&M of the improved facilities will be carried out by the regulator and intakes O&M office under supervision of Kampong Speu PDOWRAM. The technical and financial support to the O&M office will be given by Kampong Speu PDOWRAM as much as the present. In order to maintain the Project effects, the following improvement of O&M activities is necessary:

(1) Regular inspection of the gates and related mechanical and electrical equipment will

have to be carried out as routine work.

(2) The gate operation of Roleang Chrey regulator and Andong Sla intake for irrigation will have to be carried out in accordance with irrigation water supply schedule of Roleang Chrey Irrigation area.

(3) The gate operation of the river outlet structure will be carried out in accordance with irrigation water supply schedule of Kandal Steung Irrigation area. For this, communication network will have to be formed.

(4) The gate operation of Roleang Chrey regulator against flood will have to be carried out, utilizing the communication network formed among the gated structures in the downstream area of the regulator, such as Ou Krang Ambel weir, Teuk Thla weir and Kandal Steung weir, locations of which are shown in Figure 2.2.11.

(5) For the above O&M, the guideline, irrigation water supply schedule and gate operation manual will have to be prepared as well as the formulation of communication network.

Under the Japanese assistance, soft component plan will be implemented in order to assist PDORWRAM in improving the above (1) to (5) O&M works.

2-5 Project Cost Estimation

2-5-1 Initial Cost Estimation

The cost to be borne by RGOC (MOWRAM) is estimated as shown in the following table:

Table 2-9 Cost to Be Borne by the Cambodian Side

Unit :US$

Description		Amount
(1)	Land Acquisition Cost (7.12 ha)	79,200
	1) Temporary site office : 0.77 ha	
	2) Stock yards: 3.00 ha	
	3) Temporary road, spillway, diversion channel, etc. : 3.35 ha	
(2)*	Water Cut-Off Compensation Cost, (temporary coffer dams in canals)	41,000
(3)	Banking Cost	2,700
(4)	Customs Clearance Cost	1,000
Total		123,900

***:** This is the cost in the case that MOWRAM takes construction of temporary coffer dams in canals as countermeasures.

(1) Land Acquisition

The land required for the construction work is only intended for temporary facilities. The land is expected to be rented from land owners during the construction. The land will be returned to the land owners upon completion of construction work. The necessities for land acquisition are as follows:

① The land for temporary site office, which will be used by a general contractor and consultant will be necessary. The proposed location is at about 150 m downstream of the regulator on the right bank of the Prek Thnot river.

② Since water cut-off period for the construction of temporary coffer dam in the river, is only 10 days, embankment materials for the dam will have to be stockpiled near the dam site prior to the construction of the dam. Otherwise, the dam will not be constructed for 10 days. Since water-cut-off period for the removal of the coffer dam, also takes 10 days, the removed materials will have to be temporarily piled near the dam site. After the dam is removed, the removed materials will have to be transported to backfill sites. For stock yards of the embankment materials and removed materials, some area on the right and left bank areas of the coffer dam site will be necessary.

③ For the transportation of embankment materials and removed materials to or from the temporary coffer dam site, temporary access road on both bank areas will be constructed. For this, some area for the road on both bank areas will be necessary. It is noted that there is one house on the right bank area and the land acquisition will need the house removal, the cost of which is included in the above table.

④ The temporary spillway including its drainage channel to the Prek Thnot river will be constructed on the right bank area of the north approach channel for the safety of the existing irrigation facilities.

⑤ The irrigation water to the north main canal during the period of reconstruction of Andong Sla intake will have to be supplied even during the construction period of dry season except during the 20 day- water cut-off period. For this, a temporary diversion channel, which will start from the upstream of the intake and return to its downstream, will be constructed on the right bank area of the north approach channel and the north main canal.

(2) Water Cut-Off Compensation

MOWRAM will have to compensate residents who would be damaged by water cut-off. Crop damage can be avoided by altering the cultivation period, but for a lot of residents who use

water in the canals as domestic and drinking water, the water cut-off will cause inconvenience. The JICA basic design study team on the Project for improvement of Roleang Chrey headworks has strongly recommended that MOWRAM take necessary measures for them, such as deployment of water supply trucks, construction of temporary coffer dams in irrigation canals, etc. MOWRAM says that they will take necessary actions in accordance with IRC's conclusions.

(3) Banking Cost

MOWRAM will have to arrange for take banking transactions in accordance with Japan's Grant Aid Scheme, such as i) opening an account in the name of MOWRAM in an authorized foreign exchange bank in Japan, ii) issuance of Authorization to Pay, etc.

(4) Customs Clearance Cost

MOWRAM will have to take actions necessary for customs clearance of the equipment/machinery, materials and mechanical & electrical products to be imported for the construction work, and some mechanical products to be exported for processing of wheels, pins and bushings of regulator's gates in the third world country.

2-5-2 Operation and Maintenance Cost

(1) Annual O&M Cost of the Regulator and Intakes O&M Office

Annual O&M cost of the regulator and intakes O&M office is estimated at US$ 2,460 /year as shown in the following table:

Table 2-10 Annual O&M Cost of Regulator and Intakes O&M Office

Unit：US$

Items	Expense
Salary	300
Office consumables	120
Communication	240
Fuel for generators, etc.	1,000
Materials	400
Labor charge, etc.	400
Total	2,460

The replacement period of the mechanical and electrical equipment/products are as follows:

Project Life	: 30 years
Gate Leaf	: 20 to 25 years
Water Seal Rubber	: 20 to 25 years
Paint	: 10 to 15 years
Control Panel	: 15 to 20 years
Hoist system	: 20 to 25 years

(2) Financial Practicability of the Project

Roleang Chrey regulator and Andong Sla intake have been operated and maintained by the present O&M office for 33 years without any serious problems under the supervision of Kampong Speu PDOWRAM, regardless of the previous changes in names of the responsible ministry and office. The Project will be financed as in the past 33 years.

2-6 Other Relevant Issues

The issues to be noted for the implementation of the Project are as follows:

(1) Provision of Budget for the Implementation of the Project and Assignment of Personnel to the implementing agency

The cost to be borne by MOWRAM is US$ 123,900 for land acquisition, water cut-off compensation, bank arrangement and customs clearance. For the successful completion of the Project, the necessary budget will have to be timely secured. Adequate personnel will have to be assigned urgently to the national project management unit for north-western area.

(2) Timely Land Acquisition

The land acquisition will have to be finished prior to the construction of the Project.

(3) Water Cut-Off and Compensation

Two-time water cut-off will have to be accomplished to meet the scheduled completion of the Project. The necessary measures against water cut-off will have to be timely taken for the residents who depend on water in canals for domestic use. Since the necessary measures will be concluded by IRC, it will be a must to make arrangement for IRC to secure the conclusions of IRC prior to the water cu-off period.

(4) Permission for Opening and Closing of the Regulator's Gates

Apart from the two-time water cut-off, permission for the opening and closing of the Regulator's Gates will have to be provided for the following :

- Gate tests of opening and closing of the regulator: consecutive 3 days
- Gate operation training/guidance under the soft component plan: intermittent 3 days

Chapter 3 Project Evaluation and Recommendations

Chapter 3 Project Evaluation and Recommendations

3-1 Project Effect

3-1-1 Direct Effect

The direct effects by the improvement of Roleang Chrey Headworks are as follows:

(1) The present agricultural productivity of irrigated rainy season paddy of 2.3～2.4 tons/ha and gross farmers' income of US$ 450～US590 /household will be maintained due to a stable water supply to about 10,000 ha through the improvement of the regulator.

(2) The stable irrigation water supply with a discharge of about 5 m^3/sec will become possible to Kandal Steung irrigation area of about 1,950 ha (located at about 40 km downstream of the regulator) through the construction of the river outlet structure.

(3) Flood entrance to the north approach channel will be prevented, and adequate irrigation water regulation, based on an irrigation water supply schedule, will become possible through the reconstruction of Andong Sla intake.

(4) Flood damage in the downstream area of the regulator will be mitigated since communication network among the related gate facilities located in the downstream area will be formulated.

(5) The inundation risk to the upstream area of the regulator will be prevented since flood will more timely flow down owing to the smooth opening of the regulator's rehabilitated gates.

3-1-2 Other Effect

The indirect effects of the Project are to contribute to poverty alleviation in the rural area, and stable rice supply in Cambodia, by maintaining present agricultural productivity and farmers' income. In addition, the major irrigation facilities to be improved under the Project will become irrigation infrastructures, which will have possibility of increasing agricultural production of irrigated rainy season paddy and farmers' income through future improvement of water management and farming practice.

3-2 Conclusions

As stated above, the Project is expected to realize many effects, which will contribute to the implementation of RGOC's top policy. The contents and goals of the Project are in line with the guideline of Japan's grant aid scheme. After the completion of the improvement of the major irrigation facilities of the Project, MOWRAM could financially and technically manage to carry out the O&M of the improved facilities as they have done it for the past 33 years, though the strengthening of the present O&M capability is required. Considering these, the implementation of the Project under Japan's grant aid scheme is highly recommended.

3-3 Recommendations

3-3-1 Issues to be Resolved by MOWRAM

In order to sustain the Project effects, the O&M of the improved facilities will have to be strengthened. For this purpose, the following are recommended:

(1) MOWRAM will constantly support Kampong Speu PDOWRAM and the regulator and intakes O&M office in providing adequate technical and financial assistance as required.

(2) MOWRAM will provide communication facilities, such as cellular phone and desk telephone set with operators and personnel concerned for communication network, and bear the costs of said cellar phone/desk telephone and telephone charges.

(3) MOWRAM will strengthen O&M capability of FWUCs.

(4) At present there are no mechanical and electrical engineers/experts at the regulator and intakes O&M office, who can repair the gates and related electrical equipment. It is preferred that MOWRAM designate a few Cambodian mechanical and electrical engineers/experts to be responsible for all the gates and related electrical equipment in Cambodia.

(5) The present gate operator at the regulator and intakes O&M office is 69 years old. MOWRAM will initiate training of a successor by transferring his technical skills to his successor as soon as possible.

(6) For the improvement of water management, MOWRAM's engineers have acquired the technical skills from Technical Service Center for Irrigation System Project (TSC). MOWRAM will initiate transferring of such knowledge to FWUCs.

(7) For further improvement of agricultural productivity and farmers' income, MOWRAM will upgrade the present farming practices in cooperation with the Ministry of Agriculture.

3-3-2 Collaboration with Technical Cooperation and Other Donors

The JICA study on the comprehensive agricultural development of Prek Thnot river basin, has proposed several irrigated agricultural development sub-projects. When such sub-projects are implemented, the improved headworks under the Project will be effectively utilized.

TSC has been imparting knowledge on technical skills about on-farm water management to engineers of MOWRAM. Said skills are expected to be transferred to FWUCs by MOWRAM's engineers in order to increase agricultural productivity and farmers' income to more than the present level.

List of Attached Tables

Table 2.2.1 Monthly Average Runoff of the Prek Thnot River at Peam Khley ····· T-1

Table 2.2.2 Environment Related Laws and Regulations ····· T-2

Table 2.2.3 Work Sequence of the Regulator's Gates ····· T-4

Table 2.2.4 Transportation Required for Gate Rehabilitation ····· T-5

Table 2.2.5 Comparison of Temporary Diversion Plan ····· T-6

Table 2.2.6 Alternative Study on the Gate Rehabilitation Work of the Regulator ····· T-7

List of Attached Figures

Figure2.2.1 Hydrograph ····· F-1

Figure2.2.2 Detail of Wheel ····· F-2

Figure2.2.3 Standard Work Flow of Gate Rehabilitation ····· F-3

Figure2.2.4 Typical Cross Sections of Temporary Coffer Dam and Access road ····· F-4

Figure2.2.5 Steel Stoplog ····· F-5

Figure2.2.6 Alternative Plan 1 ····· F-6

Figure2.2.7 Alternative Plan 2 ····· F-7

Figure2.2.8 Alternative Plan 3-1 ····· F-8

Figure2.2.9 Alternative Plan 3-2 ····· F-9

Figure2.2.10 Alternative Plan 3-3 ····· F-10

Figure2.2.11 Downstream Area of the Regulator ····· F-11

Table 2.2.1 Monthly Average Runoff of the Prek Thnot River at Peam Khley

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1901	19.0	8.7	4.2	10.3	35.3	59.1	129.6	166.7	199.8	447.3	192.5	24.3
1902	9.1	3.1	4.2	10.3	35.3	48.6	18.5	49.1	196.5	225.6	273.1	18.9
1903	12.6	7.2	2.4	2.3	3.7	46.2	118.3	161.4	280.8	291.7	93.5	82.4
1904	17.8	8.0	4.2	23.3	345.6	131.9	298.2	252.9	309.8	333.8	535.2	45.2
1905	4.3	3.9	3.7	2.3	8.0	60.3	120.0	118.6	285.7	258.1	89.7	18.3
1906	8.3	2.6	4.2	10.3	35.3	59.7	213.7	146.9	270.5	227.4	32.8	22.9
1907	8.9	3.0	4.2	10.3	35.3	40.9	113.7	159.2	268.3	357.1	393.6	32.8
1908	10.4	3.8	4.2	10.3	35.3	50.9	122.5	163.3	198.8	555.5	134.1	22.9
1909	8.9	3.0	4.2	10.3	35.3	52.3	123.7	163.9	224.6	322.1	128.3	24.1
1910	9.1	3.1	53.3	10.3	35.3	42.1	114.7	159.7	202.9	321.5	64.1	24.0
1911	9.1	3.1	4.2	12.2	35.6	44.8	117.1	160.8	265.2	277.5	42.1	23.0
1912	9.0	3.0	4.2	10.5	35.4	40.7	113.5	159.2	237.7	273.6	53.5	22.9
1913	8.9	3.0	4.2	10.3	35.3	40.0	112.9	158.9	205.8	543.5	105.2	23.4
1914	9.0	3.0	4.2	11.9	35.5	41.4	114.1	159.4	203.2	453.8	173.5	28.2
1915	9.7	3.4	4.2	10.3	35.3	66.7	136.3	169.8	300.4	421.8	102.2	22.9
1916	8.9	3.0	4.2	10.3	35.3	50.1	121.7	163.0	251.0	824.4	293.3	22.9
1917	8.9	3.0	4.2	10.3	35.3	65.9	135.7	169.5	369.2	672.9	521.8	24.9
1918	9.2	3.2	4.2	10.3	35.3	52.4	123.8	164.0	200.9	454.4	100.3	22.9
1919	8.9	3.0	4.2	14.6	35.9	44.6	116.9	160.7	269.2	313.9	140.1	22.9
1920	8.9	12.7	4.2	10.3	35.3	44.8	117.1	160.8	183.1	265.1	385.6	67.4
1921	15.5	6.8	4.2	7.3	38.1	47.3	149.3	248.9	365.0	667.0	249.2	29.8
1922												
1923	10.1	3.7	4.2	54.7	40.5	44.3	116.6	160.6	233.3	278.0	171.5	22.9
1924	8.9	3.0	4.2	5.8	46.3	92.7	161.6	182.1	296.4	770.0	339.8	40.6
1925	11.6	4.5	4.2	10.3	35.3	42.1	114.8	159.7	217.4	287.0	52.5	22.9
1926	19.0	17.0	16.7	15.5	9.3	7.0	16.3	63.0	116.7	528.5	36.7	136.0
1927	16.6	10.5	2.7	5.5	29.1	54.8	338.0	140.5	108.7	253.0	31.8	7.9
1928	5.5	2.2	2.4	18.6	16.6	19.5	100.4	48.7	69.8	146.6	20.2	2.4
1929	2.4	4.1	2.9	7.8	11.2	19.9	38.1	47.7	132.4	453.0	41.7	13.8
1930	7.7	2.2	24.3	9.3	16.6	5.4	136.3	32.9	260.0	45.6	177.2	10.8
1931	7.1	2.0	4.2	10.3	11.1	6.3	5.3	292.1	209.4	761.4	18.6	6.2
1932	6.5	1.6	5.2	16.3	6.1	3.9	38.0	12.7	237.7	522.0	232.2	15.5
1933	7.8	2.4	4.2	10.3	7.7	9.4	36.0	95.3	76.4	367.9	72.9	22.9
1934	8.9	3.8	4.2	11.2	4.9	24.2	72.4	103.7	214.6	383.6	69.4	22.9
1935	8.9	3.0	4.2	10.3	35.3	5.4	95.2	150.6	251.1	473.6	336.9	41.8
1936	11.7	4.6	4.2	10.3	35.3	52.5	123.9	164.0	207.0	262.2	40.0	22.9
1937	8.9	3.0	4.2	10.3	35.3	41.7	114.4	159.5	257.4	320.9	85.7	22.9
1938	8.9	3.0	4.2	14.7	35.9	71.7	140.7	171.9	249.0	489.2	144.4	22.9
1939	8.9	3.0	4.2	10.3	35.3	45.6	117.8	161.2	318.9	291.7	319.3	22.9
1940	8.9	3.0	4.2	10.3	35.3	40.0	112.9	158.9	229.1	265.0	146.9	33.7
1941	10.5	3.9	4.2	10.8	35.4	40.6	113.4	159.1	214.5	529.3	460.4	45.0
1942	12.2	4.9	4.2	13.1	35.7	45.0	117.3	160.9	294.2	467.8	425.3	22.9
1943	8.9	3.0	4.2	18.4	36.3	41.3	114.0	159.4	255.5	462.0	142.7	22.9
1944	8.9	3.0	4.2	10.8	35.4	48.2	120.1	162.2	194.2	512.8	160.9	50.6
1945	13.0	5.3	4.2	10.3	35.3	40.5	113.3	159.1	304.6	411.1	70.8	28.1
1946	9.7	3.4	4.2	10.7	35.4	43.8	116.2	160.4	207.8	353.1	84.4	22.9
1947	8.9	3.0	4.2	18.4	36.3	45.3	117.5	161.0	254.0	457.0	115.7	22.9
1948	9.0	3.0	4.2	14.7	35.9	43.3	115.8	160.2	347.6	338.0	123.2	22.9
1949	8.9	3.0	4.2	10.7	35.4	45.8	118.0	161.3	192.9	418.2	227.2	25.5
1950	9.3	3.2	4.2	10.3	35.3	44.0	116.4	160.5	304.2	313.9	61.2	22.9
1951	8.9	3.0	4.2	10.3	35.3	44.3	116.7	160.6	219.4	285.7	281.3	22.9
1952	8.9	3.0	4.2	10.3	35.3	46.4	118.5	161.5	261.5	585.2	170.0	22.9
1953	8.9	3.0	4.2	10.3	35.3	40.8	113.6	159.2	223.5	349.6	102.7	22.9
1954	8.9	3.0	4.2	10.7	35.4	44.6	117.0	160.8	211.3	274.6	41.5	37.8
1955	11.2	4.3	4.2	10.3	35.3	48.0	119.9	162.1	247.5	468.2	430.9	22.9
1956	8.9	3.0	4.2	11.9	35.5	84.0	151.5	176.9	230.2	284.9	84.3	40.0
1957	11.5	4.4	4.2	10.7	35.4	40.0	112.9	158.9	344.4	511.7	105.9	22.9
1958	8.9	3.0	4.2	10.3	35.3	41.6	114.3	159.5	194.9	438.0	74.8	22.9
1959	8.9	3.0	4.2	10.5	35.4	41.4	114.1	159.4	202.2	366.5	75.0	28.3
1960	9.7	3.5	4.2	10.3	35.3	41.5	66.8	137.3	193.0	349.9	90.4	83.6
1961	13.3	9.6	7.7	12.0	48.9	72.4	167.7	184.5	237.7	414.0	110.8	22.9
1962	8.9	3.7	3.4	5.4	20.8	32.2	354.5	271.9	501.1	583.8	61.1	30.4
1963	20.7	12.5	13.2	12.3	24.2	24.3	23.4	76.4	140.6	156.1	89.6	12.7
1964	7.4	5.1	0.4	7.3	84.3	45.5	94.1	176.4	332.5	482.0	142.0	26.3
1965	7.5	4.6	4.7	9.5	32.1	96.8	52.3	47.5	458.3	565.7	137.2	34.2
1966	10.6	5.5	4.9	13.3	42.1	82.8	135.7	148.2	174.7	270.9	110.7	48.3
1967	12.0	5.6	3.4	5.4	20.6	88.9	93.7	355.0	228.0	456.0	32.1	14.5
1968	7.6	4.5	3.3	6.0	21.4	29.9	67.1	136.8	85.8	241.2	21.2	7.9
1969	5.0	3.1	2.0	1.5	14.3	5.4	27.8	65.4	505.8	472.5	189.0	17.8
1970	10.1	7.6	4.5	9.8	19.4	221.6	149.7	373.9	220.0	368.6	288.8	391.5
1971	63.5	34.1	4.2	10.3	35.3	55.9	126.9	165.4	298.3	475.8	83.3	22.9
1998	3.6	2.4	2.3	2.1	9.3	3.0	11.3	48.2	228.0	418.3	158.1	32.0
1999	13.5	4.8	4.0	38.8	197.8	204.9	161.2	319.4	338.8	851.0	614.7	182.3
2000	35.2	12.8	25.2	54.0	63.5	103.2	212.2	142.2	178.4	716.6	167.2	53.0
2001	36.2	8.1	14.7	8.6	5.2	22.4	220.3	141.5	238.0	790.5	79.4	17.5
2002	5.0	1.9	0.5	3.5	5.0	5.0	10.1	62.7	100.0	113.2	55.0	36.4
2003	3.7	0.4	10.4	4.7	10.6	10.2	256.9	117.2	173.9	627.5	56.2	42.3
2004	36.3	17.2	8.1	7.7	9.3	33.3	30.6	65.2	72.7	107.4	12.0	8.3
2005	6.6	5.5	5.0	7.6	7.4	6.6	30.1	158.2				
Mean	11.3	5.0	5.7	11.6	36.1	48.2	116.6	155.7	238.2	408.1	158.6	35.0
Max	63.5	34.1	53.3	54.7	345.6	221.6	354.5	373.9	505.8	851.0	614.7	391.5
Min.	2.4	0.4	0.4	1.5	3.7	3.0	5.3	12.7	69.8	45.6	12.0	2.4

Source: 1901-1972 Prek Thnot Multipurpose Project, Reappraisal Report Volume 5.2 - Annexe I, Australian Catho
by Euroconsultant, The Netherlands December 1991 (Only monthly rainfall data is available)
1997-2004 Department of Meteorology, MOWRAM

Table 2.2.2 Environment Related Law and Regulation (1/2)

Title	Issued in	Provisions
Basic Law		
Law on Environmental Protection and Natural Resource Management (LEPNRM)	1996	• It is the supreme legal instruments under the Constitution controlling environmental protection and natural resource management of the country which includes: ➢ To protect and promote environmental quality and public health through prevention, reduction, and control of point sources and non-point source of pollution (Environmental Protection), ➢ To assess the environmental impact of all proposed projects prior to the issuance of the decision by the Government (Environmental Impact Assessment), ➢ To encourage and enable the public to participate in environmental protection, and natural resource management (Public Participation and Information Disclosure), and ➢ To suppress any act that cause harm to the environment (Management and Penalty). • LEPMRM consists of 11 chapters, 6 of which are the key to environmental protection, an important part of sustainable development in environmental friendly manner. Those chapters cover: (i) national environmental action planning and regional environmental planning, (ii) protected area management, (iii) environmental impact assessment, (iv) pollution control, (v) an environmental endowment fund, and (vi) penalties for violation of the law.
Environmental Management Institution		
Sub-Decree on the Organization and Functions of the Ministry of Environment	1997	• Structures of MOE and its functions including tasks of six line departments are defined • Provincial and/or Municipal Department of Environment are established in each Province and/or Municipality responsible for coordinating and implementing MOE activities at respective Provinces and/or Municipalities.
Environmental Impact Assessment		
Sub-Decree on Environmental Impact Assessment Process	1999	• Project Owners, including private or public, shall prepare Environmental Impact Assessment (EIA) or Initial Environmental Impact Assessment (IEIA) reports prior to the projects. • The sub-decree also fosters public participation in the environmental impact assessment process so as to empower communities in decision-making.
Declaration on Guidelines for Conducting Environmental Impact Assessment Report	2000	• The Guideline defines the format of EIA report consisting of: (i) Project Summary, (ii) Introduction, (iii) Purpose of the Project, (iv) Project Description, (v) Description of Environmental Resources, (vi) Public Participation, (vii) Environmental Impact Analysis, (viii) Environmental Impact Mitigation Measures, (ix) Economic Analysis and Environmental Value, (x) Environmental Management Plan, (xi) Institutional Capacity, (xii) Conclusion and Suggestion and (xiii) References.
Protected Areas Management		
Royal Decree on the Protection of Protected Areas	1993	• The Decree consists of six chapters defining protected areas classified into four categories corresponding to international classifications as follows: (i) National Parks, (ii) Wildlife Sanctuaries, (iii) Protected Landscapes and (iv) Multiple Use Areas in the country.
Royal Decree on the Establishment and Management of Tonle	1994	• The Tonle Sap Biosphere Reserve shall fulfill three complementary functions: (i) a conservation function to contribute to the conservation of biological diversity, (ii) a development function to foster sustainable development of ecology,

Table 2.2.2 Environment Related Laws and Regulations (2/2)

Title	Issued in	Provisions
Sap Biosphere Reserve		environment, society, and culture, and (iii) a logistic function to provide support for demonstration projects, environmental education and training. • The Tonle Sap consists of three zones: (i) Core Zone, totaling 42,257 ha (Prek Toal: 21,342 ha, Boeng Tonle Chhmar: 14,560 ha and Stoeng Sen: 6,355 ha), (ii) Buffer Zone, totaling 541,482 ha and (iii) Transitional Zone amounting to 899,600 ha each of which are defined as follows: ➢ Core Zone: Defined likewise national park or wildlife sanctuary devoted to long term protection and conservation of natural resources and ecosystem ➢ Buffer Zone: Managed to be consistent to the protection and conservation plan of the core areas ➢ Transitional Zone: The integrated economic zone managed for the sustainable agriculture, human settlement and land uses without having adverse effects on the flooded forest, water quality and soils around the Tonle Sap Lake
Declaration No. 1033 on Protected Area	1994	• It is the declaration dealing with activities prohibited within protected areas such as hunting, deforestation, exploitation of minerals, and water pollution
Draft Decree on the Establishment and Management of Protected Areas	Draft	• It is to provide a regulatory framework for the classification, establishment, amendment, management and financial support of all classes of protected areas in the country in order to contribute to biodiversity, national socio-economic development and local community livelihood.
Pollution Control		
Sub-Decree on Water Pollution Control	1999	• Standard on effluent discharge and water quality is defined. • Type of pollution sources are categorized which requires permission from MOE. • MOE has responsibilities for monitoring the pollution sources and the situation of the water pollution in public water bodies.
Sub-Decree on Solid Waste Management	1999	• This sub-decree is to regulate solid waste management with proper technical manner and safe way in order to ensure the protection of human health and the conservation of biodiversity. • Type of the hazardous waste are defined which may cause the danger to human health and animal or damage plants, public property and the environment. • MOE shall establish guidelines on household waste management and hazardous waste management. • The Provincial and/or Cities' Authorities shall establish the waste management plan and have the responsibilities for the collection, transport, storage, recycling, minimizing and dumping of waste.
Sub-Decree on Air Pollution and Noise Disturbance	2000	• The sub-decree has a purpose to protect the environmental quality and public health from air pollutants and noise pollution through monitoring and curing activities.
Land		
Land Law	2001	• There are some provisions including land ownership and property rights, land acquisition for public works, resettlement aspects and legal requirement for compensation for the loss of land.

Source: Asian Development Bank (2003), Compendium on Environment Statistics 2003 Cambodia

Sok Sphana and Sarin Denora, Laws & Regulations on Environment Biodiversity & Protected Areas

Table 2.2.3 Work Sequence of Rehabilitation of Regulator's Gates

Sequence	Work
1	Temporary Diversion Work : For the gate rehabilitation, temporary diversion work, such as steel stoplog method or temporary coffer dam method, will be carried out.
2	As-built Drawings: The gates were installed in 1974. It is said that the installation was involved in the civil war and the gate manufacturer left the site without submitting as-build drawings. At present, as-built drawings are not available although the tender drawings are available. Since the tender drawings are different from the actual gates, it is a must to know the details of the gates by seeing and measuring.
3	Drilling Holes : In order to remove wheels, bushings and pins, drilling ten holes (diameter 40 cm, length 50 cm) in the concrete piers is necessary. One set of wheel, bushing and pin has to be removed urgently for measurement and procurement order to makers of bushings and pins has to be issued soonest.
4	Removal of Wheels, Bushings and Pins : A gate is raised to adjust location of wheel, bushing and pin to that of hole. Pin has to be manually removed with hammer and jack through a hole. One set of wheel, bushing and pin, has to be removed urgently for measurement. After this, the remaining 39 sets of wheels, bushings and pins have to be removed.
5	Measurement of Bushing and Pin : For procurement of new bushings and pins, correct drawing and technical specifications are necessary. After removal of wheel, bushing and pin, bushing and pin must be precisely measured, and drawings and technical specifications have to be prepared urgently. However, removal of bushing from the wheel can not be done at site since proper equipment for removal and measuring equipment with a precision of 1/100 mm are not available in Cambodia. The removed wheels, bushings and pins are transported to a factory in the 3rd country. Due to limited time, transportation by air cargo is necessary.
6	Manufacturing of New Busing and New Pins : New bushings and new pins are manufactured in Japan since maintenance free bushings are not manufactured except Japan in Asian countries and manufacturing period (45 days) is very short.
7	The removed wheels are grounded with lathe with a precision of 1/100 mm at a factory in the 3rd country for smooth insertion of new bushings into wheels before new bushings and pins are delivered to the factory. If necessary, wheels are painted.
8	Rust removal / Re-painting of Gate Leaves & Replacement of Rubber Seals : Before wheels with new bushings and new pins are delivered to site, rust removal and re-painting of gate leaves are carried out at site. Replacement of rubber seals is also carried out at site.
9	Insertion of New Bushings to Wheels : After new bushings and new pins are manufactured in Japan, they are transported to a factory in the 3rd country. At the factory, new bushings are inserted into the existing wheels, and new pins are processed for easy installation of pins to the wheels and gate leaves.
10	Installation of Wheels with Bushings and Pins on Gate Leaves : Wheels with new bushings and new pins are transported to site and installation of such wheels and pins on the gate leaves and wheels is carried out. For installation of pins, adjustment by means of eccentric pin is done.
11	Others : The existing hoists, wire ropes, motors and control panels are replaced with new ones and new control panel is additionally installed at O&M office in due consideration of progress and schedule of the above works 1 to 10 .
12	Removal of Temporary Diversion Facilities : Steel stoplog or temporary coffer dam is dismantled or removed from the site after the gate rehabilitation is finished.

Table 2.2.4 Transportation Required for Rehabilitation of Regulator's Gates

Route	Type of Transportation	Alternative Plan 1	Alternative Plan 2	Alternative Plan 3-1	Alternative Plan 3-2	Alternative Plan 3-3
From Site to 3rd Country	Air Cargo	One set of existing wheels (220 kg) & existing bushings (5 kg) : 225 kg 7 sets of existing wheels (220 kg) & existing bushings (5 kg) : 1.575 tons =225 kg x 7sets (Total :1.8 tons)		One set of existing wheels (220 kg) & existing bushings (5 kg) : 225 kg		
	By Truck	32 sets of existing wheels (220 kg) & existing bushings (5 kg) : 7.2 tons (=225 kg x 32 sets)		39 sets of existing wheels (220 kg) & existing bushings (5 kg) : 8.775 tons (= 225 kg x 39 sets)		
From 3rd Country to Site	By Air Cargo	8 sets of existing wheels (220 kg) & existing bushings (5 kg) : 2.0 tons (= 250 kg x 8)		–		
	By Truck	Existing wheels with new bushings (=220 kg + 5 kg) & new pins (25 kg) for 4 sets of gates : 8.0 tons (=250 kg x 32 sets)		Existing wheels with new bushings (=220 kg + 5 kg) & new pins (25 kg) for 5 sets of gates : 10.0 tons (= 250 kg x 40sets)		
From Japan to 3rd Country	Air Cargo	New bushings & new pins for one set of gates : 0.24 ton (= 30 kg x 8sets)		New bushings & new pins for 5 sets of gates : 1.2 tons (= 30 kg x 40 sets)	New bushings & new pins for 3 sets of gates : 0.72 tons (=30 kg x 24 sets)	New bushings & new pins for 5 sets of gates : 1.2 tons (= 30 kg x 40 sets)
	By Ship	New bushings & new pins for 4 sets of gates : 0.96 tons (=30 kg x 32 sets)		–	New bushings & new pins for 2 sets of gates : 0.48 tons (=30 kg x 16 sets)	–

Table 2.2.5 Comparison of Temporary Diversion Plans (River Course Diversion Plan, Temporary Coffer Dam Plan, Partial Closure Plan)

	River Course Diversion Plan	Temporary Coffer Dam Plan	Partial Closure Plan
Temporary Diversion Plan	A temporary coffer dam and a temporary diversion channel are constructed at the upstream of the regulator in order to divert the river water into the diversion channel. At the downstream of the regulator, the temporary diversion channel joints the river.	Instead of the temporary diversion channel in the River Course Diversion Plan, the existing north approach channel (capacity : about 70 m^3/s) is used to divert the river water to the approach channel. For safety of the north approach channel, a temporary spillway is constructed. See Figure (1).	At the immediate upstream of the regulator, 1st temporary coffer dam is constructed to surround a part of the working area (1^{st} closure). After the work is finished, 2^{nd} temporary coffer dam is constructed to surround the remaining part of the working area (2nd closure). The remaining work is finished. For Roleang Chrey regulator, 3^{rd} temporary coffer dam has to be constructed (3^{rd} closure) because of the reasons stated in Figure (2).
Design Discharge	Design discharge of the diversion channel should be a 10-year probable flood for dry season of 50 m^3/s.	Design discharge of the existing north approach channel should be a 10-year probable flood for dry season of 50 m^3/s..	The regulator has a flow capacity of more than 10-year probable flood for dry season of 50 m^3/s .
Necessary Facilities and their Dimensions	Temporary diversion channel (length :1,000 m), Temporary coffer dam (height :8 m, top width : 7 m, bank slope : 1:2、 berm : 2 m)	Temporary coffer dam (height :8 m, top width : 7 m, bank slope : 1:2、 berm : 2 m) + Temporary spillway (design discharge : 40 m^3/s) with related facilities	Three (3) temporary coffer dams (height :8 m, top width : 4 m, bank slope : 1:2、berm : 2 m), Total length of the dam: 100 m + 100 m + 80 m = 280 m.
Water Cut-Off Period	20 days in total consisting of 10 days for construction and 10 days of removal of the dam	20 days in total consisting of 10 days for construction and 10 days of removal of the dam	60 days in total (3-time construction and 3-time removal of the dam)
Compensation	For the construction of temporary diversion channel, land acquisition of about 5 ha is necessary. The channel cross existing paddy field, roads and houses. The compensation is very hard.	Little compensation	Little compensation
Cost	Highest	Lower than that of River Course Diversion Plan	Lower than that of River Course Diversion Plan
Safety	Excellent	Excellent	The end of the coffer dam has to be in touch with concrete piers or steel gates. The coffer dam is not safe due to this connection.
Evaluation	X : Highest cost and difficult compensation	○ : Lower cost, shortest water cut-off, little compensation	X : Longest water cut-off period and the coffer dam is not safe.

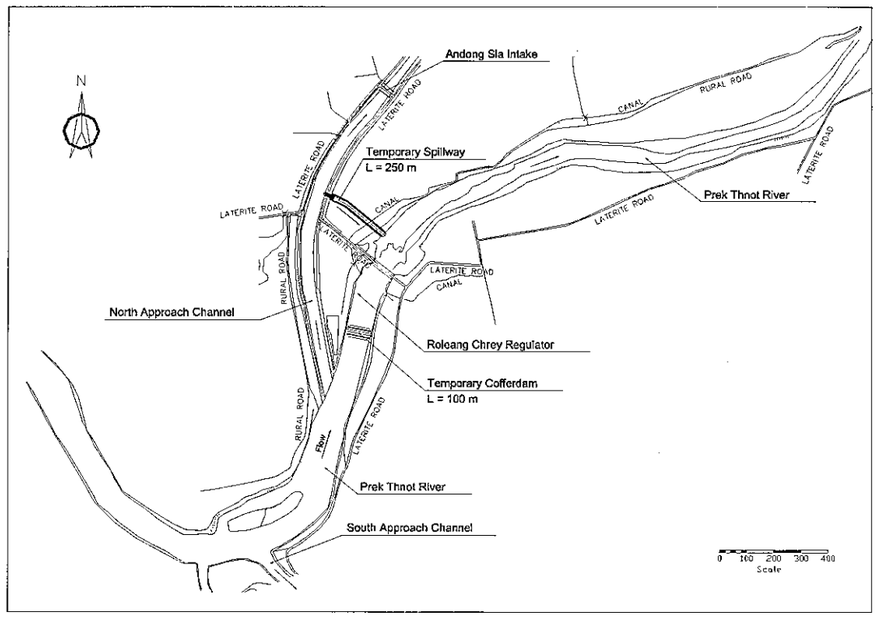
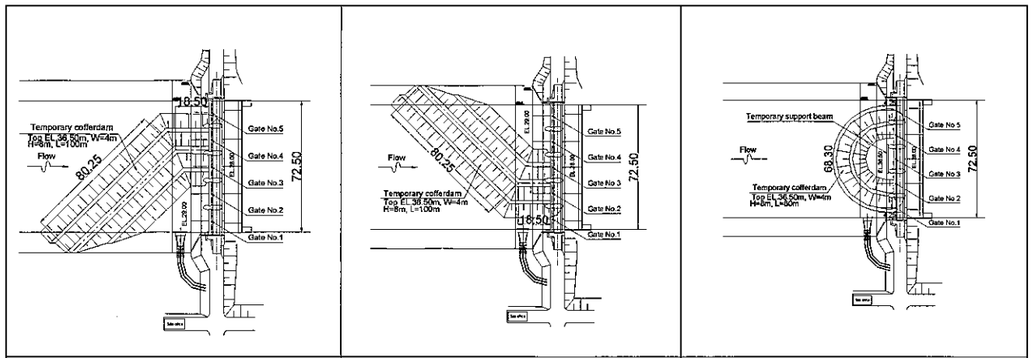


Figure 1 Temporary Coffer Dam

The temporary coffer dam, which is constructed at the immediate upstream of the regulator, is 8 m high since the river water is 7 m deep. The top width of the dam is 4 m and the dam slope is 1:2. A berm of 2m on the dam is necessary for the safety. The total base length of the dam comes to 40 m. After the 1^{st} closure (100 m) shown in (1) of Figure 2 is finished, No.1 and No.2 gates can be rehabilitated. After the 2^{nd} closure (100 m) shown in (2) of Figure 2, No.4 and No.5 gates can be rehabilitated. For No.3 gate rehabilitation, the 3^{rd} closure (80 m) is necessary since the dam base length is 40 m. See (3) of Figure (2).



First Closure (1) | Second Closure (2) | Third Closure (3)

Figure 2 Partial Closure Plan

Table 2.2.6 Alternative Study on the Gate Rehabilitation Work of the Regulator

Items	Alternative Plan 1	Alternative Plan 2	Alternative Plan 3-1	Alternative Plan 3-2	Alternative Plan 3-3
Temporary Diversion Method	Steel Sotplog (One Set)	Steel Sotplog (Two Sets)	Temporary coffer dam is constructed in the 1st dry season.	Temporary coffer dam is constructed in the 1st and the 2nd dry seasons.	Temporary coffer dam is constructed in the 2nd dry season.
Study Conditions (For All Alternative Plans)	1) The rehabilitation/construction work starts on September 01, 2009 in due consideration of Japan's grant aid scheme. 2) A water cut-off period should be set up during dry season from December 01 to April 30, and a water cut-off period should not be set up during rainy season from May 01 to November 30. 3) The rehabilitation / construction work in the river should not be carried out during flood season from July 01 to October 31 for safety of the workers. 4) The inlet portion of the river outlet structure is constructed during two months out of three (3) months from February to April. 5) It takes 7 months and 20 days for a contractor to prepare manufacturing drawings, receive approval of the design, procure material, manufacture and transport hoisting equipment of regulator's gates. 6) It takes 10 months for a contractor to prepare manufacturing drawings, receive approval of the design, procure material, manufacture and transport river outlet structure's gates. 7) It takes 12 months for a contractor to prepare manufacturing drawings, receive approval of the design, procure material, manufacture and transport Andong Sla intake's gates. 8) The other works take the following periods: temporary work (2 months), river outlet structure (civil work 5 months, installation of gates 10 days), rehabilitation of downstream river bank protection (5 months), downstream river bed protection (5 months), reconstruction of Andong Sla intake (civil work 4 months, installation of gates 10 days), miscellaneous work (2 months)				
Study Conditions (For Steel Stoplog Method & Temporary Coffer Dam Method)	1) Prior to steel stoplog installation, a contractor removes silt and mud on an installation place and fix anchor pads on the concrete piers, which are hooked with stoplogs. For these works, a water cut-off period of 10 days is set up. 2) It takes at least 6 months for a contractor to prepare manufacturing drawings, receive approval, procure material and manufacture steel stoplogs. 3) It takes 3 months and 10 days for a contractor to rehabilitate the 1st gate. 4) It takes 8 months for a contractor to rehabilitate four (4) sets of the 2nd, 3rd, 4th and 5th gates.		1) It takes 30 days for a contractor to prepare and construct a temporary coffer dam. 2) A water cut-off period for construction of the coffer dam is 10 days from December 01 to December 10. 3) Gate rehabilitation period is 4 months and 10 days from December 11 to April 20. 4) A water cut-off period for removal of the coffer dam is 10 days from April 21 to April 30. 5) It takes 30 days for a contractor to transport the removed dam material to disposal area. 6) After construction of a coffer dam, the river water is diverted to the north approach channel as temporary diversion channel. A temporary spillway is constructed on the approach channel in order to protect the approach channel and the coffer dam.		
Main Features	Water cut-off period of 2 months is necessary for construction of inlet of the river outlet structure.			Water cut-off period of 2 months is not necessary for construction of inlet of the river outlet structure.	
	Construction needs small coffer dam(s) and dewatering since river water flows during dry season.		No river water is flowing during dry season and dewatering is easy.		
	Temporary spillway is not necessary.		Construction of temporary spillway on the north approach channel is necessary.		
Gate Rehabilitation Sequence*	No.3→No2→No.1,5→No.4	No.3→No2,4 → No.1,5	5 gates at one time	No.1,3,5→No.2,4	5 gates at one time
Air-Cargo Weight 1) Site→ 3rd Country	8 sets of existing wheels and bushings of 1st gate: 1.8 tons		1 set of existing wheels and bushings : 225 kg		
Air-Cargo Weight 2) Japan→ 3rd Country	8 sets of new bushings and pins of 1st gate: 240 kg		40 sets of new bushings and pins : 1.2 tons	24 sets of new bushings and pins of 3 gates : 720 kg	40 sets of new bushings and pins : 1.2 tons
Air-Cargo Weight 3)3rd Country→ Site	8 sets of existing wheels, new bushings and new pins of 1st gate: 2 tons		Zero		
Time Allowance against Delay in Construction Commencement	Time allowance is very limited in the schedule.		Time allowance of 4 months is available in the schedule.		
Time Allowance against Long Customs Clearance	Very limited.		10 to 15 days of time allowance is available in the schedule.		
Gate Rehabilitation Period	21 months 20 days	19 months 20 days	20 months 20 days	21 months	21 months 20 days
Water Cut-Off Period	2 months 20days	2 months 20 days	2 months 20 days	40 days	20 days
Tempo. Diversion Cost **	Yen 48.8 million	Yen 75.1 million	**Yen 42.5 million**	**Yen 85.0 million**	**Yen 42.5 million**
Merits	・Low cost	・Rehabilitation of 2 sets of gates is possible.	・Time allowance against risks is included. ・Air-cargo weight of Site⇔3rd country is minimum.		
	・Air cargo weight from Japan is minimum. ・Temporary spillway is not necessary. ・Skilled staff can be arranged easily since 5 gates are rehabilitated at 3 or 4 stages.		・Lowest cost	・Water cut-off period is short. ・Skilled staff can be arranged easily since 5 gates are rehabilitated at two times.	・Water cut-off period is the shortest. ・Construction cost is the lowest.
Demerits	・Time allowance is very limited. ・Air cargo weight of Site⇔3rd country is the largest.		・Air cargo weight from Japan is the largest. ・Temporary spillway is necessary.		
	・Water cut-off period is the longest.	・2-time installation of stoplog is necessary. ・Water cut-off period is the longest and cost is very high.	・Contractor is hard to arrange plural working groups of skilled staff since 5 gates are rehabilitated at one time.	・2-time coffer dam construction is necessary.	・Contractor is hard to arrange plural working groups of skilled staff since 5 gates are rehabilitated at one time.
Evaluation	△	△	○	○	◎
	Time allowance against delay and waiting for customs clearance is not included in the schedule.		Time allowance against delay and long waiting for customs clearance (10 to 15 days) is included in the schedule.		
	Longest water cut-off period and low cost.	Longest water cut-off period and high cost.	Longest water cut-off period and lowest cost.	Short water cut-off period and high cost.	Shortest water cut-off period and lowest cost.

* The number of gate is given No.1, No.2, No.3, No.4, No.5 from the right bank to the left bank of the regulator.
** Construction cost of temporary spillway is included.

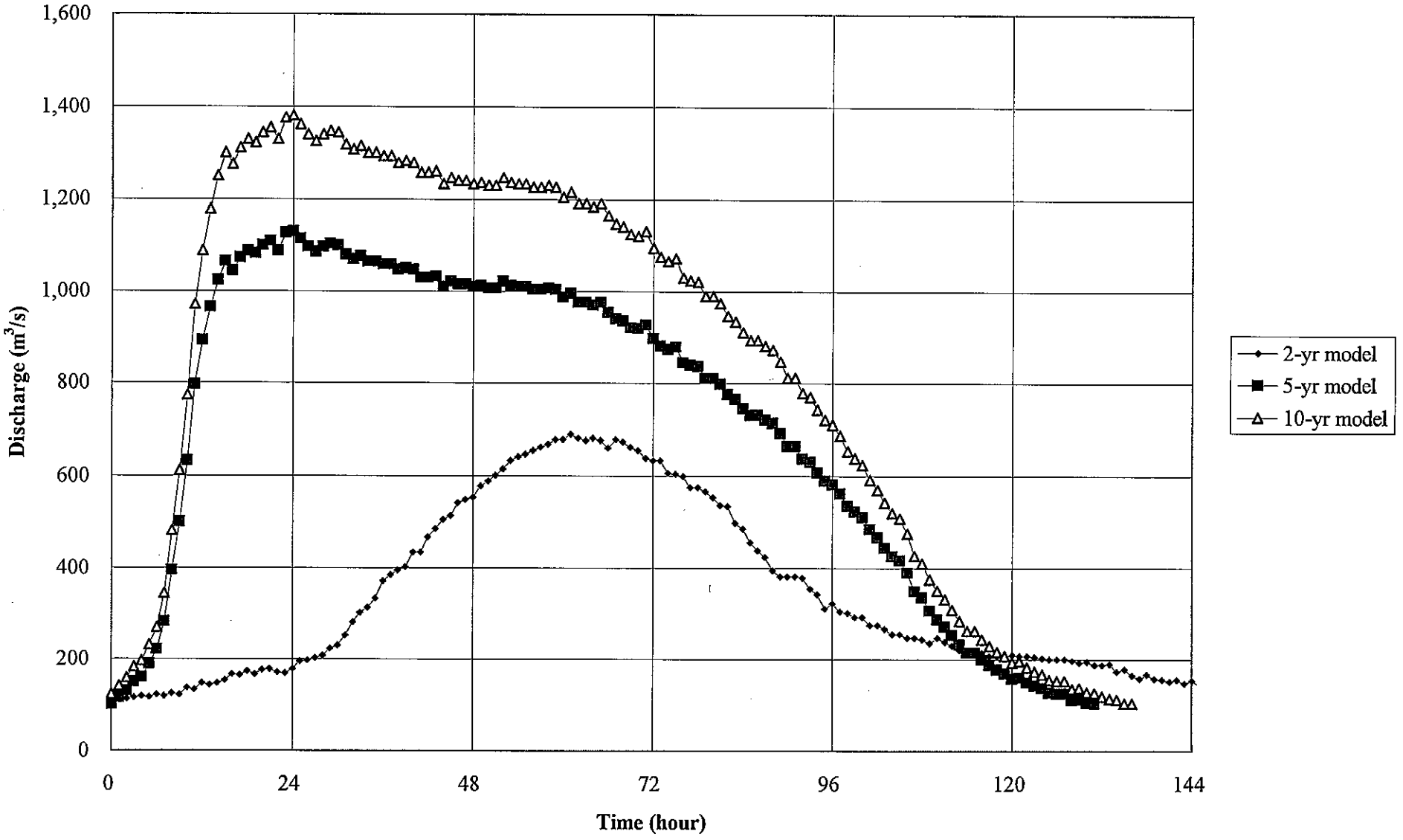


Figure 2.2.1 Hydrograph

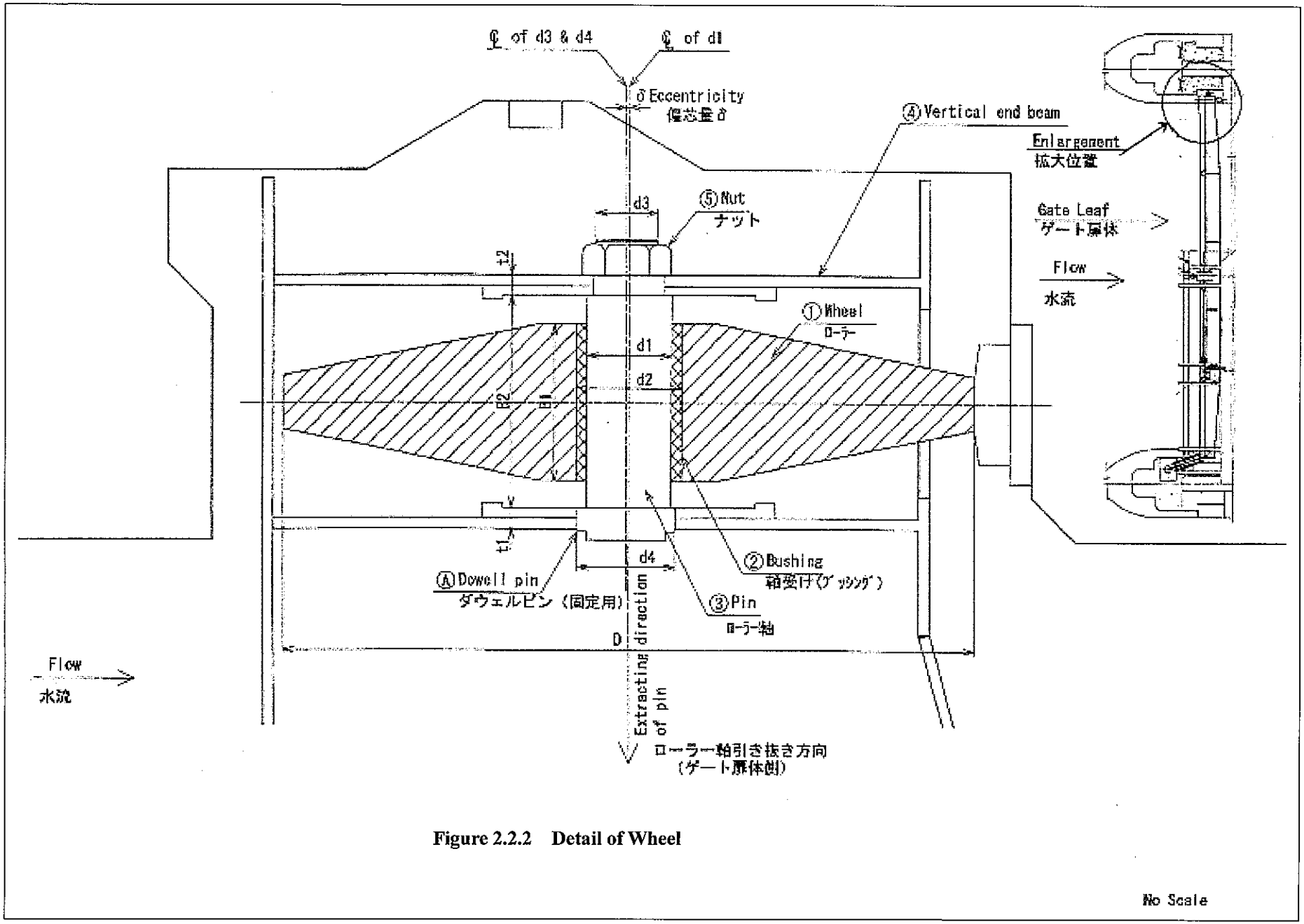


Figure 2.2.2 Detail of Wheel

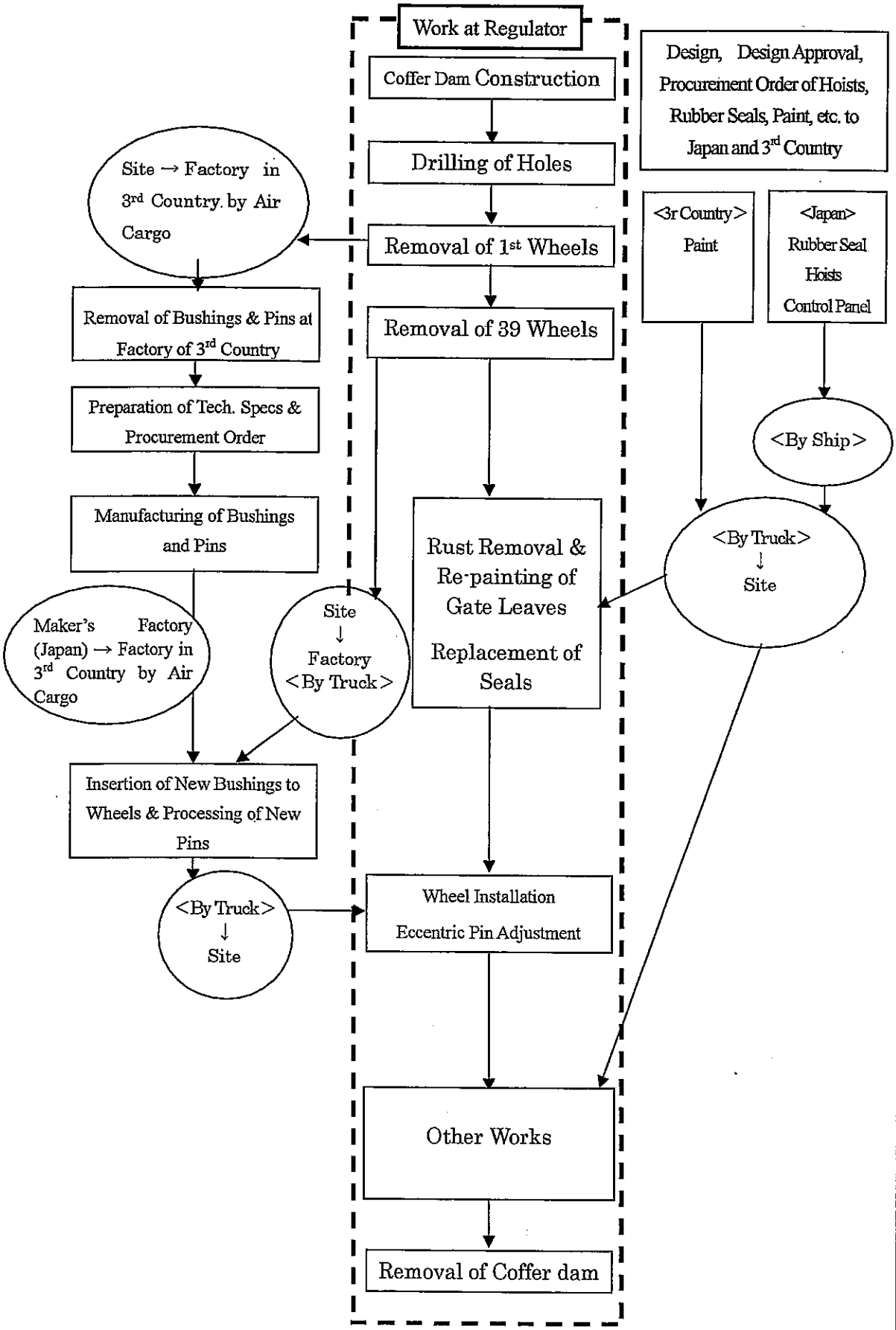
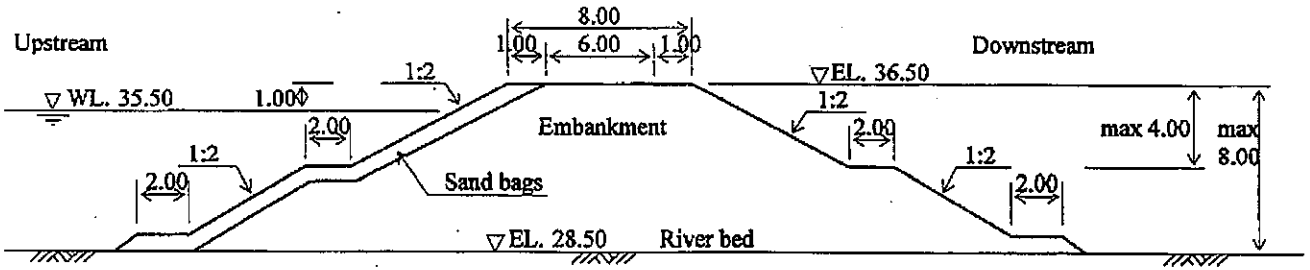


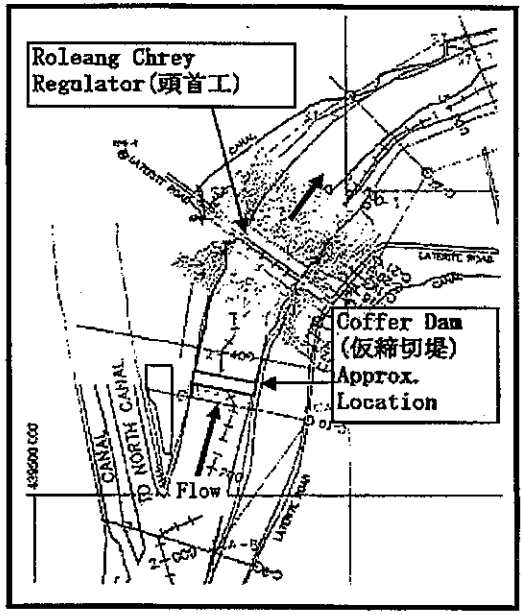
Figure 2.2.3 Standard Work Flow of Gate Rehabilitation

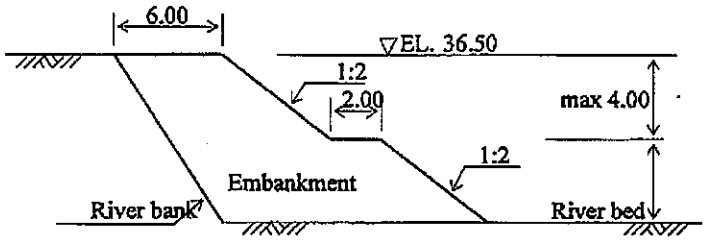


Typical Cross Section of Cofferdam

Top length of cofferdam L = 100 m

PLAN





Typical Cross Section of Access Road

Slope of road I = 8.0%
Length of road L = 100 m

Figure 2.2.4 Typical Cross Sections of Temporary Coffer Dam and Access Road to the River

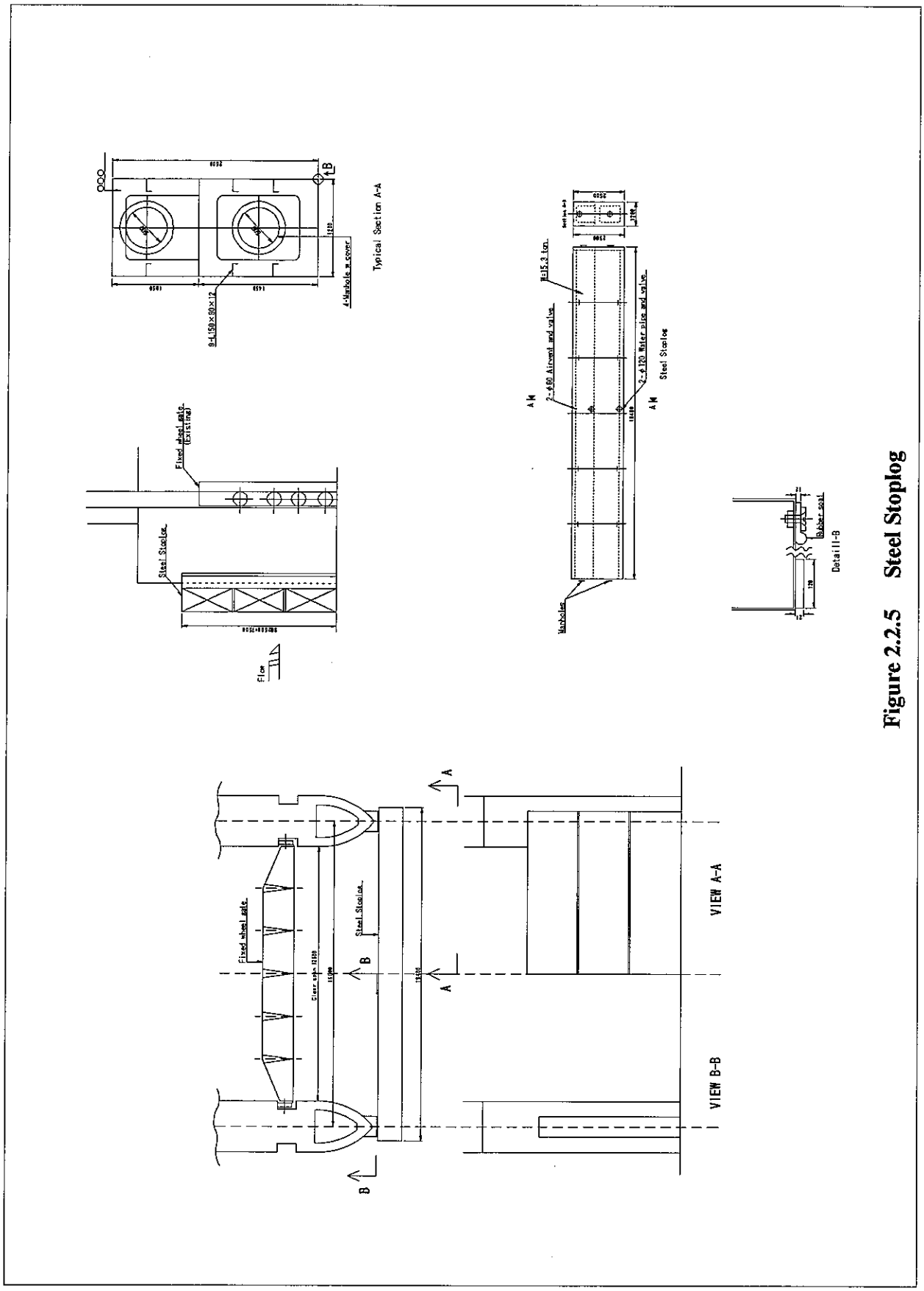


Figure 2.2.5 Steel Stoplog

(One Set of Steel Stoplog)

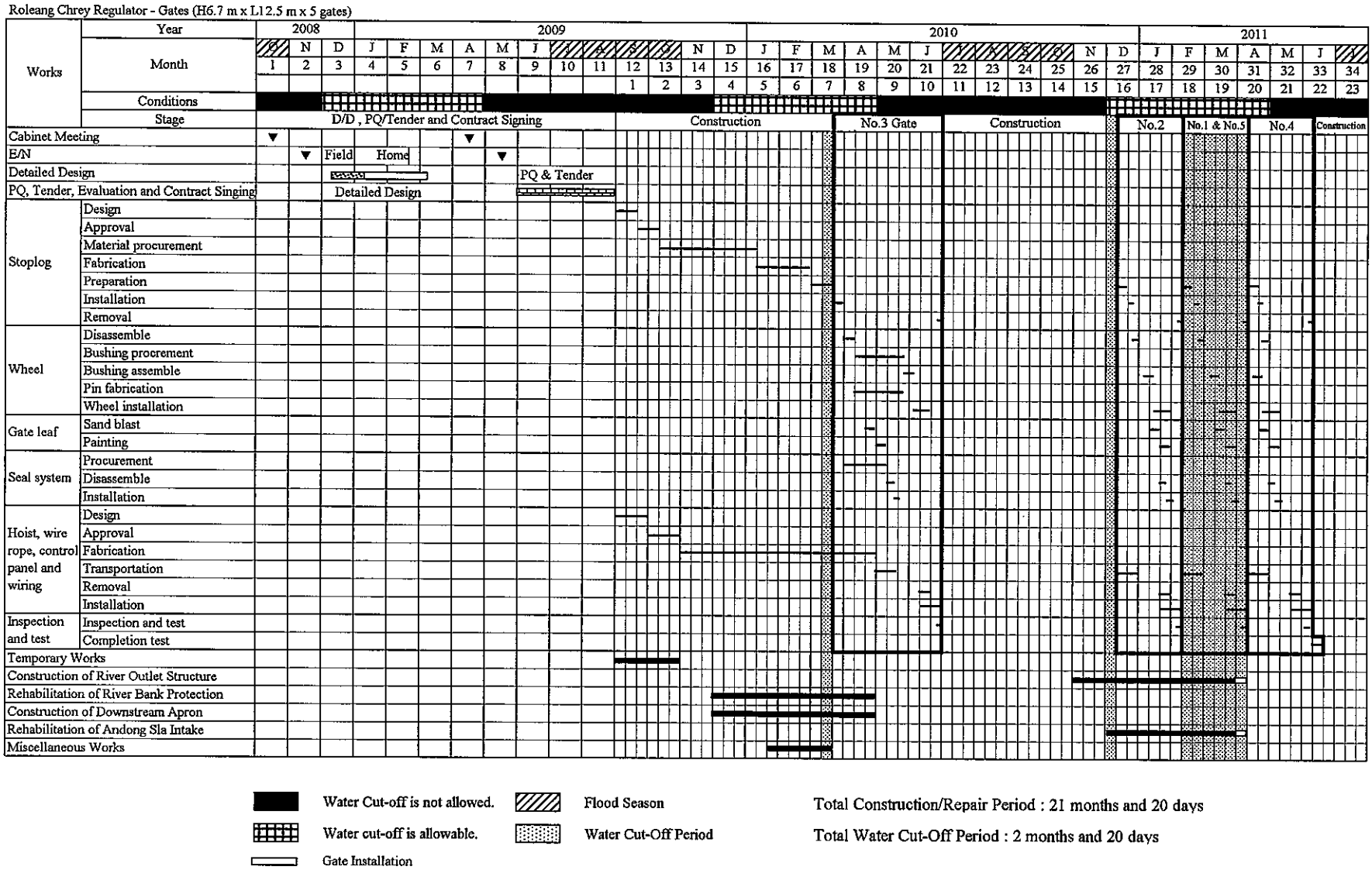


Figure 2.2.6 Alternative Plan 1

(Two Sets of Steel Stoplog)

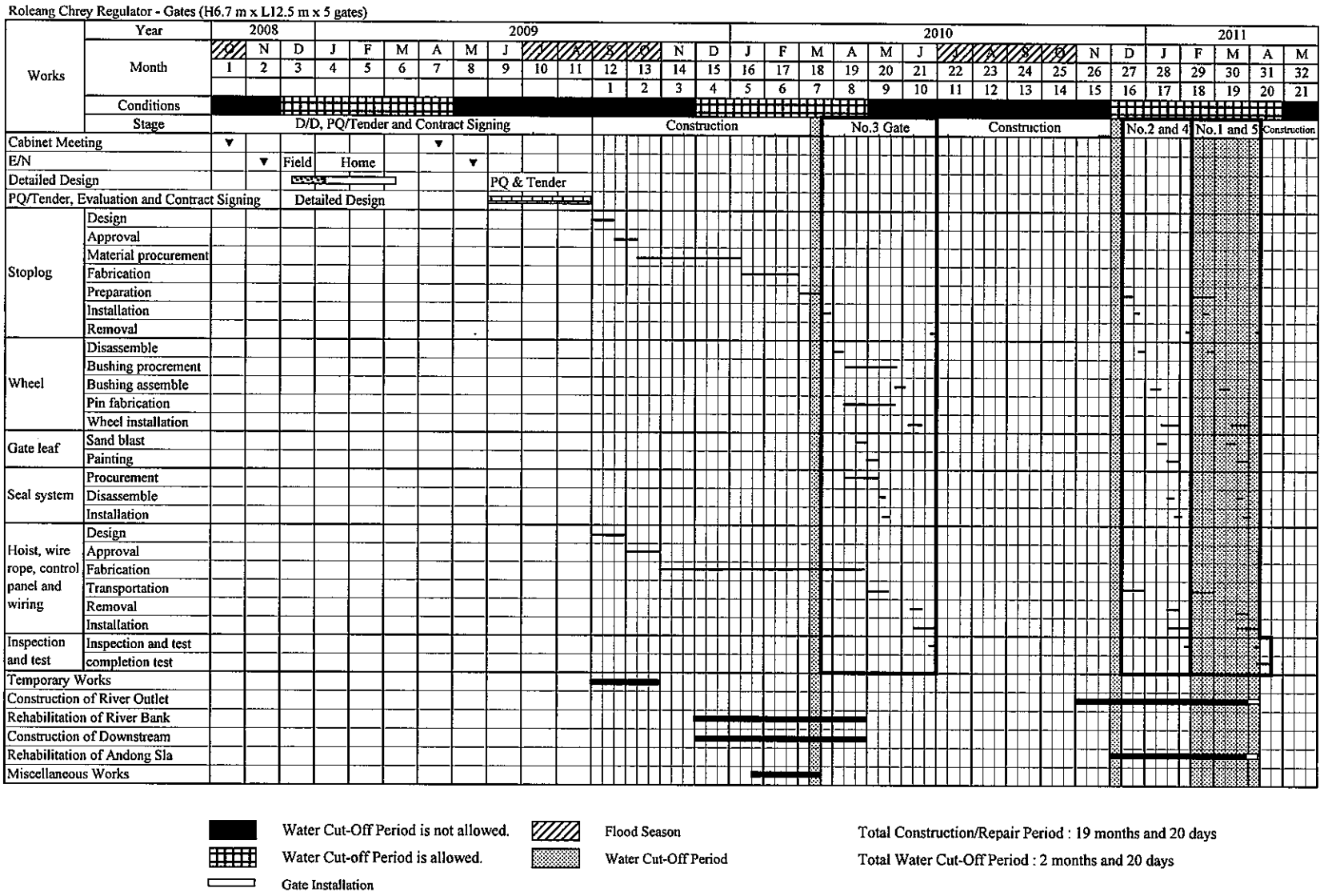


Figure 2.2.7 Alternative Plan 2

(Tempoary Coffer Dam in the 1st Dry Season)

Roleang Chrey Regulator - Gates (H6.7 m x L12.5 m x 5 gates)

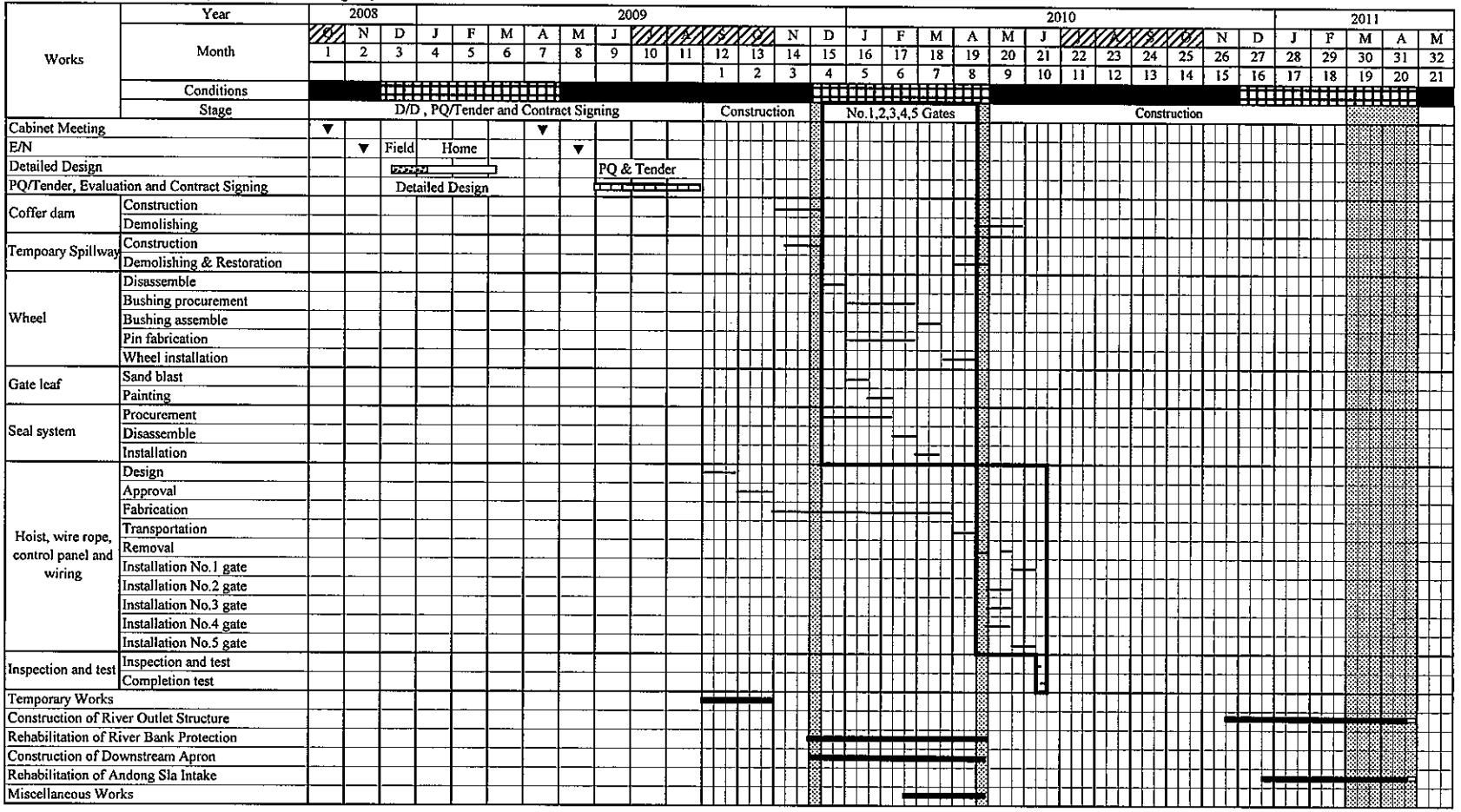


Figure 2.2.8 Alternative Plan 3-1

(Temporary Coffer Dam in the 1st and 2nd Dry Seasons)

Roleang Chrey Regulator - Gates (H6.7 m x L12.5 m x 5 gates)

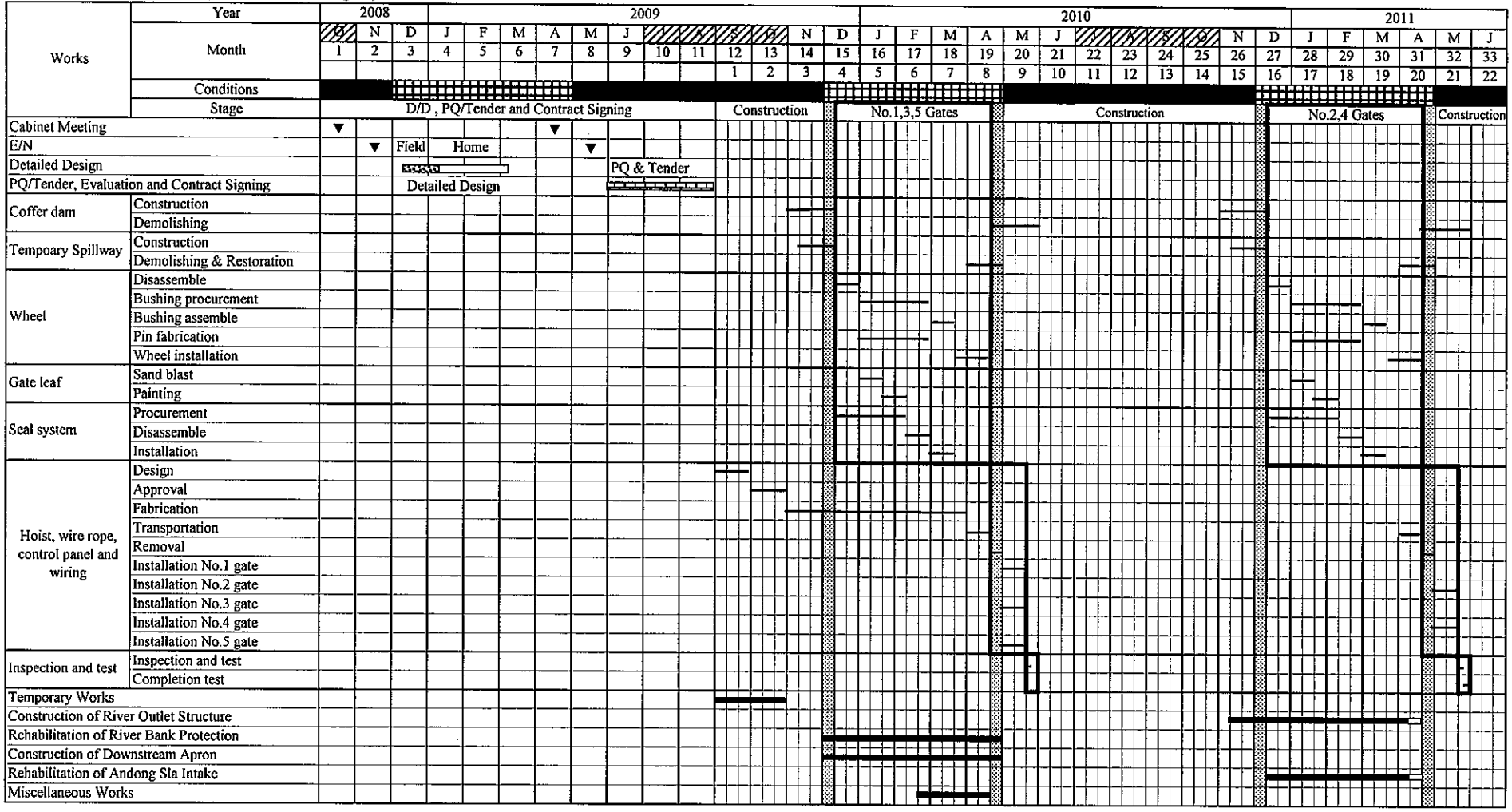


Figure 2.2.9 Alternative Plan 3-2

(Temporary Coffer Dam in the 2nd Dry Season)

Roleang Chrey Regulator - Gates (H6.7 m x L12.5 m x 5 gates)

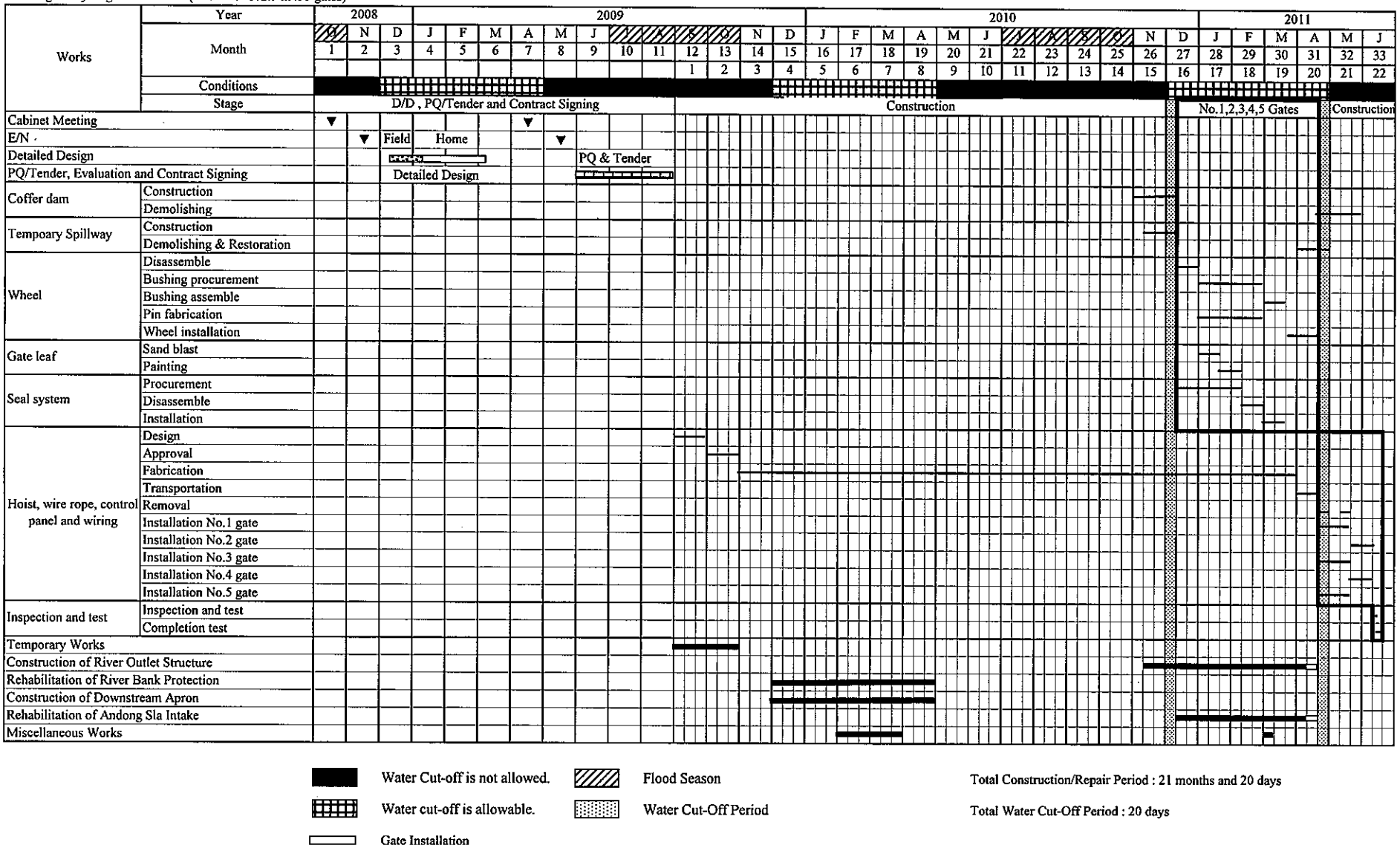


Figure 2.2.10 Alternative Plan 3-3

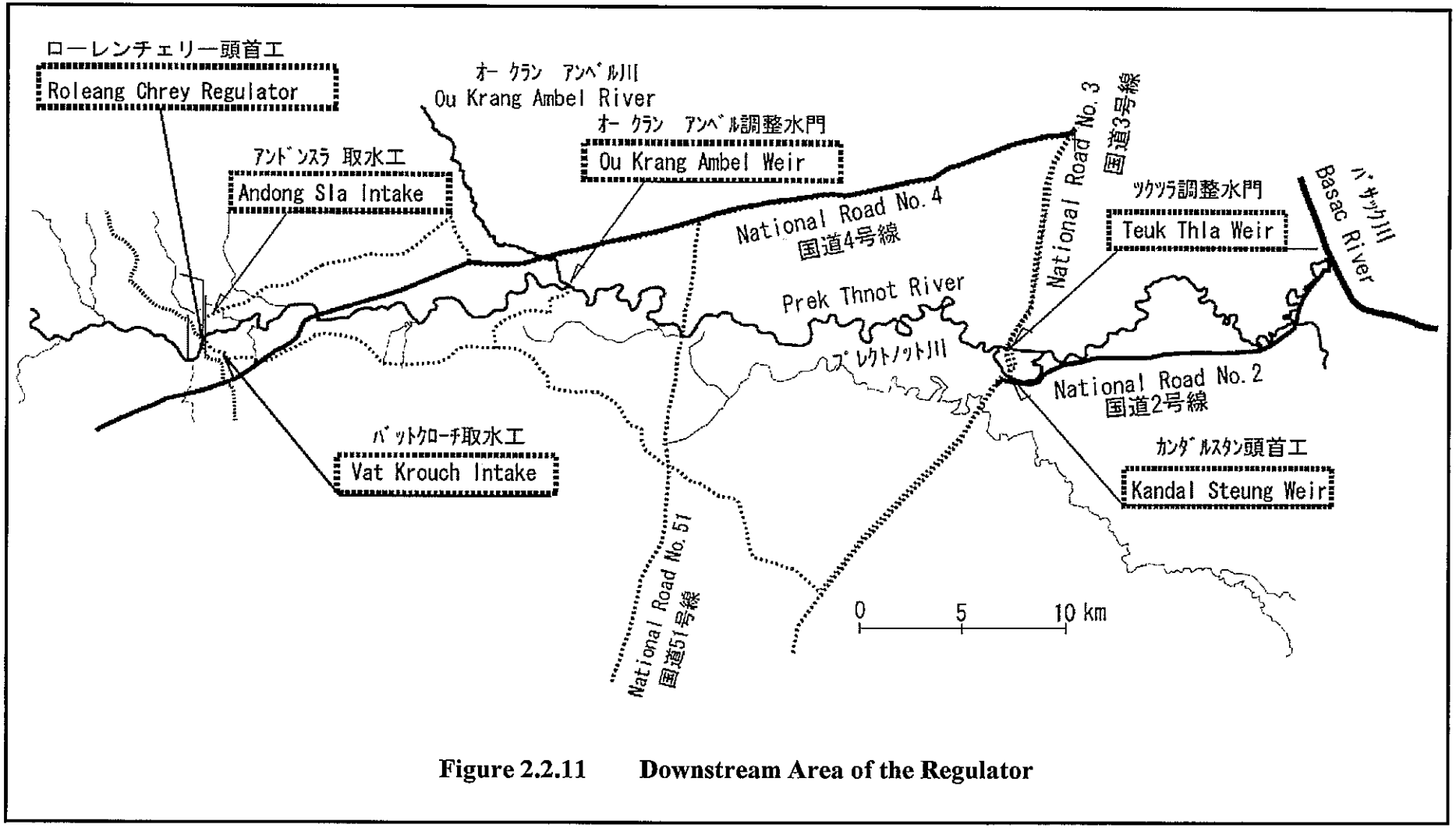


Figure 2.2.11 Downstream Area of the Regulator