CHAPTER 4. OUTLINE OF THE PROJECT

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4-1. Objective

The tidal regulators, which are planned to be constructed on the Mae Nam Bang Nara running along the coastal line, are the very important structures of the Bang Nara Irrigation and Drainage Project. The Bang Nara Irrigation and Drainage Project has a project component of the irrigation water supply to the paddy at rainy season, field crop and vegetable at dry season, trees and so on. And the objective of the Bang Nara Irrigation and Drainage Project is to improve agricultural productivity by the irrigation and agricultural development as well as regional economic development. The tidal regulator will be constructed for making Mae Nam Bang Nara a desalting reservoir for the irrigation purpose, and for run-off the flood safety.

The gates of tidal regulator shall be operated not only by the reservoir level but also the tidal level. It will be very difficult to remove out the saline water, if the saline water goes into the desalting reservoir by the misoperation. The operation works of Bang Nara Desalting Reservoir is to be carried out with not only two tidal regulators to be constructed under this Project but also existing Nam Baeng Regulator.

The Bang Nara Irrigation and Drainage Project based on the freshening reservoir is water resource development newly introduced, specially, two tidal regulators, which will be constructed on the soft foundation, have technical and financial difficulties, involving construction methods as well-point watering and long pile foundation works. Accordingly, the Japan's grant-aid is assisted the construction of two tidal regulators.

4-2. Examination on the Request

The Feasibility Study of the Bang Nara Tidal Regulator has been carried out by the Japan International Cooperation Agency as a part of the Bang Nara Irrigation and Drainage Project. Therefore, the examination on the request has been carried out including the demarcation of the scope of works between Thailand budget and Japanese Grant-Aid according to this basic design study and field survey based on the proposed dimensions of the Feasibility Study Report as follows.

4-2-1. Tidal Regulators and Closure Dams

Tidal regulators consist of two regulators; one is Upper Tidal Regulator (UTR) located at northern part of Mae Nam Bang Nara and other is located at southern part of the Mae Nam Bang Nara named as Lower Tidal Regulator (LTR). Both the UTR and LTR will be located at the short cut of winds of Mae Nam Bang Nara. Namely, the regulators will be constructed on the land being not river at present, and feeder canals constructs at upstream and downstream of the regulators for the connection to the existing river, then the closure dams will be constructed at the river bed for the completion of the tidal regulators.

The center line, regulator axis and so on of the UTR and LTR was determined under this basic design study, and as a result, the structure and dimensions of the regulator are shown on the drawings attached in thsi Basic Study Report.

The outline of the regulators and closure dams are tabulated as follows:

Table 4-1. Dimensions of Regulators and Closure Dams

Description		UTR	LTR
Regulator	Total width	138.0 m	29.0 m
"	Length	19.0 m	19.0 m
"	Pier height	16.1 m	17.1 m
"	Pier width	3.0 m	2.5 m
Apron length	Upstream	8.0 m	7.0 m
" "	Downstream	10.0 m	13.0 m
Riprap	Upstream	20.0 m	20.0 m
"	Downstream	45.0 m	40.0 m
Bridge	Effective width	6.0 m	6.0 m
"	Span	23.0 m	14.5 m
"	Number	6	2
Feeder Canal	Invert width	150.0 m	30.0 m
Bang Nara Closure	Crest width	9.0 m	9.0 m
"	Crest length	220.0 m	75.0 m
Sapi Yo Closure	Crest width	9.0 m	-
"	Crest length	50.0 m	-

4-2-2. Operation and Maintenance Road

The operation and maintenance road will be used exclusively for operation and maintenance of the regulators connecting between the regulator and existing road. Road elevation is planned at the elevation not to overflow by the flood of 50 years probable rainfall. Road widths of both UTR and LTR are 9.0 m for overall and 6.0 m for effective width.

The route of UTR operation and maintenance road is started from the Amphoe road connected with Highway No. 4084, and reached to the Bang Nara closure dam and operation road through the Sapi Yo closure dam and tidal regulator. The RID has a plan to make the monument on this road, then the road of 500 m from Amphoe road including the Sapi Yo Closure Dam will be constructed by the autumn of 1987 under the RID's budget for the stone ceremony holding under the King's participation, accordingly.

The LTR operation and maintenance road has about 820 m in length from Highway 4057 to LTR and the RID has a budget for road contruction of 813 m from highway. Therefore, remained operation and maintenance road will be constructed under the Japanese Grant-Aid.

4-2-3. Gate and Related Equipment

(1) Gate and Motor

The basic dimensions of gate and motor are tabulated as follows:

Table 4-2. Dimension of Gate and Motor

Description	UTR	LTR
Gate dimension	20.0 m x 5.1 m	12.0 m x 6.6 m
Gate seal elevation	-4.0 m	-5.0 m
Gate crest elevation	+1.10 m	+1.60 m
Number of gate:		
Single stage	5	1
Double stage	1	1
Motor:		
Single stage gate	7.5 KW	3.7 KW
Double stage gate	5.5 KW x 2	3.7 KW x 2
Gate type:		
Single stage gate	shell	girder
Double stage gate	shell	shell

The single stage gate will be lifted up by wire rope with one motor and one dram, and the double stage gate will be lifted up by the wire rope with one motor and one dram for each gate and the double gate can not be separated during the operation.

(2) Related Equipment

The tidal regulator is planned to be constructed for desalting reservoir to supply the irrigation water, so that saline water should not intrude into the desalting reservoir. For this purpose, gate to be operated in accordance with the overall observation of Bang Nara water level, Yakang river, tide and gate opening. The related equipment to the gate are as follows:

- Gate, motor and site operation equipment
- Remote operation and observation
- Telecommunication
- Calculation and record
- Power receiving and emergency generator

Power supply line from existing high tension line to the site was certified to be constructed under the RID responsibilities.

1) Remote operation and observation

The operation of the tidal regulators is the optimum opening and closing of the gates directly. That is, the operation of gates should be carried out taken into consideration the tide, water level of the Bang Nara, runoff of the Yakang, discharges from two tidal regulators, acidity and electric conductivity of reservoir and other information, and their movement. In the UTR operation house, having the function of water operation, maintenance and control house, the following operation and observation equipment will be installed:

- Remote operation: To operate the gates of tidal regulator from the operation house in addition to operation on site for both UTR and LTR.

° Monitoring: To protect the accident, to forecast the flood and to carry out the optimum gate operation, by the central observation of gate opening, water level, and runoff of the Bang Nara and the Yakang. T.V camera will be installed to supervise the overflow condition on two stage gate and to prevent the damage of gate by drift wood.

2) Telecommunication

It is unavoidable to use the telephone for the transmission of information and direction between operators in the wide area. The transmission of the above-mentioned information by the voice will help the safe gate operations of tidal regulators in addition to the information of water level and gate opening transmitted by the telemeter system. Therefore, wireless handy-talkie system will be introduced based on the existing RID's wireless system.

3) Calculation and Record

The discharge from the tidal regulator will be carried out when the reservoir level is higher than the tide. The discharge will be calculated with two formula: perfect overflow formula and submerged overflow formula by the off-lined computer. Monthly report and observed data arrangement such as water qualities (acidity and electrical conductivity), water level (tide, reservoir level and Yakang water level), discharge from the tidal regulator, etc. will be prepared in calculation and record by the off-lined computer.

4) Emergency Generator

Electric power will be used in gate operation. It is expected that gate opening and closing will be done at the rainy season frequently taking into consideration the rainfall in the Bang Nara Irrigation and Drainage Project Area. Many structures were seriously damaged as a result of power failure at flood time. For preventing such damages, emergency generator will be installed. The capacity of the generator shall be enough to operate the two stage gate and lighting of operating room on pier and bridge and road.

Diesel generator will be installed in the UTR and LTR operation houses with the following capacity, respectively:

UTR ----------	92.5 KVA
LTR ----------	92.5 KVA

These generators shall start generating when power failure occurs.

4-2-4. Tidal Regulator Operation House

The operation house for the gate operation and controlling the environment of water will be constructed on the UTR and LTR sites, respectively. Each operation house has the following rooms:

° UTR Operation House (220 sq.m in area)
  - Office
  - Meeting room
  - Remote control room
  - Generator room
  - Reference room

° LTR Operation House (120 sq.m in area)
  - Office
  - Operation room
  - Generator room

4-2-5. Supply of Machinery and Equipment

Machinery and equipment can be separated into two categories; equipment for construction supervision, and machinery and equipment for operation and maintenance, other than the machinery and equipment to be installed in the structures constructed under the grant-aid.

(1) Equipment for Construction

1) Survey equipment

The tidal regulator is requested to be made as water tight structure to prevent sea water from intruding into the reservoir. The water tight should be made between rubber of gate on sides and bottom and embedded stell materials in the piers. That is, water tight should be kept by the mechanical part being the very high degree of manufacturing accuracy and the concrete structure being low degree of construction accuracy, and rubber and embedded metals will work as the water tight structure.

Therefore, checking of water tight structure is very important during the construction and after completion. In case this checking would fail during the irrigation period and sea water would intrude into the reservoir, irrigation water will be not suitable and agricultural production will be damaged. Accordingly, construction of tidal regulator and installation of mechanical part shall be supervised with the transit and levelling equipment during the construction period.

2) Machinery and equipment for concrete test

The tidal regulator will be constructed between the freshening water on the upstream and sea water on the downstream. The main body is composed with placing concrete except prestressed concrete beam and piers. It is necessary to use the machinery and equipment for the concrete test such as concrete compression machine, 150 ton, slump testing equipment, etc. because of concrete mixing design will be varied due to the allowable maximum aggregate size. Concrete test should be carried out on the side with wet curing or dry curing.

Table 4-3 shows the list of concrete testing machines and equipment, these machines and equipment will be used for the determination of mixing design of concrete before concreting and daily concrete tests. Quality control for concrete works will be carried out by the supervisor on the basis of tests, including specified mix and/or field mix for daily works.

Table 4-3. List of Concrete Testing Machines and Equipment

Name	Quantity
Concrete compression machine (150 ton)	1
Slump test set	2 sets
Concrete cube mole, 6"	20 "
Sieve set (for coarse and fine)	1 "
Balance, 3,000 g	1 "
Solution Balance, 20 kg	1 "
Electric oven, 4 cu.ft.	1 "

(2) Machinery and Equipment for Operation and Maintenance

After completion of the tidal regulator, it is necessary to carry out the patrol of sites, repair, measurement of pH and EC, inspection of water level meter and gate opening measurement. For this purpose, following machinery and equipment for operation and maintenance is to be required.

1) Vehicle and boat

- Land cruiser ---------- 2 units
- Pick-up truck ---------- 2 units
- Motorcycle ---------- 6 units
- Speed boat ---------- 1 unit

These vehicles and boat will be used for the following purposes:

Land cruiser, carrying the transceiver with UTR operation and maintenance house, will be used for patrolling the automatic water level to be installed, and also used as a relay station of transmission of run-off condition on the rivers.

Pick-up truck will be used for the transportation of materials for repair of structures such as stone, cement, etc. and transportation of materials and equipment for repair and maintenance of gate, hoist, motor, etc., as well as the transportation of fuel of diesel generator. Motorcycle will be used for the survey of water qualities of the Bang Nara and the Yakang from the land.

Speed boat will be used for the survey of water qualities of the Bang Nara and the Yakang on the reservoir. In general, the survey of water qualities should be carried out at certian points and certain times; accordingly, the speed boat is required to be used for moving from point to point within the limited time.

2) Audio-visual aids

The operation manual of tidal regulator's gates and management and control manual of the Bang Nara Reservoir will be prepared at the completion of the works. The training of gate operation to the RID's operator will be carried out at the trial of the gate and related parts, therefore, the actual operation procedure and method will be recorded by the audio recorder. After training, the operator will study the operation procedure and method recorded and try to level up the gate operation, and also non-trained staff at training time can be trained by the recorded videotape. THe flood can be recorded by the audio camera and video recorder, and this recorded tape can be used for the gate operation in future. The following audio-visual aids will be installed in the meeting room of UTR operation house.

Table 4-4. List of Audio-Visual Aids

Name	Quantity
Video Camera	1
Portable Video Recorder	1
Video Player and Recorder	1
26" Color T.V. set	1
Overhead Projector	1
Hanging Screen, 70" x 70"	1

3) Copy machine

Records of the Bang Nara water level and operation of gate shall be reported to RID regional office and RID main office in Bangkok. Therefore, copy machine will be used to copy the record in the Bang Nara operation office.

As a consequently studied on the grant-aid programme under the Bang Nara River irrigation and drainage project, those contents are principally the same as that the preliminary idea prepared in the inception report of bisic design study. In addition to the preliminary idea, another requested equipment is selected, including concrete testing equipment and O & M equipment as mimized as possible under grant-aid assistant.

4-3. Outline of the Project

4-3-1. Executing Agency

(1) Project Execution

The executing agency of the Bang Nara Tidal Regulator is the Royal Irrigation Department, Ministry of Agriculture and Cooperatives. RID established the Project Office for the Bang Nara Irrigation and Drainage Project. The engineering section and construction section of the Project Office will be responsible for the project implementation.

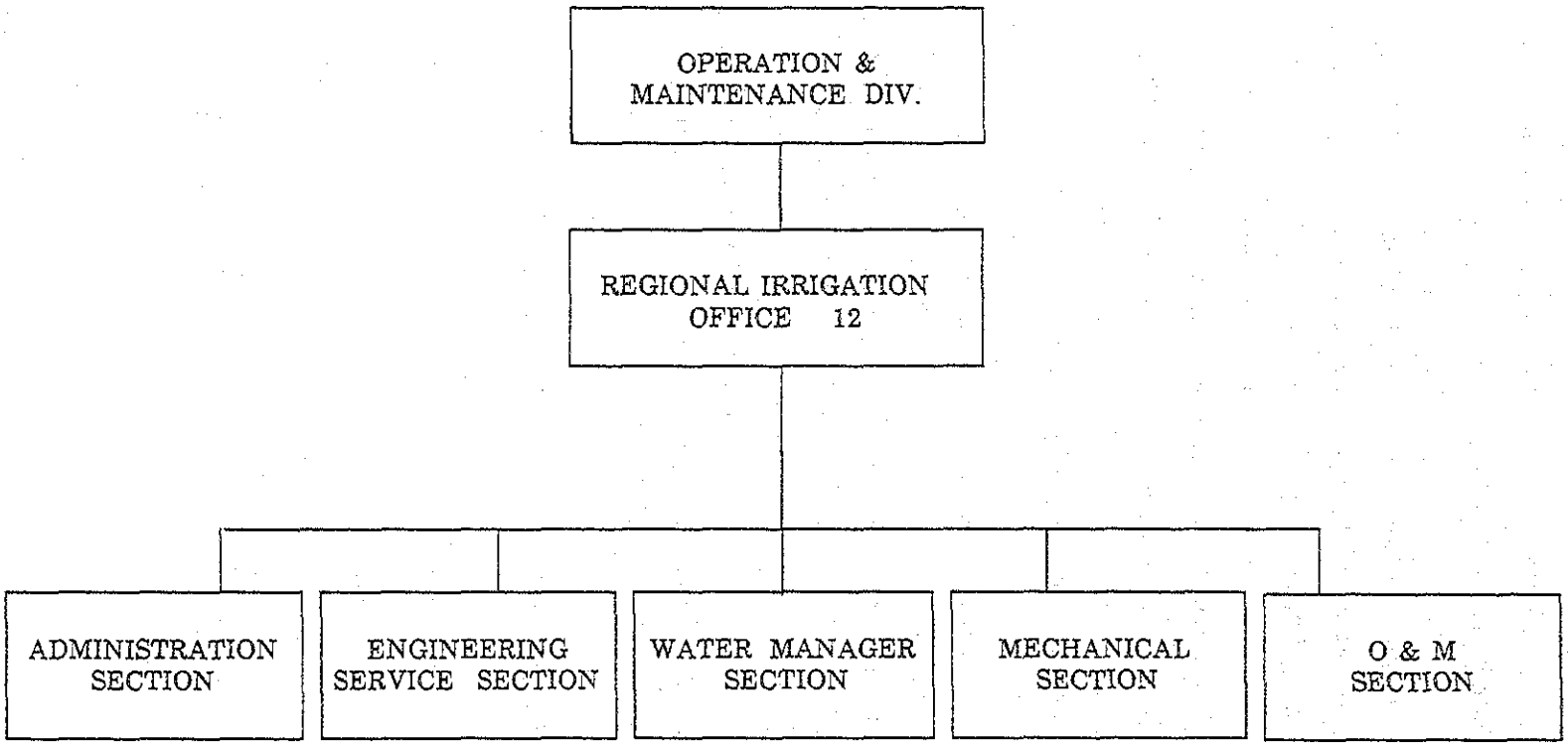
(2) Operation and Maintenance

The operation and maintenance of the tidal regulator will be carried out as a part of the Bang Nara Irrigation and Drainage Project. Operation and Maintenance Office, under the supervision of RID Regional Office 12, will be established after discontinuance of the Bang Nara Project Office for the construction at the completion of the Project because the Bang Nara Irrigation and Drainage Project is a large-scale project. The proposed organization of the operation and maintenance office is shown in Fig.4-1.

Table 4-5. Operation and Maintenance Staff of Tidal Regulators

Staff	UTR	LTR
Engineer	3	1
Technician	6	4
Clerk and others	12	8
Total	21	13

FIGURE 4-1 ORGANIZATION FOR OPERATION & MAINTENANCE



4-3-2. Project Planning

The following project planning was established in discussion with RID during the site survey in Thailand based on the request. The following show the comparative table between the request and planning.

Table 4-6. Comparative Table of Request and Planning

Description		Request	Planning	Note
A. UTR				
Regulator	Width	138.0 m	same	
"	Length	19.0 m	"	
"	Pier height	16.1 m	"	
"	Pier width	3.0 m	"	
Apron length	Upstream	8.0 m	"	
"	Downstream	10.0 m	"	
Riprap	Upstream	20.0 m	"	
"	Downstream	45.0 m	"	
Bridge	Effective width	6.0 m	"	
"	Span	23.0 m	"	
"	Number	6	"	
Feeder Canal	Width	150.0 m	"	
Bang Nara Closure:				
	Crest width	9.0 m	"	
	Crest length	220.0 m	"	
Gate	Dimension	20.0 m x 5.1 m	"	
"	Sill EL.	-4.0 m	"	
"	Crest EL.	+1.10 m	"	
Gate No.	1 Stage Gate	5	"	
"	2 " "	1	"	
Road	Width	6.0 m	9.0 m	by RID standard
"	Effective width	6.0 m	6.0 m)	

Operation Office		212.0 m^2	220.0 m^2
Emergency Generator		1 set	same
Gate Operation	Manual on site		"
	Motor on site		"
	Remote operation		"
Monitoring equipment	Panel		Panel & ITV
Operation system			Operation consol
Telemeter	Wire		Radio System
Measuring	Water level & gate operation		same

B. LTR

Regulator	Width	29.0 m	same	
"	Length	19.0 m	"	
"	Pier height	17.1 m	"	
"	Pier width	2.5 m	"	
Apron length	Upstream	7.0 m	"	
"	Downstream	13.0 m	"	
Riprap	Upstream	20.0 m	"	
"	Downstream	40.0 m	"	
Bridge	Width	6.0 m	"	
"	Span	14.5 m	"	
"	Number	2	"	
Feeder canal	Width	30.0 m	"	
Bang Nara closure dam	Crest Width	9.0 m	"	
"	Crest EL.	75.0 m	"	
Gate	Dimension	12.0 m x 6.6m	"	
"	Sill EL.	-5.0 m	"	
"	Crest EL.	+1.60 m	"	
"	1 stage gate	1	"	
"	2 stage gate	1	"	
Road	Width	6.0 m	9.0 m	by RID standard
"	Effective Width	6.0 m	6.0 m	)

	Operation office	Area	119 m^2 120m^2
	Emergency generator	1 set	same
	Gate operation	Manual on site	
		Motor on site	"
		Remote operation	
	Operation system		Operation desk
	Telemeter	Wire	Radio system
	Measuring	Water level & Gate operation	same
C.	Water Level Meter (X 73 & X 162)	Water level	same
		Transmitter	"
		Water level room	"
		Antenna and tower	"
D.	Machinery & equipment		
	Survey equipment	Transit	"
		Level	"
	Concrete testing equipment	Concrete compression machine (150 ton)	"
		Slump test set	"
		Concrete cube mole	"
		Sieve set	"
		Electric oven	"
		Balance, 3,000 g	"
		Solution Balance, 20 kg	"
	Vehicle and boat	Land cruiser	"
		Pick-up truck	"
		Motor cycle	"
		Speed boat	"
	Audio-visual aids	Video camera	"
		Portable video recorder	"
		Video player & recorder	"
		26" color TV set	"
		Overhead Projector	"
		Hanging screen (70"x70")	"
	Others	Copy machine	"

4-3-3. Site conditions

(1) UTR

Detailed topography and geological profile for the UTR at proposed site of the Bang Nara river are described in Chapter 5, item of 5-3 "Tidal Regulator and Closure Dam". The proposed site of UTR is located about 6.0 km from an estuary Narathiwat side of the Bang Nara river. The site of UTR is selected on the straight line on the field (not on the river) taking into consideration the curve part of the Bang Nara River improvement, safety factor and economical construction manner. After completion of the main structure, an access canal located upstream and down stream of the main structure will be opened to the Bang Nara river.

The site of structure which is about 1.0 m above sea level with trees and bushes was selected as the most suitable based on the study of few alternative locations. The site is composed of a tidal regulator and access canals at both front and back sides of the regulator to connect to the Bang Nara River. The access canal of the back side is located on the existing Sapi Yo River to save the dredging quantity, however, both rivers should be closed in order to prevent saline water intrusion to the Bang Nara reservoir.

A geotechnical investigation on the proposed site of two tidal regulators has been carried out in the Basic Design stage based on the information and data prepared by RID, and the results of survey are shown in Figs. 4-2 and 4-3. The geological profile is mainly divided into the alluvium formation in upper zone inclined from left side at -7.0m to right side at 15.0m below sea level and diluvial formation (or weathered zone of granite) in lower zone. The geological profile of upper portion about 1.0m depth is covered with sand/silty and -7.0m below sea level consisting of sand zone.

In case of -7.0m below sea level, the sand and clay zone is alternated with gravel mixing. N-count in the zone shows less than 5 times up to -7.0m to -15.0m below sea level. In case of -15.0m below sea level, the N-count principally shows the tendency to increase in proportion to its depth, and at -19m below sea level, the N count reached more than 30 times. The groundwater elevation is about -1.0m below sea level. Under those sandy-clay soft foundation, the prestressed concrete (pc) pill for the foundation works of main structures should be driven into the N count more than 30 times.

(2) LTR

Proposed construction site of the LTR in the Bang Nara river is located about 7.0km upstream from conjunction point of the Bang Nara river and Golok river. The selection manner is also same as that of the UTR which is built on the land with straight line, and not on the existing river. The proposed location is still using the paddy field at +0.75m above sea level and its right side area has been inundated by tidal back-water through the Golok river when monthly high tidal water level occurs.

The geological profile of upper zone up to -21m below sea level consists of clayey layer including organic matter, however, sand zone laid at -11m to 13m below sea level and N count is less than 2.0 times. Meanwhile, lower zone up to -29m below sea level consists of sand layer included a few clay and N count generally shows a tendency to increase in proportion to its depth, and at -30m below sea level, the N count is more than 30 times. As a consequence, the pc pill should be driven into this N-count portion.

Fig. 4-2 Geotechnical Profile (UTR)

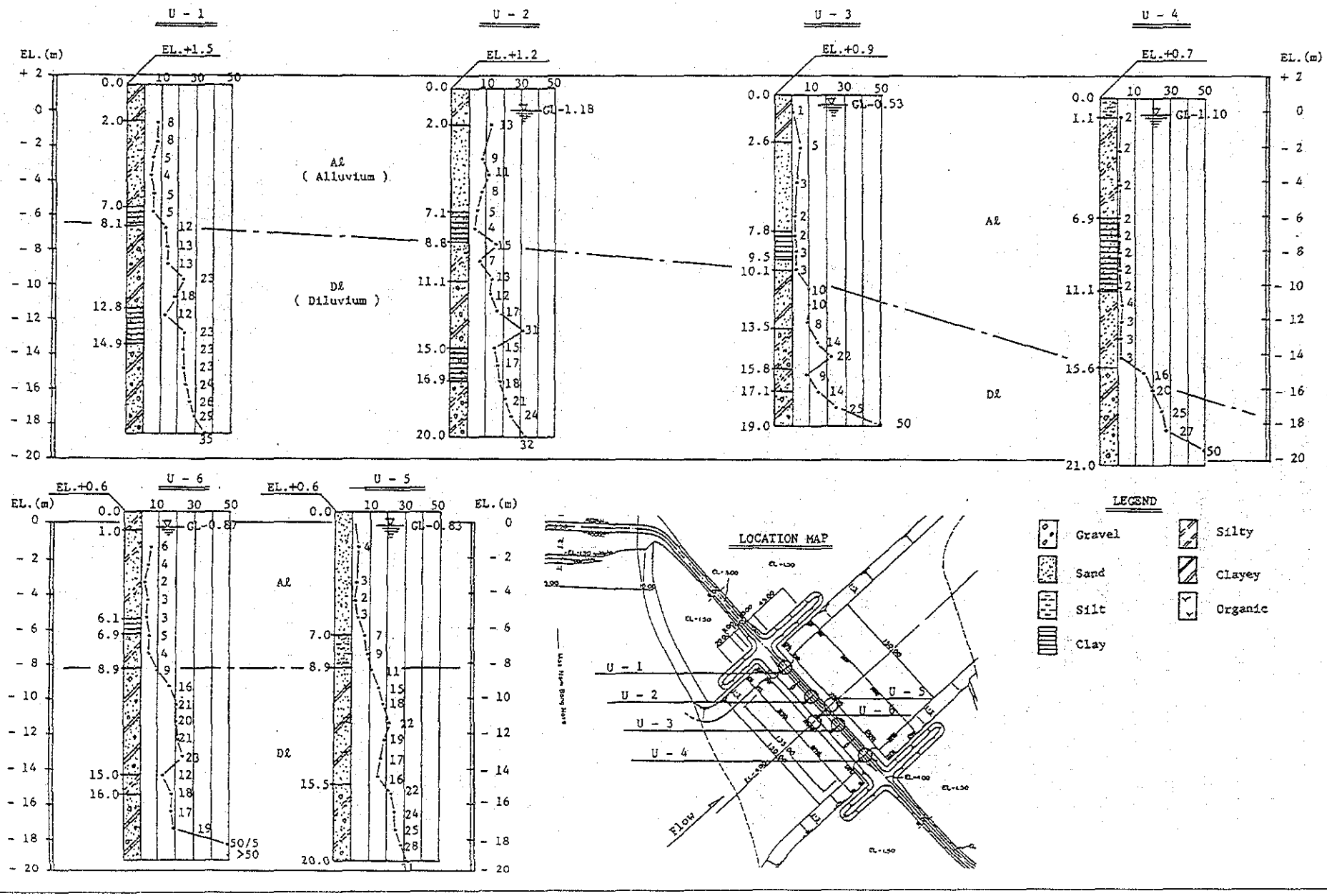
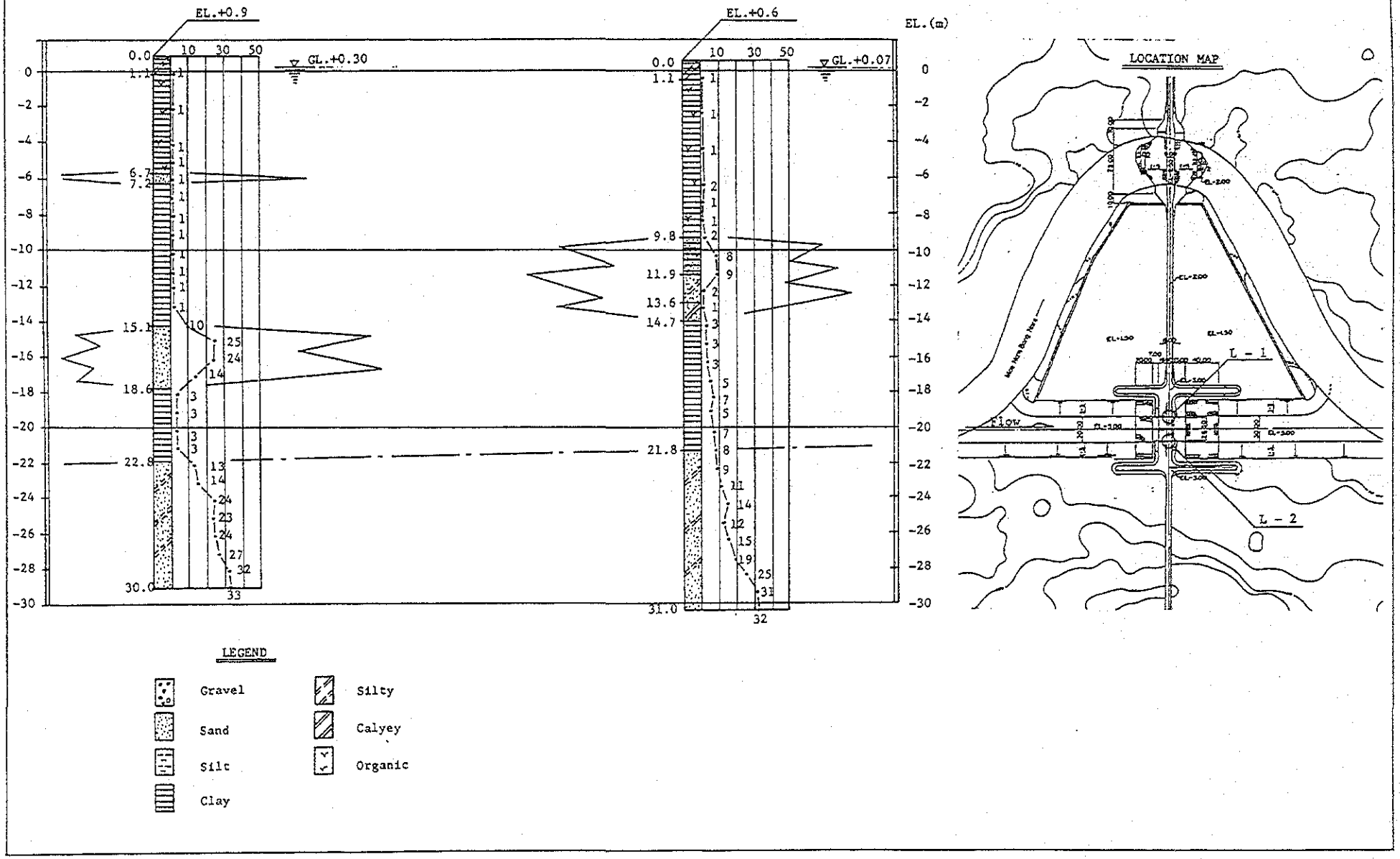


Fig. 4-3 Geotechnical Profile (LTR)



CHAPTER 5. BASIC DESIGN

CHAPTER 5. BASIC DESIGN

5-1. Design Standards

Laws, regulations and standards which must be conformed to in designing the concrete structure of the tidal regulator and appurtenant facilities are as follows.

5-1-1. Civil Engineering Design

The particulars of the engineering works for the tidal regulator and its appurtenant facilities shall be determined in accordance with the "Design: Headworks" of the Design Standards for Land Improvement Project established by the Agricultural Structure Improvement Bureau, Ministry of Agriculture, Forestry and Fisheries of Japan.

The said Standards stipulate the various matters which must be observed in designing the headworks for intaking irrigation water in Japan.

However, the design load and allowable stress in calculating the stress of structures shall be in accordance with the values adopted by either RID or the Highway Department, and the materials used shall conform to the Thai Industrial Standards (TIS).

In designing the pile foundation of the tidal regulator, its allowable bearing capacity shall be calculated according to the Design Manual of Road Bridge established by the Japan Road Association and the stress of pile body shall be in accordance with the standards of ASTM.

The Operation and Maintenance Office shall be in accordance with RID's design standards and the materials for constructing them shall be in accordance with TIS.

5-1-2. Mechanical Equipment

Principal mechanical equipment comprising the tidal regulator are the gate body, wire rope and the hoisting equipment.

As a rule, the materials used for the gate shall be those stipulated in Japanese Industrial Standard (JIS). The types of materials used for designing and manufacturing and the places where they will be used shall be in accordance with the Technical Standards for Hydraulic Gate and Penstock established by the Water Gate and Penstock Association of Japan.

5-1-3. Electrical Equipment

Electrical equipment of the tidal regulator may be divided into the electrical power system for operating the gate and the electric system for general lighting.

JIS shall be applied to the electric power system which must function safely and facilitate opening and closing of the gate so that its materials used and its service life shall be consistent with the materials and the service life of the gate. The control unit of the gate shall be in accordance with the standards of either the Japan Electrotechnical Committee (JEC) or the Japan Electric Machine Industry Association (JEM).

The electric system for general lighting shall be in accordance with JIS and the regulations of the Narathiwat Provincial Electric Authority.

5-1-4. Telemetry System

The materials for telemetry system shall be in accordance with JIS. For equipment, the standards of JEC and JEM mentioned previously as well as the Broadcasting Technical Standards (BTS) of the Japan Broadcasting Corporation shall apply. The equipment design shall also conform to the standards established by the Post and Telegraph Department (PTD) of the Kingdom of Thailand.

5-2. General Plan

The following matters were agreed upon as a result of consultation with the Government of the Kingdom of Thailand during the basic design study for the Tidal Regulators Construction Project.

5-2-1. UTR

(1) Regulator Body

In order to desalinate the water of Mae Nam Bang Nara, a tidal regulator shall be constructed at a site 6 km upstream of the rivermouth on the side of Narathiwat to prevent seawater from intrusion. The effective width of the tidal regulator shall comprise a movable section of 120 m through which to safely discharge a flood of 50-year return pioerd. The regulator body shall be of reinforced concrete in order to control the storage volume of Bang Nara Reservoir by operating of the gates and to safely discharge flood water.

(2) Gate

As a result of economic and technical study, the movable gates capable of maintaining the water of Bang Nara Reservoir at a constant level, of desalinating its water and effectively operating the reservoir and of draining water as fast as possible from the inundated area at the time of flood were determined to be 20 m in span and 5.1 m high.

(3) Connection Channel

A channel shall be constructed to connect the tidal regulator with the river in the upstream and downstream of said regulator. It shall be an earth channel as the flow velocity is planned to be not too fast and the flow can be made stable if the channel is constructed in a straight line.

(4) Closure Dam

As soon as the excavation of the connection channel in the upstream and downstream of the tidal regulator is completed, a closure dam shall be constructed in order to prevent seawater from intruding the area through the main stream of Mae Nam Bang Nara. Rubbles shall be placed underneath the dam to stabilize the toe of slope, then embankment shall be performed by dredger and also stone pitching to stabilize the sloped face of dam. The reason why the work on the closure dam shall be started only after completion of the connection channel is to prevent the area from damage by inundation in the event of a flood while the drainage river is blocked for construction of the dam, and this point must be strictly observed in planning the construction schedule.

RID has already launched on the construction of the closure dam on Khlong Sapi Yo which flows near the site proposed for constructing the tidal regulator and is scheduled to complete it by September this year. RID is also scheduled to undertake the construction of the diversion channel in the upstream of Khlong Sapi Yo in conjunction with the construction of said closure dam.

(5) Operation and Maintenance Office

The O & M office shall be of a scale large enough to accommodate the required minimum facilities and personnel for administration, maintenance and operation of both UTR and LTR.

The O & M office was originally planned to be located on the right bank of the connection channel of the tidal regulator in the feasibility study report. But as a request was later made to construct said office on the left bank since RID's Narathiwat Irrigation Office is scheduled to be relocated to the peninsula on the left bank of the connection channel in the future, the plan which is consistent with RID's building plan in terms of both location and design must be developed.

(6) O & M Road

A 5.5 m wide O & M road shall be provided in the section between the existing road on the right bank of Mae Nam Bang Nara and the existing road on the left bank of said river. It has been confirmed during the current field survey that RID's schedule is to complete the 500 m section from the existing road on the right bank, or, in other words, the section of the road leading to the top of the slope of the revetment on the right bank of the connection channel planned under the current project, by September this year. It has been agreed also that the section of the road connecting the closure dam on the left bank of Mae Nam Bang Nara with the existing road shall be undertaken by the Thai side according to the grant-in-aid system of the Government of Japan. Hence, the section of the O & M road which shall be undertaken by the Japanese side is the section between the tidal regulator and the closure dam on Mae Nam Bang Nara. The road surface shall be paved with asphaltic concrete.

5-2-2. LTR

(1) Regulator Body

As in the case of UTR, a tidal regulator shall be constructed at about 7 km upstream of the point where Mae Nam Bang Nara merges with Nae Nam Kolok on the side of Tak Bai in order to desalinate the water of Mae Nam Bang Nara. The effective width of the tidal regulator shall comprise a movable section of 24 m through which to discharge a flood of 50-year return period.

(2) Gate

As the total width of LTR will be smaller than that of UTR, the effective width per gate of LTR will be also smaller. However, the height of the gate would have to be made taller than that of UTR in view of the height of the existing river bed nearby and the flood level which

must be coped with. Width due regard to operability of the gate, the steel roller gate with a shell and girder type, 12 m in span and 6.6 m in height, shall be adopted.

(3) Connection Channel

As in the case of UTR, the site for constructing the LTR shall be the linear connection channel which will take the shortest cut through the meandering section of the river with due consideration to both cost and safety of execution. The regulator body shall be constructed onshore at the center of the channel, and when this is completed the upstream and downstream portions of the channel shall be dredged and connected with the river.

(4) Closure Dam

After the channel has been excavated in the upstream and downstream of the tidal regulator, a closure dam of the same type as UTR shall be constructed on Mae Nam Bang Nara.

(5) Operation and Maintenance Office

The scale of the O & M office which will be used for administration, maintenance and operation of only LTR shall be smaller than the one for UTR but large enough to accommodate the required minimum facilities and personnel.

In the feasibility study report, the location of the O & M office had been planned on the right bank of the channel where the tidal regulator will be constructed, but it was confirmed during the current survey that RID plans to construct the other offices and living quarters for the staff in the area enclosed by the channel and the former river course of Mae Nam Bang Nara. A new layout, therefore, shall be planned to suit RID's plan.

(6) O & M Road

Although the feasibility study had proposed the alignment of the O & M road on the right bank along the Mae Nam Bang Nara, RID explained that due to difficulty in acquiring the land along said river because of the many private houses. The new route has been accepted to be changed in the direction of the extension of the axis of the tidal regulator and that the land along this new route has already been acquired. Also, RID is scheduled to construct the 815 m section of the road leading from National Highway No.4057, or, in other words, as far as near the top of the slope of the revetment on the right bank of the connection channel within this year, and it was confirmed during this survey that this section shall be within the scope of work to be borne by the Thai Government. It has already been agreed that the section of the road between the closure dam on the left bank of Mae Nam Bang Nara and the existing road shall also be included within the scope of work to be undertaken by the Thai Government. Accordingly, the section of the O & M road which must be constructed by the Japanese side is between the tidal regulator and the closure dam on Mae Nam Bang Nara, which shall be paved with asphaltic concrete as in the case of UTR.

5-3. Tidal Regulators and Closure Dams

The designing of facilities and principal parameters of the tidal regulators and closure dams which are the principal structures to be constructed under this Project are basically as follows:

5-3-1. Tidal Regulators

(1) UTR

1) Location and topography

UTR is planned to be constructed at a point 6 km upstream of the rivermouth of Mae Nam Bang Nara on the side of Narathiwat.

The Mae Nam Bang Nara makes a large curve near the proposed site and merges with its tributary, the Khlong Sapi Yo near where the curve ends. The site for construction of the UTR was selected where it could be constructed onshore by utilizing the aforesaid curved section and the river course of Khlong Sapi Yo and yet where no large scale construction would be required for excavating the connection channel at either end of the tidal regulator.

Also, as National Highway No. 4084, which leads to Tak Bai, passes at a point 1 km immediately downstream of the tidal regulator, the site can be reached within a short time and would therefore be convenient for future operation and maintenance.

The land near the site where the tidal regulator will be constructed is about + 1.0 m in elevation and is almost flat, but the land on the opposite side of Khlong Sapi Yo which flows near the site is 4 m to 7 m high in elevation which gradually rises up to the mountains in the back, the Khao Lek and Khao Sapi Yo. The urban district of Narathiwat spreads out on the opposite bank of Mae Nam Bang Nara and houses stand along the river. The Mae Nam Bang Nara, around here, is about 200 m wide.

2) Geological condition

The results of RID's boring tests which were presented at the time of the feasibility study showed that RID had not made any permeability tests on the sand layer which is the foundation ground at the site of UTR or any consolidation tests on the clay layer which is the foundation ground at the site of LTR. The results of these tests are very important because it is based on those factors that the bearing power of pile is selected and appropriate measures are taken to cope with the occurrence of springwater during excavation for constructing

the tidal regulator. During the current survey, therefore, these tests, as well as a standard penetration test, were conducted to confirm the bearing layers in order to obtain a more accurate estimate of the construction cost. The spots of boring test and the geological columns are shown in Fig. 4-2. The geological conditions are described as follows.

The ground of the site proposed for the construction of the tidal regulator consists of alluvium which form the top layers beneath which, at a depth of 8 m to 16 m and deeper lies diluvium. The bedding of diluvium dips from Mae Nam Bang Nara toward Khlong Sapi Yo with a gap of 8 m within a distance of 140 m. The top soil consists of sand layers such as sand, silty sand or clayey sand. According to the results of the standard penetration test, it is extremely soft in nature with N value of less than 5.

Silty sand layers generally dominate the alluvium, but thin layers of clay soil are intercalated at around (-)7m to (-)9 m in elevation. According to the results of the permeability test at the alluvium layer, the permeability coefficient was around 8×10^{4} cm/sec.

Diluvium in the deeper section which is stratified in clayey gravel layers is inferred to be a heavily weathered zone of granitic rocks which had settled as residual soils. The N values of these residual soil layers vary wildly between 10 and 50 which is inferred to be due to the varying degrees of weathering of granitic rocks depending on the spot. In view of the condition, the pile length was determined to be $l = 15.0$ m by assuming the bearing layer to have an N value of above 30 and also by assuming the location of the pile to be unfavorable.

3) Structural stability during the extra-ordinary floods

The tidal regulator and its appurtenant facilities are designed considering the 50-year return period flood in accordance with RID's design criteria. The conditions of such structures during the extra-ordinaryfloods at 100-year and 200-year return period are reviewed using new hydrological data which were collected through the current field survey. As a result of review, the tidal regulator and its appurtenant facilities are found to be stable to the extra-ordinary floods.

4) Gate height

The crest elevation of gate was determined to be EL 1.10 m which was obtained by adding tidal range (0.05 m) and the run-up (shallow water significant wave: 0.44 m) at the site of tidal regulator to the high wate rlevel at Narathiwat (HWL +0.58 m) as calculated in the feasibility study which is high enough to prevent water from overflowing across the gate in the event the outside tidal level should rise. The elevation of the gate sill will be EL -4.0 m to conform with the bottom elevation of the aforementioned connection channels in the upstream and downstream of the regulator. Accordingly, the height of the gate was determined to be 5.1 m.

5) Pier

The pier shall be designed to be mechanically stable and to facilitate operating of the gate and shall be of such a construction as to minimize its becoming obstacles to discharging of flood water.

a) Pier height

The flood elevation of the gate hoist house is obtained by adding freeboard(1) gate height, freeboard(2), and thickness of floor slab to the design flood water level. The design flood water level here refers to the one in the upstream side of the tidal regulator. Freeboard(1) is the interval between the design flood water level and the lower end of the gate at full opening, and it shall be larger than the approaching velocity head at the time of flood and also larger than the value stipulated in the Japanese design manual. Considering this condition, the freeboard for the design flood of this project is about 0.8 m. The gate height is as stated above. Freeboard(2) is the clearance between the crest of gate and lower end of floor slab when the gate is hoisted, and it is determined according to the structural components of the gate such as spoiler, sieve, metal fixture for stoppage as well as the allowance given for hoisting up the gate. In this case, it shall be 1.75 m. From the above, the floor elevation of the gate hoise house for the design flood stage of HWL 3.50 m was determined to be EL 12.1 m.

b) Pier length

The length of pier at the upper part in the direction of flow is determined by the space required for the embed metal for contacitng each gate and by adding a little for stability of the pier. In this project, it shall be 5.0 m. The lower part of the pier requires a certain roundness on the upstream side to prevent the occurrence of vortex in the flow in addition to the length of the upper part of pier, and also a certain leength to set up an O & M bridge on the downstream side. The length, therefore, shall be 17.0 m.

c) Pier thickness

The pier thickness is obtained according to the following empirical formula using pier height and span length as parameters based on past performance data in Japan.

$$t_p = 0.12\ (D_p + 0.2\ B_i) \pm 0.25 \text{ m}$$

where, t_p : thickness of pier (m)

D_p : height of pier (m)

B_i : length of span (m)

When D_p = 16.1 m and B_i = 20 m are substituted in the above formula, t_p becomes 2.7 m. Using this figure as a reference, the thickness was determined to be 3.0 m in consideration of the space for the embed of gate metal and for stability of the pier.

d) Gate hoist house

A house shall be provided to protect the hoisting equipment and electrical equipment on the pier from being adversely affected by rain, sunlight and briny air as to hamper operation of the gate.

The size of the gate hoist house is determined by the type of hoisting machine to be installed on the pier and the method of operating the gate on the pier. For this project, the house was determined to be 7.0 m long in the direction of flow and 7.5 m long in the direction of weir axis and 4.0 m high.

The house shall be of reinforced concrete structure capable of suspending a chain block from the ceiling for maintenance and inspection of hoisting machine and other machines. The side walls, with the exception of the columns, however, shall be of concrete block masonry.

e) Stability calculation for pier

For the above described sectional form of pier, the size of the footing slab capable of stably supporting the pier was assumed to be 19.0 m in the direction of flow and 8.0 m in the direction perpendicular to flow. Based on these assumptions, the stability of the pier was studied under the following conditions:

° Stability of pier in the upstream and downstream directions when wind load acts toward upstream while the gate is closed at the time of low water (highwater level on the outside and low water level on the inside).

° Stability in the upstream and downstream directions when wind load acts toward downstream while the gate is closed at the time of low water (low water level on the outside and high water level on the inside).

° Stability in the direction of weir axis when both the horizontal force caused by the tension of wire rope for keeping the gate opened and the wind load act in the direction of weir axis while the gate is opened during flood.

° Stability in the upstream and downstream directions when wind load acts while the weir is empty and the gate is open.

The aforementioned form and dimensions were adopted in consideration of the fact that they secure for the pier a stable condition that prevents it from collapsing because the moment to resist collapsing becomes larger than the moment to collapse under the foregoing conditions, and also with due consideration to making the pier balance with the rest of the structure.

6) Apron

An apron shall be provided to prevent the tidal regulator from being adversely affected by scouring of the river bed in the upstream and downstream of the regulator as a result of flood. The apron shall be of concrete structure to withstand some uneven shinking.

a) Upstream apron

The upstream apron is to prevent the flow velocity increased by the reduction of the flow area on account of the pier from scouring the river bed, and it shall be installed over an area about three times the width of pier beginning from the upstream end of the pier. As the pier is 3.0 m thick, the apron length would be 9.0 m, but in this case, it shall be 8.0 m by taking the 1.0 m of the footing slab of pier on the upstream side into account.

b) Downstream apron

The downstream apron is installed to prevent the river bed in the downstream from being scoured by the submerged supercritical flow or turbulent flow generated by the water which is discharged from the lower end of the gate to regulate the water level of the reservoir. The apron length required to protect the bed is calculated according to the following formula.

$$l_1 = 0.9\ C\sqrt{D}$$

Where, l_1 : length from the center of gate to downstream end of apron

C : value of the Bligh's coefficient (to be in the case of fine sand)

D : height from crest of gate to low water level on the downstream side.

7) Cut-off wall

When the water level is heightened by damming up by a weir on permeable ground, the seepage water which permeates the ground due to the head generated by the difference in water levels between the upstream and downstream tends to migrate the soil particles of the smallest grain size which comprise the ground. As this action advances, it creates water holes in the ground which eventually develops into a cavity and leads to the collapsing of the foundation. To prevent this, cut-off wall is installed to secure the length of the percolation path along the bottom surface of sill bed. The length of cut-off wall is determined by the following formula.

$$1 + L/3 = C' \cdot H$$

where, 1 : length of percolation path in the vertical direction

L : length of percolation path in the horizontal direction

C': weighted creep ratio of Lane (8.5 in the case of fine sand)

H : maximum difference in water levels between upstream and downstream.

Now, if L is assumed to be the horizontal length of the sill bed of gate which is 19.0 m and the value of D in the preceding paragraph (6) is used for H, 1 becomes nearly equal to 7 m. As this value may be estimated to be the combined length of both sides of the cut-off wall, the length of the cut-off wall shall be determined to be 4.0 m.

8) Foundation work

Upon determining the ground conditions at the site proposed for construction of the tidal regulator, foundation treatment which is necessary to maintain the stability of structures, shall be studied.

a) Foundation work method

As a result of boring test conducted at the construction site of the tidal regulator, the ground for supporting the structures was found to be extremely soft and to require some foundation treatment work.

The foundation treatment methods which may be considered are: (1) improvement of foundation ground, (2) pile foundation, (3) caisson foundation, etc. In this project, adoption of the pile foundation method is considered appropriate based on the judgments that the supporting layer is deep and the method permits quick execution from the viewpoint of construction schedule and is easy to execute locally.

b) Selection of the type of pile

The types of pile which may be considered for the foundation work of structures are: (1) RC pile, (2) PC pile, (3) steel pipe pile. Each pile has its own characteristics, but PC pile will be used for the following reason:

i) Long piles must be driven in as the sand layer with N value of more than 30, which shall be used as the bearing layer, is deep.

ii) In this event, the allowable bearing capacity will become around 65 tons per pile, and the pile body must be strong enough to withstand the big percussion impact given at the time of driving.

iii) The pile material must contain displacement at the pile head to a minimum.

iv) The pile must be simple and easy to manufacture at the site or near the site.

v) The pile which have been driven in must be highly homogeneous and reliable.

vi) The construction must be low.

c) Allowable bearing capacity

The pile shall be securely driven into the sand layer of more than 30 in N value which shall be bearing layer. When the pile length is calculated on the basis of the geological column at a spot where the bearing layer is deepest, it becomes l = 15.0 m.

Estimation of the allowable bearing capacity of pile shall be in accordance with the Meyerhof's formula which uses the value obtained by standard penetration test, but since the area of the leading end of rod in the static penetration test is smaller than the actual pile's tip area, estimation shall be made according to the following formula which was derived from actual cases of loading tests and cone tests.

$$R_a = 1/3\ (R_p + R_f)$$

$$R_p = 30\ \tilde{N}\ A_p$$

$$R_f = U\ \Sigma l_i f_i$$

Where,

R_a : allowable bearing capacity of pile (ton)

R_p : bearing power at the leading end (ton)

R_f : bearing capacity due to skin friction of pile (ton)

$\tilde{N}$: mean N-value of the ground into which the leading end of pile is driven in

A_p : pile tip's area (m^2)

U : skin friction length of pile (m)

l_i : thickness of the layer for which skin frictional force must be taken into consideration (m)

f_i : intensity of maximum skin frictional force (ton/m^2)

$\tilde{N}$ = 31 in the above formula. If piles of 0.4 m x 0.4 m which are the most popular size and which can be manufactured locally are to be used, A_p = 0.16 m^2 and U = 1.6 m. If the skin frictional force of pile is to be calculated based on the pile length in well-consolidated diluvium in the lower layers of the boring columnar section, l_i = 6.5 m. Also, since the intensity of the maximum skin frictional force in the above layer is assumed to be 1/5 of the mean N value in said layer, f_1 = 4.0 ton/m^2 from $\tilde{N}_s$ = 20. The allowable bearing capacity of pile obtained from the above is R_a = 63 ton/pile.

d) Necessary number of piles

For the required allowable bearing capacity, the intensity of bearing capacity of the pile placed at the edge of the pier, on which the largest load is applied according to the results of the previously mentioned stability calculation for the pier and the assumed layout of piles, was investigated, and the alignment of piles which would be most stable was sought for. As a result, it was decided that four columns x 10 lines = 40 piles shall be arranged for each pier.

As for the gate sill slab section, its stability was investigated by assuming the entry of a truck crane of about 50 tons for lifting up partitions of gate weighing about 15 tons each in order to assemble and install the gate. As a result, it was decided that the alignment of piles at the gate sill slab section shall be four columns x 5 lines = 20 piles.

As for the wing wall section, layout of piles in the direction of the extension of wing wall was calculated from the degree of allowable margin in the bearing power of piles, the layout of which was assumed from the ground reaction generated on the footing slab of the wing wall. As a result, it was decided that four columns x 1 llines = 44 piles shall be respectively arranged for the left and right bank wing walls on the upstream side, and four columns x 12 lines = 48 piles for the wing wall on the downstream side.

(2) LTR

1) Location and topography

LTR is planned for construction at about 7 km upstream of the point where Mae Nam Bang Nara merges with Mae Nam Kolok on the side of Tak Bai. As in the case of UTR, a place where onshore construction of the tidal regulator is possible by short-cutting through the portion of Mae Nam Bang Nara where it makes a large curve was selected as the proposed construction site.

Access to the tidal regulator is quite convenient as National Highway No. 4057 runs about 800 m from the right bank of the tidal regulator. As the site is located at a distance of about 4 km from the administraiton office of the adjacent Mu No Project through said highway, it is quite favorably located for implementing this project.

Paddy fields are spread around the site proposed for construction of the tidal regulator. Elevation of the bank of Mae Nam Bang Nara along the weir axis is +0.75 m, and around the weir center, +1.0 m, and rises slightly toward the national highway on the right bank but in general, the topography of the site is flat. Mae Nam Bang Nara becomes substantially narrow in this neighborhood compared to UTR, the width of the river here being only about 60 m. A thick growth of trees is seen only in a very limited portion along the river.

2) Geology

The results of additional boring test conducted during the current survey are presented on Fig. 4-3.

Silty clay is thinly distributed in the surface layers around the site proposed for construction of the tidal regulator, underneath which clay containing humus is thickly distributed for about 20 m. This stratum comprises a soft and weak ground of less than 5 in N-value, and about in the middle of this stratum, sand layers or sandy silt layers are intercalated in lenticular form.

Underneath the thick clay layer containing humus, an almost flat silty sand layer is thickly distributed. This sand layer tends to increase in N-value as it goes deeper, and uniformly shows N-values of more than 30 at around the depth of 30 m, so that it may be regarded as a good bearing layer in this project. When the elevation of the gate sill slab is taken into consideration, the pile length shall be $l = 25.0$ m.

3) Structural stability during the extra-ordinary floods

As in the case of UTR, the tidal regulator and its appurtenant facilities are found to be stable to the extra-ordinary floods.

4) Gate height

Since LTR functions as a tidal regulator, and also functions to prevent back flow of medium and small scale overflooding from Mae Nam Kolok into the area, the crest elevation of the gate must be EL. +1.6 m to satisfy both the high water level (HWL +0.8 m) at Ta BA and the 5-year return period flood level of +1.58 m of Mae Nam Kolok. The elevation of the gate sill shall e EL -5.0 m to conform to the bottom level of the aforesaid connection channels in the upstream and downstream of the tidal regulator. Accordingly, the gate height shall be 6.6 m.

5) Pier

a) Pier height

The height of pier shall be calculated as for UTR. Assuming that the design flood stage is +2.20 m, freeboard (1) is 0.8 m if the design flood discharge is about 320 m^3/sec., gate height is 6.6 m, and if freeboard (2) for this gate is 1.75 m, the floor elevation of the gate hoise house would be EL 12.1 m.

b) Pier length

The space necessary for fitting metal to contact the gate at the pier section are approximately the same as in the case of UTR. Also, as the O & M bridge shall be installed on the downstream side, thelength of pier shall be the same 17.0 m as in the case of UTR.

c) Pier thickness

If the approximate thickness of pier calculated in the same way as for UTR, 2.6 m when D_p = 17.1 m and B_i = 12m, but in consideration of the space for the embedded metal of the gate and other matters, the pier thickness was determined to be 2.5 m.

d) Gate hoise house

The size of the gate hoise house is related to the type of the hoisting equipment and also to the relationship between the location where the hoisting equipment is installed and the thickness of the pier. With due regard to the foregoing, the size of the house was determined to be 7.0 m long in the direction of the flows, 7.0 m long in the direction of weir axis and 4.0 m high. The house shall be of the same construction as in the case of UTR.

e) Stability calculation for the pier

The same studies as in the case of UTR were made to confirm the stability of the pier, as a result of which the size of the footing slab in the lower section of the pier was determined to be 19.0 m in the direction of the flow and 7.5 m in the direction of weir axis.

6) Apron

a) Upstream apron

The length of upstream apron shall be about three times the pier width. As the pier width is 2.5 m, the apron length becomes 8.0 m, but by taking the 1.0 m of footing slab of the pier on the upstream side into account, the length was determined to be 7.0 m.

b) Downstream apron

As in the case of UTR, the length from the gate to the downstream edge of apron shall be obtained. Assuming the downstream water level to be WL - 0.42 m and using D = 2.02 m and C = 18, the length of l_1 = 23.0 m was obtained. In consideration of the pier length on the downstream side of 10 m, the length was determined to be 13.0 m.

7) Cut-off wall

When C' = 3.0 and ΔH = 2.02 m are assumed in the formula for estimating the length of the vertical percolation path because the foundation ground of UTR is soft clay, $\Sigma l \neq 0$ is obtained. In other words, as the ground is clay soil, cut-off wall is considered unnecessary. However, in view of the possible generation of percolation path due to inadequate compacting of the ground beneath the concrete floor slab during execution or due to lenticular intercalation of sand layers, a 4.0 m cut-off wall shall be placed for the sake of safety as in the case of UTR.

8) Foundation work

The same method of foundation work and the type of pile as for UTR shall be selected.

a) Allowable bearing capacity

The pile shall be supported by the sand layer having N value of more than 30, and judging from the results of boring test, the pile length shall be l = 25.0 m.

If in the formula for calculating the bearing capacity of pile, that the same pile size as for UTR, N = 31, l_i = 7.6 m, and f_i = 3.5 t/m^2 based on the mean N value in diluvium of N_s = 17.6 are assumed, the allowable bearing capacity becomes R_a = 63 ton/pile.

b) Necessary number of piles

The optimum layout of piles was sought by examining the intensity of bearing capacity of pile based on the results of the stability calculation for pier and by assuming the layout of piles. The result was 4 columns x 9 lines = 36 piles for each pier.

As for the gate sill slab section, the pile layout shall be the same as in the case of UTR, but because of the shape of slab, 3 columns x 5 lines = 15 piles will be laid out.

The pile layout for the wing wall section is to be calculated according to the same method as for UTR, 4 columns x 14 lines = 56 piles for each of the left and right bank wing walls on the upstream side and 4 columns x 17 lines = 68 piles for the wing wall on the donwstream side must be laid out.

5-3-2. Closure Dam

(1) Scale of the dam body

Upon completing the construction of the regulator body and the connection channels in its upstream and downstream, the old river must be closed to prevent saline water from intruding into the area through the old river. It shall be closed by embankment of closure dam using sandy soil materials, and judging from the cross-section of Mae Nam Bang nara at each of the closing points, the length of the closure dams was determined to UTR: 220 m, LTR: 75 m, respectively; and in the front and rear of each dam, an approach of 10 m shall be provided to connect the dam with the O & M road.

Around 1/2 of the dam height of closure dams on both the upstream and downstream sides are affected at all times by the reservoir water and tidal water. Accordingly, in order to stabilize the dam body, a gentle slope of 1:5 which is gently of the slope gradients for dams built by embankment will be adopted. The inside and outside water level differential indicates a reversible characteristic, but since the differential is not so large, the section of the dam body on the upstream and downstream sides shall be symmetrical. In order to prevent the sloped face from collapsing due to wages generated on the water surface, the slopes shall be protected by riprap.

The crest of closure dam at UTR shall have the elevation not to be overflowed by the flood water at the flood stage of the 50-year return period at construction site, which shall be EL 3.50 m. At LTR, the crest elevation of closure dam shall be above the water level of the flood of 50-year return period of both the project area and of Mae Nam Kolok as to prevent overflowing, which shall be EL 2.50 m. The elevation of river bed at the deepest closing point is EL -4.0 m at UTR and EL -5.0 m at LTR. As sediments are considered to be deposited on the river bed at these closing points, the river bed probably have to be dredged 1 m deep at the most, in which event the dam height would be 8.5 m at both UTR and LTR.

The crest width of dams shall be 9.0 m to be in agreement with the width of O & M roads in the front and rear. And, the entire crest width shall be paved with asphaltic concrete so that in the event that the water level on the upstream side exceeds the design flood stage and overflows across the dam crest, scouring which proceeds from the crest will not cause collapsing of dam body.

(2) Embankment materials

Embankment work of closure dam is broadly divided into two modes, the underwater embankment work and above water embankment work. For underwater embankment work, sediments generated at the time of dredging the connection channel on the upstream side of the tidal regulator or dredging of waterway of Mae Nam Bang Nara shall be diverted for use. Prior to launching on the underwater embankment work, a retaining levee shall be constructed at the toe of slope of embankment by riprap. Embankment is performed by filling the space between the retaining levee with dredged sediments. When embankment has been performed up to the crest elevation of said retaining levee, the embankment method shall be switched to the method of dumping sediment from above the water surface. Embankment is effected by pushing out the hauled-in soils from one side.

5-4. Gate and Other Devices

5-4-1. Gate Body and Motors

(1) General

The Bang Nara reservoir consists of about 60 km long, 15.8 MCM of reservoir capacity and 1,390 ha of area in the river basin about 1,400 km^2. Meanwhile, annual runoff capacity which is about 1,834 MCM will be controlled by three regulators as UTR, LTR and NBR. The control shall be safely carried out for releasing the small runoff at dry season and various floods at rainy season. For this purpose, the gate type,

operating device and back-up equipment shall be designed taken into consideration operation and maintenance technical level and intentions to operate and maintain the structures.

Under the run-off simulation model into the reservoir for each three month interval, the run-off water is summarized as follows:

- Dry season, mid-February to mid-June: 5.0 m^3/sec - 30 m^3/sec
- Initiating rainy season, mid-June to mid-October: 30 m^3/sec - 50 m^3/sec
- Flood season, mid-October to mid-February: 50 m^3/sec - 180 m^3/sec.

The operation system and monitoring devices shall suit with the above conditions. The basic concept of equipment system and various devices are described below.

(2) Type of Gate in UTR

Gate type of UTR shall be shell form fixed wheel gate since clear span is 20 m as a result of study on technical and economical feasibility. Shell type gate is suitable for long span gate, however, one is double leaf from for normal discharge control and other is for flood control. Shell type gate consists of skin plate, top plate, bottom plate, diaphram plates and stiffners. Diaphram plate preserves shell structure. Skin plate are reinforced by stiffners. Proper drain halls are provided with bottom plate at even intervals.

Each gate is provided with main wheels, guide wheels and sheave blocks on each side of the gate. Skin plate of single leaft gate is located on the seaside and as for the double leaf gate, skin plate of lower gate leaf is located on the seaside. Each gate is provided with seal rubbers at the gate bottom, both sides, and the opening space between upper gate leaf and lower gate leaf. These seal rubbers shall keep a good sealing performance against the both side pressure, lake side and seaside.

(3) Type of gate in LTR

Gate type of LTR is girder type fixed wheel gate. Lower gate of double leaf gate is, however, shell type because its span-height ratio is high and it suffers high pressure.

Girder type gate consists of skin plate, main horizontal beams, vertical side girders and auxiliary girders. And other skin plate, wheels and seal rubbers of girder type gate is provided as shell type gate.

(4) Embedded parts

The embedded parts consists of sill beam and side guide frame on each side and other necessary components capable of transferring the loads into concrete. Side guide frame is provided with stainless steel wheel track and sealing plate. Sill beam is provided with sealing plate.

All embedded parts are set in blockout and aligned with the use of studs welded to embedded anchors. The blockouts are filled with concrete after final aligning.

Side guides of double leaf gate consist of 2 sets ones. One is for upper gate leaf and the other is for lower gate leaf. Removable side guides are provided upper than EL +4.0 m for UTR and EL +3.0 m for LTR because of maintenance.

(5) Gate hoist machinery

All gate hoists shall be wire rope winch type ones with one electric motor and one wire rope drum. One set of hoist shall be provided for one-leaf gate and two sets of hoists shall be provided for two-leaf gate, one for lower gate and the other for upper gate. Each hoist shall be mounted on piers located at the both sides of gate and consists of the following component.

a) Drive unit mounted on one side pier, including one set of electric motor, brake, speed reducer, pinion and gear, wire rope drum, sheave block and common frame.

b) Driven unit mounted on the other side pier, including one set of sheave block and frame.

c) Two sets of guide sheaves mounted on both side piers near the bridge.

Gate shall be lifted from two points near both ends of gate leaf, and at each point, sufficient number of sheaves shall be provided on pier and gate leaf. Two wire ropes from each lifting point shall be wound on one wire rope drum. One rope shall be wound directly and the other rope shall be wound through guide sheaves.

Hoist for each gate shall be equiped with the following accessories:

a) Dial type gate position indicator
b) Gate position transducer for remote indication
c) Limit switches to detect gate travel upper and lower limits, wire rope over load and slacking
d) Gate dogging device
e) Handle operation device
f) One ton capacity manual hoist for maintenance

(6) Motor

As for the electric motor, the capacity of motor is as follwos:

Gate Type	UTR	LTR
One leaf	7.5 KW x 1 No.	3.7 KW x 1 No.
Double leaf	5.5 KW x 2 Nos.	3.7 KW x 2 Nos.

5-4-2. Devices

(1) General

At the site of tidal regulators, safety operation of gate opening or closing under the water level fluctuation on upstream and tidal levle, the gate operation will be carried out by operator at the site and remote operation house based on the information which will be transferred from the sites of water level data in the Yakang river, the Bang Nara river and gate opening meters in UTR and LTR as a reasonable centralized supervisory operation devices. Meanwhile, as a result of operation data, it will be applied to maintenance and operation for kind of new desalinization project in other districts.

From the concept of water operation, maintenance and control in the Bang Nara reservoir, the plan of main devices are proposed in the following:

- Gate operation : Site and remote
- Supervisory : Water levels and gate opening
- Computation/recording : Gate opening, discharge, pH and EL values
- Data-Transmission/Communication : Telemeter, radio communication
- Power source : Diesel generator for emergency

(2) Local controls

The local control panels are installed near the hoist to operate each gate at local place. All control switches are mounted in the control station of the door, which has the window for viewing the indicators and the lamps. These are applied to both UTR and LTR.

Type	:	Outdoor, self-standing, moisture proof type, constructed sheet steel
Control devices	:	Push buttons (Open, Close) Selector switches (Remote, Local) Circuit breakers Magnetic contractors Control relays Space heaters Voltmeters Ammeters
Quantity	:	UTR 6 sets LTR 2 sets

(3) Remote controls

The remote control panel is installed in the Operation House to operate each gate at remote place. Control devices are mounted on its desk part. The indicators and the indicating lamps are mounted at its front panels. The remote controls are available when the selector switches mounted on the control panels are changed to "Remote" position. The gate position indicators and the indicating lamps for 3 gates of LTR are mounted on the remote control panels of UTR, too.

Control devices	:	Push bottons (Open, Close) Indicating lamps Gate position indicators (Digital type) Ammeters Control relays Water level indicators (Digital type, only LTR)

Quantity : UTR 1 set
LTR 1 set

(4) Supervisory equipment

The graphic panel and the ITV monitor panel are installed in the Operation House of UTR. The graphic panel has all river basins drawing of Yakang River and Bang Nara River and mounts indicators and indicating lamps as follows:

a) UTR, LTR and NBR (Indicating lamps)
b) Pump stations (Indicating lamps, 10 points)
c) Equipment of countermeasure for acid water (Indicating lamps, established: 7 points, newly established: 6 points)
d) Demonstration farms (Indicating lamps, 3 points)
e) Intake (Indicating lamp)
f) Water level indicators for the rivers (Digital type, UTR: 2 points, Bang Nara River: 1 point, LTR: 2 points, Yakang River: 1 point)
g) Discharge quantity (Digital type, UTR, LTR, NB)
h) Places where pH measuring points are shown (Indicating lamps, Bang Nara River: 3 points)
i) Places where the electric conductivity measuring points are shown (Indicating lamps, UTR, LTR, NBR)
j) Places where the rainfall measuring instruments were installed (Indicating lamps, 16 points)
k) Places where the water level measuring instruments were installed (Indicating lamps, 11 points)

Note: item f): The signals from Bang Nara River, LTR and Yakang River come through the telemeters.
item g): Manual input of calculation value by personal computer

One (1) monitor is mounted in the ITV monitor panel for the camera installed at the upper side of UTR. The camera has rotation function and zoom lens and can be operated by devices mounted on desk part of ITV monitor panel.

Type : Controldesk type, constructed sheet steel

Quantity : 1 set

(5) Calculation and record equipment

Sixteen (16) Bit personal computer, CRT display, key board and printer are provided for the calculation of the quantity of discharge in UTR, LTR and NBR and for the record and the arrangement of the date of the water analysis in Bang Nara River, etc.

(6) Communication equipment

Wireless telemeters are provided for transmission of data to UTR from LTR (Gate position signal x 3, water level signal x 2, indication signal), Bang Nara River (Water level signal x 1) and Yakang River (Water level signal x 1). The equipment in each station are as follows:

UTR

Floating type water level indicators	:	2 sets
Tower for installation of antennas	:	1 set
5 elements Yagi antennas	:	3 sets
Input/output terminal board	:	1 "
Terminal board	:	1 "
Telemeter, transmitter including installation receivers and transmitters	:	1 "
Withstand lightning transformer	:	1 "
Distribution board	:	1 "
Constant voltage and constant frequency (CVCF)(Alkaline battery)	:	1 "

LTR

Floating type water level indicators	:	2 sets
Tower for installation of antenna	:	1 "
5 elements Yagi antennas	:	1 "
Input/output terminal board	:	1 "
Terminal board	:	1 "

Telemeter, transmitter including installation receivers and transmitters	:	1 "
Withstand lightning transformer	:	1 "
Distribution board	:	1 "
CVCF (Alkaline battery)	:	1 "

Bang Nara River

Floating type water level indicator	:	1 set
Tower for installation of antennas	:	1 "
5 elements Yagi antenna	:	1 "
Telemeter, transmitter including installation receivers and transmitters	:	1 "
Withstand lightning transformer	:	1 "
CVCF (Alkaline battery)	:	1 "

Yakang River

Floating type water level indicator	:	1 set
Tower for installation of antennas	:	1 "
5 elements Yagi antenna	:	1 "
Telemeter, transmitter including installation receivers and transmitters	:	1 "
Withstand lightning transformer	:	1 "
CVCF (Alkaline battery)	:	1 "

The VHF fixed stations are used for the communication between UTR and LTR. The VHF wireless telephones are used for the communication between UTR and the observatory of NBR, Yakang River and Bang Nara River, and these river basins.

VHF fixed stations (for UTR, LTR)	:	2 sets
VHF mobile stations (for cars)	:	2 "
VHF portable wireless telephones	:	6 "

(7) Power supply equipment

For high tension (33 KV) incoming, low tension distribution and emergency power supply equipment, the following equipment are provided at the Generator Room in the Operation House. These are applied to both UTR and LTR.

Switch gear panel	:	1 set
Low tension cubicle (Indoor, self-standing)	:	1 "
Emergency generator	:	1 "
(AC 400V, 50 Hz, cooling by radiator, floor type. The output capacity is 92.5 KVA and it is sufficient for operating 1 gate and the lighting systems.)		

5-5. O & M Road Plan

5-5-1. Purpose of Providing the Roads

O & M roads are to be used for inspection and maintenance of the facilities constructed in order to keep them in good working condition at all times so that they might function effectively. Accordingly, O & M roads shall permit the entry of specified machinery and motor vehicles for inspection and maintenance or for major repair work. Especially, as the scale of facilities becomes larger, the passage of larger machinery and motor vehicles will become necessary, so that the road will need to be of a certain specified strength. Also, the scale of the municipal roads to which the new O & M roads shall be connected must be widened and repaired to match the level of O & M road.

With due regard to these conditions, O & M roads shall be palnned around each tidal regulator, and existing roads shall be reviewed.

5-5-2. General Condition of Roads

The present conditions of the roads for gaining access to UTR and LTR are as follows:

1) UTR

Access to UTR from Narathiwat may be gained by taking National Highway No. 4084 which leads to Tak Bai and by crossing Mae Nam Bang Nara over Ban Kai Bridge and shortly turning to the right off National Highway and entering Amphoe Road (under the control of the Amphoe Office). The National Highway is 9.0 m wide, of which 6.0 m is paved with asphaltic concrete. Amphoe Road, which branches off the National Highway, goes south along Mae Nam Bang Nara. The road was buitl for connecting hamlets, and is only around 3.0 m wide and unpaved so that only small vehicles are passable. The new O & M road branches off toward right from this Amphoe Road at a point about 1 km from the National Highway. The tidal regulator can be reached through said O & M road which is now under construction by RID.

2) LTR

National Highway No. 4057 branches off toward Sungai Kolok at a point 31 km from Narathiwat and 2 km from Tak Bai on National Highway No. 4084, National Highway No. 4057 is of the same scale as National Highway No. 4084 and the road surface is paved with asphaltic concrete. Highway No. 4057 which branches off from Highway No. 4084 goes south and crosses Mae Nam Bang Nara over Tha Phraek Bridge at about 1.5 km from the branching point. At a point about 600 m further south, the new O & M road branches off from this Highway toward right. At a point about 1 km further south from where it branches off toward LTR on the National Highway, the access road to the O & M office of Mu No Project, a project similar to this one, branches off toward left.

5-5-3. New O & M Road to be Constructed

1) UTR

The new O & M road to be constructed from the branching point of Amphoe Road in conjunction with the construction of the tidal regulator at UTR goes by the tidal regulator and the closure dam on Mae Nam Bang Nara and connects with the existing road on the opposite bank. The distance covered is about 1,190 m. Of this, the breakdown of the scope of construction to be undertaken by RID and the sections to be constructed as part of structures is shown below.

- Section to be constructed by RID (under construction) : 500 m
- Section of the O & M bridge of the tidal regulator : 140 m
- Embankment section to be constructed by Japan: 250 m
- Section of the closure dam : 240 m
- Section to be constructed by RID : 60 m

According to RID's plan, the 500 m section on the right bank is scheduled for completion within this year. This section also includes the closure dam to be constructed on Khlong Sapi Yo. During the current field survey, clearing and levelling work on the right bank of Khlong Sapi Yo and the dredging of the foundation of the closure dam on Khlong Sapi Yo by dredger were already in process.

Also, according to RID's plan, the O & M road is of the same sacle as the national highways in the surroundings, with a road width of 9.0 m, road surface pavement width of 6.0 m and paved with asphaltic concrete. However, the road surface pavement of the section which is now under construction by RID will be executed only upon completion of all other works. In

view of the above, the road section and pavement method consistent with RID's plan will be adopted for the embankment section to be constructed by the Japanese side.

The scale of the closure dam to be constructed by RID on Khlong Sapi Yo is 50 m of dam body, and 70 m if the approach sections in the front and rear of dam body are included. The crest width of dam body is 9.0 m, of which 6.0 m will be eventually paved with asphaltic concrete. The upstream and downstream slope faces will be graded at 1:3 and are planned to be stone pitched.

Accompanying the construction of the closure dam onKhlong Sapi Yo, a diversion channel to discharge water from Khlong Sapi Yo in its upstream into Mae Nam Bang Nara will become necessary, and the construction of said diversion channel with a discharging capacity of 12 m^3/sec is also included as a part of the construction of O & M road to be undertaken by RID.

Regarding the elevation of road, the section now under construction by RID is at EL. 4.0 m, which is a height that will not allow the road to become submerged even in the event of a flood of the 50-year return period. The elevation of the embankment section to be constructed by the Japanese side is proposed to be EL. 3.0 m in the feasibilty study report. However, according to RID's plan confirmed during the field survey, the Narathiwat Irrigation Office is scheduled to be relocated to the area enclosed by the connection channel in the downstream of the tidal regulator and the Mae Nam Bang Nara in the future. In view of this plan, the road height of the section to be constructed by the Japanese side, which will also serve as a flood-prevention levee for the Narathiwat Irrigation Office, will be changed to EL. 4.0 m.

2) LTR

The new O & M road to be constructed at LTR is a section of about 1,540 m leading from the branching point of National Highway No. 4057 to the tidal regulator and the closure dam on the Mae Nam Bang Nara and connecting with the existing road on the opposite bank. As with UTR, the breakdown of this section by type of work is shown below:

° Section to be constructed by RID	:	815 m
° Section of the O & M bridge of the	:	30 m
° Embankment section to be constructed by Japan	:	310 m
° Section of the closure dam	:	95 m
° Section to be constructed by RID	:	290 m

According to RID's plan, the construction of the 815 m section on the right bank is scheduled for completion within this year. The scale of this road is the same as the O & M road of UTR. Accordingly, the cross-section and pavement method of the section to be constructed by the Japanese side shall be consistent with RID's plan. Paving of the sections to be executed by RID, however, is scheduled to be implemented only after all construction of the road has been completed.

Also, according to RID's plan, the elevation of the O & M road on the right bank of LTR is EL. 3.0 m as proposed in the feasibility study report. This is an elevation that will prevent the road from submerging as it is above the level of the flood of 50-year return peirod to be drained from the area and above the flood level when the same flood flows down the Mae Nam Kolok. However, the feasibility study report also proposes that the O & M road in the section enclosed by the connection channel and the river course of old Mae Nam Bang Nara shall be at EL. 2.0 m. According to RID's plan which was

confirmed during the field survey, the construction of office buildings, living quarters of the staff, warehouses and other operation and maintenance facilities is planned in the area enclosed by the connection channel in the downstream of the tidal regulator and Mae Nam Bang Nara in the future. In view of this, the road elevation of the section to be constructed by the Japanese side which will also serve as a flood-preventing levee for these facilities shall be EL. 3.0 m.

5-5-4. Improvement Works on Existing Roads

As stated in the previous paragraph on general condition of roads, Amphoe Road as an access to UTR is too narrow in width, and because of the trees stand that nearby the road, it was feared that entry of heavy vehicles and hauling of long and large material for executing work might be hampered. However, according to RID's plan which was confirmed during the current field survey, the improvement works on the section between the National Highway and the point at which the new O & M road is to be branched off is scheduled for completion within this year. Extension of the improved section will be 1.1 km and the road width, 9.0 m. In the current RID's plan, the road surface will only be paved with laterite soil after compacting. As to other roads, asphaltic concrete pavement is scheduled to be applied on the road surface only upon completion of all work.

5-5-5. O & M Bridge

The purpose of installing the O & M bridge is to be able to observe every gate at all times for inspection and maintenance and to enable passage of specified vehicles as necessary. The bridge therefore shall be of a dynamically safe structure.

(1) Width

A width necessary for inspection and maintenance of gate and for operating the gate at the time of emergency shall be secured for the O & M bridge. For this purpose, the width of the bridge shall match the effective width of the O & M road in the front and rear and also with due consideration to the structure of the bridge, it shall have the width of 6.0 m.

(2) Length

An O & M bridge is to be provided on each pier to make inspection and maintenance of all gates possible, the extended lengths would be 24.5 m x 6 spans = 138 m at UTR and 14.0 m x 2 spans = 28 m at LTR.

(3) Structure

The O & M bridge may be a steel bridge, prestressed concrete bridge, reinforced concrete bridge or any other type of bridge. From among these, the type of bridge with PC box girder beam which can be manufactured at factories nearby the site was adopted upon considering various conditions, such as the bridge span, relative ease of raw materials procurement, locations of the installation site relative to the national capital and natural environment in the surroundings which might give rise to problems in future maintenance and operation. As for design load, loading of T-20 was assumed to be required for maintenance and operation of the gate, and to this, dead weight, etc. were also taken into consideration on the basis of which is structurally safe was designed. Based on the foregoing, the section of the box girder shall be 1.0 m wide and 0.85 m high at UTR and 1.0 m wide and 0.75 mhigh at LTR. Six of such box girders shall be arrayed in parallel and tightly bound together, on which pavement concrete shall be placed to protect the girder and ensure smooth running of vehicles on the structure.

As an O & M bridge, the stairs to connect the foregoing PC bridge with the gate hoisting house will be provided on the pier. Said O & M bridge will be made of steel in consideration of workability and other matters, and rust-preventive coating will be applied to prevent corrosion due to briny air.

5-6. Plan for Operation and Maintenance Office

5-6-1. Overall Conception of Operation and Maintenance

The new irrigation and drainage facilities to be constructed under the Bang Nara Irrigation and Drainage Project and the existing facilities are briefly described below.

	New	Existing
° Reservoir facilities	2 locations	1 location
° Irrigation facilities		
- WUG pump irrigation facilities	193 spots	-
- RID pump irrigation facilities	10 spots	-
- RID gravity irrigation "	1 spot	-
° Drainage improvement	7 drainage basins	-
° Acidic water flow checking facility	8 spots	9 spots
° Demonstration farms	3 places	-

If each of these facilities are to function effectively by maintaining mutual linkage with each other, it is necessary to launch on the Bang Nara Operation and Maintenance Project to operate and maintain all these facilities. The implementation of the Bang Nara Operation and Maintenance Project in parallel with the construction of the facilities will not only promote agricultural development in the basin area of Mae Nam Bang Nara but will contribute to development of the region as a whole. RID plans to hae the following five sections carry out said Operation and Maintenance Project.

- Administration Section
- Engineering Service Section
- Water Management Section
- Mechanical Section
- O & M Sections

The O & M Sections will consist of irrigation engineers, administrators, janitors, watchmen, laborers, zonemen, gate tenders, canal tenders, mechanical engineers, electrical engineers, telecommunication engineers, skilled laborers (at workshops), etc.

5-6-2. Operation and Maintenance of UTR

The role of UTR's O & M Office will primarily consist of centralized control of data of the entire catchment area relevant to the water level, water volume and water quality of Bang Nara Reservoir and operation of UTR itself based on an analysis of those data.

The contents of data which will be subject to centralized control are water levels inside and outside of UTR, water levels inside and outside of LTR, degree of opening of UTR gates, degree of opening of LTR gates, water levels-discharges at X73 spots, water levels at X162 spots, precipitation at representative spots in the catchment area of reservoir, operating status of RID's pumps, pH and EC at principal spots of the reservoir, etc. For transmitting these data, the radio band will be used for transmitting important or urgent ones, while others will be transmitted either over the telephone or by the patrolman who makes his rounds.

The UTR O & M Office will operate its own gates as necessary based on the results of analyzing its centrally controlled data, and if necessary, will also issue instructions to LTR and NBR.

5-6-3. Operation and Maintenance of LTR

UTR's O & M Office will normally regulate the water level of the reservoir, but if operation of the gates of not only UTR but those of LTR should be considered necessary based on an analysis of the centrally controlled data, and instructions to that effect is received by LTR, LTR's O & M Office shall operate the gates of LTR.

The LTR O & M Office's role will be to drain flood water from the rea and also to prevent back-flow of flood run-off from Mae Nam Kolok into the area. Therefore, if run-off inside the area is quicker than the run-off of Mae Nam Kolok, it will open the gates to drain flood water as, in the initial stage, the water level inside would be higher than the water level on the outside. With the passage of time, however, when the water level of Mae Nam Kolok becomes higher than the water level inside the area and back-flow begins, it will close the gates. If, on the contrary, the flood run-off of Mae Nam Kolok is quicker, the gates would have to be operated in the reverse sequence. This operation of the gates which must be effected according to the condition of the water level will be performed by the gate operator upon judgment of the water level indicated on the instrument panel at LTR. He will also base his judgment on UTR's instructions which are based on an analysis of the data transmitted (from LTR) to UTR and on an analysis of the precipitation in the entire catchment area.

As the water levels of the reservoir near LTR will hardly be regulated in normal times, the water quality is anticipated to deteriorate due to stagnation. Therefore, it is necessary that the pH and EC values of the entire reservoir area be observed, and if the values exceed the allowable limits, to improve the water quality by operating the LTR gates. Operating the LTR for the above purpose is another important role of this facility.

5-6-4. Operation and Maintenance of NBR

The purpose of NBR is to drain flood water from around the middle reaches of Mae Nam Bang Nara where flooding time tends to be longer than in other places due to slow drainage of this 60 km-long river which has a river mouth at both its upstream and downstream ends. Accordingly, even if construction of UTR and LTR are completed and operation of Bang Nara Reservoir begins, it is most likely that NBR would be operated for quickly draining water only at times of flood.

Since NBR will have a large bearing upon the gate operation of UTR and LTR, a system of communicating with the gate operation must be firmly established.

As the water will stagnate while NBR is closed, it is anticipated that the quality of water stored in Nam Baeng Canal which branches off from Mae Nam Bang Nara will deteriorate. It was therefore decided that pH and EC values within Nam Baeng Canal should be closely observed, and that if their values exceed the allowable limits, the water quality should be improved by operating NBR.

5-6-5. Plan for Operation and Maintenance Offices

As stated before, UTR and LTR will each have an office area of 220 m^2 and 120 m^2, respectively, in consideration of the equipment and instruments, engineers and clerical staff that are assigned to each office for operating the UTR and LTR in association with the operation of the reservoir. Each area includes a space for the generator room as the emergency power source in the event of an electricity supply stoppage.

The design and specifications of these offices will be in conformity with those of the buildings works executed in the Mae Kuang Irrigation Agriculture Development Project as requested by the Thai side.

For NBR, the existing operation and maintenance office located near the site of NBR shall be used as is since the operation of NBR is not complicated and the installation of any new equipment is not called for.

5-7. Basic Design Drawings

Drawing No. BN-01 to Drawing No. BN-10 are the basic design drawings which summarize the contents of plans for the various structures, their layout and scales which have been described thus far. The following roughly supplments or explains these drawings.

5-7-1. General Design Drawing for UTR

The first 500 m section of the new O & M road which starts from Amphoe Road located on the right bank of Mae Nam Bang Nara and leads to the site of UTR is now under construction by RID. At 95 m in front of the 500 m point, a monument is scheduled to be constructed in the future. Only the foundation of this monument will be constructed before completion of the O & M road while the rest of the monument will be completed after the tidal regulator has been constructed.

The Thai side requests that the use of land around the monument be restricted accompanying the execution of the foundation work for the monument. The concrete plant required for construction of UTR, therefore, will be planned to be located on the right bank of the connection channel in the upstream of UTR where it is close to the site and therefore convenient for construction. For locating the camps and stock yard necessary for construction, the land of about 4 - 5 m in elevation which spreads on the north side of where the new O & M road starts will be used. As this area is slightly sloped, it will have no drainage problems during the rainy season or during flood.

For electricity supply, RID will apply to Narathiwat PEA to lead in power to the site from the existing line (high tension 33 KV) which runs along the National Highway. Installing of the service wires will be executed by PEA, and these service wires will be installed as far as the concrete plant or the campsite before construction begins. Upon completion of construction, RID will be responsible for extending the power lines to the operation and maintenance office.

Potable water and construction water will be supplied in the same way as electricity. The water necessary for construction will be drawn from the existing pipeline laid along the National Highway to the campsite and to the concrete plant through a ϕ5" service pipe. RID will apply to Narathiwat PWWA to have the water supplied, upon which PWWA will execute the necessary work. When construction of the tidal regulator is completed, RID will be responsible for extending the pipeline.

At the time of dredging the connection channel in the upstream of UTR, not only the water channel but the river bed of Mae Nam Bang Nara in the upstream of the connection channel will also be dredged. This river bed in the upstream of the connection channel is, in some places, shallower than the bed height of the connection channel which is EL. -4 m, and unless such places are dredged, they are likely to cause bank sand to become deposited not only on the bottom of the connection channel but on the sill bed of the gate as to hamper operation of the gate and damage the gate itself. Accordingly, those shallow places of the river bed of Mae Nam Bang Nara will be dredged up to the point where its height becomes EL. -4 m, in the same width as the connection channel.

In placing concrete at the pier section, a space necessary for fitting embedded metal of gate shall be reserved in advance. In so doing, anchor rods shall be embedded in concrete so that concrete, which is later filled to fix said metal, will fix.

In order to prevent slaine water from infiltrating the area from the outside through a gap between the lower edge of the gate and sill bed of gate generated due to uneven settlement of pier and sill bed of gate, a dowel bar shall be provided at the joint section.

Also, in order to prevent run-off of soil particles of the foundation ground through the gap in the same joint section due to uplift pressure arising from beneath of sill bed, a water stop shall be provided.

Hand rails shall be provided on each side of the O & M bridge to ensure safety of pedestrians. For hand rail, materials which are strong and which do not corrode by briny air, such as aluminium alloy shall be used.

RC stairs shall be provided on the upstream bulkhead of the double leaf gate which will be installed on the left bank of the tidal regulator. This is for removing debris which tend to concentrate at the double leaf gate. Unless the flowing debris which collect at the double leaf gate for regulating the water level of Bang Nara Reservoir are removed, they will not only hamper operation of the gate but will damage the gate itself. Hence, a facility to remove debris by means of a float or otherwise will be provided on the upstream side of the gate to lift up debris onto the stair for disposal.

A dowel bar shall be provided at the joint section to prevent uneven settlement of sill bed of gate, rear- and fore-aprons. This is to prevent the river bed from becoming scoured during flood by turbulent flows or eddy flows being unnecessarily generated due to uneven settlement.

Also, a water stop shall be provided at the joint section to prevent run-off of soil particles from the foundation ground due to uplift pressure.

Drain pipes for release of uplift pressure below the apron shall be provided in the concrete cut-off for preventing scouring, which is provided at the end of the downstream apron. Grading-controlled gravel shall be laid at the inlet side of drain pipes to prevent run-off of soil particles from the foundation ground.

An industrial TV camera shall be set on the upstream side of the pier at the farthest end on the left bank side so that conditions of overflow at the double leaf gate section can be monitored in the O & M office. The camera shall be set on a flat place of +4.0 m in elevation where the cross-section of the pier changes. This elevation is appropriate for setting the camera as it will not become submerged even in the event of a severe flood. The camera shall be of the stationary type as it will only be for monitoring the double leaf gate section.

At the time of placing concrete of the pier, a conduit tube which houses a cable for connecting the control and illumination cable laid along the O & M bridge with the gate hoise house shall be buried.

The necessary number of weep holes shall be provided in the wing wall section on each side of the tidal regulator in order to lower the ground water level behind the wing wall. Grading-controlled gravel shall be placed at the ground water inlet side of weep holes to prevent run-off of soil and sand.

A dowel bar and a water stop shall also be provided at the joint section of the wing wall to prevent uneven settlement and run-off of soil and sand, respectively.

5-7-2 General design drawing for LTR

The site for setting up camps and stockyard necessary for construction shall be secured within the land acquired by RID on the right bank of the connection channel. The proposed site is around EL. 1.0 m in elevation. Since the flood stage of the five-year return period is close to WL. 1.5 m, banking of about 0.5 m is considered necessary to provide for the occurrence of such a flood during the construction period.

Leading in of electricity into the site from the existing line (high tension 33 KV) which runs along the national highway will be the responsibility of RID as in the case of UTR. Service wires shall be extended as far as the stockyard in front of the connection channel prior to commencing construction, and extension of the service wires to the O & M office upon completion of construction shall also be the responsibility of RID.

Potable water and water for construction work shall be supplied to the construction site by installing a new ϕ 5" water pipe to be branched from the existing water pipe from Tak Bai, which is laid along the national highway, at RID's responsibility. The water pipe shall be extended as far as the construction site in front of the connection channel in time for commencing construction, and its extension as far as the O & M office after construction of the tidal regulator is completed shall also be the responsibility of RID.

(1) Regulator body of LTR

When placing the concrete for pier, a space necessary for fitting embedded the metal of gate shall be reserved in advance, and anchor rods shall be embedded in the concrete.

A dowell bar shall be provided at the joint section in order to prevent uneven settlement of footing of pier, sill bed of gate and apron. A water stop shall be provided at the joint section to prevent run-off of soil particles from the foundation ground through the gap in the joint section.

Hand rails made of materials such as aluminium alloy shall be provided on each side of the O & M bridge for safety.

RC stairs shall be provided on the upstream bulkhead of the double leaf gate to be installed on the left bank of the tidal regulator to remove debris which tend to collect there.

Drain pipes for release of uplift pressure, and grading-controlled gravel shall be provided in the cut-off section in the end of downstream apron.

At the time of placing concrete for pier, a conduit pipe housing cables for control and for lighting shall be buried.

The necessary number of weep holes and grading-controlled gravel shall be provided in the wing wall section on each side of the tidal regulator. A dowell bar and a water stop shall also be provided in the joint section of the wing wall.

(2) Closure dams of UTR and LTR

Protection of slope faces shall be effected by rubble mound, and the transition materials which are to be placed underneath the rubble-mound shall be adequately controlled in grading to prevent soil and sand in the embankment from being sucked out due to fluctuation of water level. Riprap work shall also be executed with the utmost care.

The crest of closure dams shall be paved with asphalt to prevent collapsing of dam body due to overflow in the event of an extra-ordinary flood. The foundation course of pavement shall be carefully executed and shall be strong enough as not to be stripped off or collapse under the weight of overflow. Both sides of pavement shall be compartmentalized by reinforced concrete to prevent collapsing from the end face.

5-7-3. Gate and its Operation System

"Open" and "Close" operation of each gate is carried out by the local control panel installed near the hoist. 1 local control panel is installed respectively for a pair of 2 leaf gates and 1 control panel is installed respectively for the 1 leaf gate. Each water level indicator is installed at the upper side and lower side of the 2 leaf gate. The water level at UTR is indicated on the graphic board panel in the Operation Room, and one at UTR is indicated on the remote control panel digitaly.

The operation of all gate such as "Open" and "Close" is carried out by the remote control panel in the Operation Room. Each gate position indicators (Digital type indicator), various display lamps and ammeters are mounted on the remote control panel, and it is able to supervise the condition of the gates always. 1 ITV camera is installed at the upper side of UTR, and it is able to supervise the upper side of each gate at UTR by the monitor mounted on the ITV monitor panel. The camera has rotation function and zoom lens and can be operated by the controlers mounted on the ITV monitor panel. The picture of the all river basins including Yakang River and Bang Nara River is drawn on the graphic panel, and the indicating lamps showing the places of the establishments, the water level indicators of the upper and lower sides of UTR and LTR, the water level indicators of Yakang River and Bang Nara River and the indicators of quantity of the water drainage are mounted on it, so that the condition of the all river basins are understood. The data of the water level of LTR, Yakang River and Bang Nara River are

transmitted from each transmitter of the wireless type telemeters installed at above mentioned areas to the receivers of it installed at UTR and indicated on the graphic panel. The quantity of the water drainages of UTR, LTR and NB indicated on the graphic panel is calcurated by the personal computer by means of the data of the water level and the gate position, etc. inputted from the key boards. The attachments of these equipments are the CRT display and the key board. The communication between UTR and LTR is performed by VHF fixed stations and the communication between UTR and the observatory of NBR, Yakang River and Bang Nara River, and these river basins are performed by VHF wireless telephones. The commercial power is 33kv, A.C. 3 ϕ, 50 Hz, and the high tension cubicle and the switch gear panel are installed. In case of the commercial power failure, the power is supplied from the emergency generator. The low tension cubicle is provided for the power transfer and low tension distribution.

5-7-4. Operation and Maintenance Building

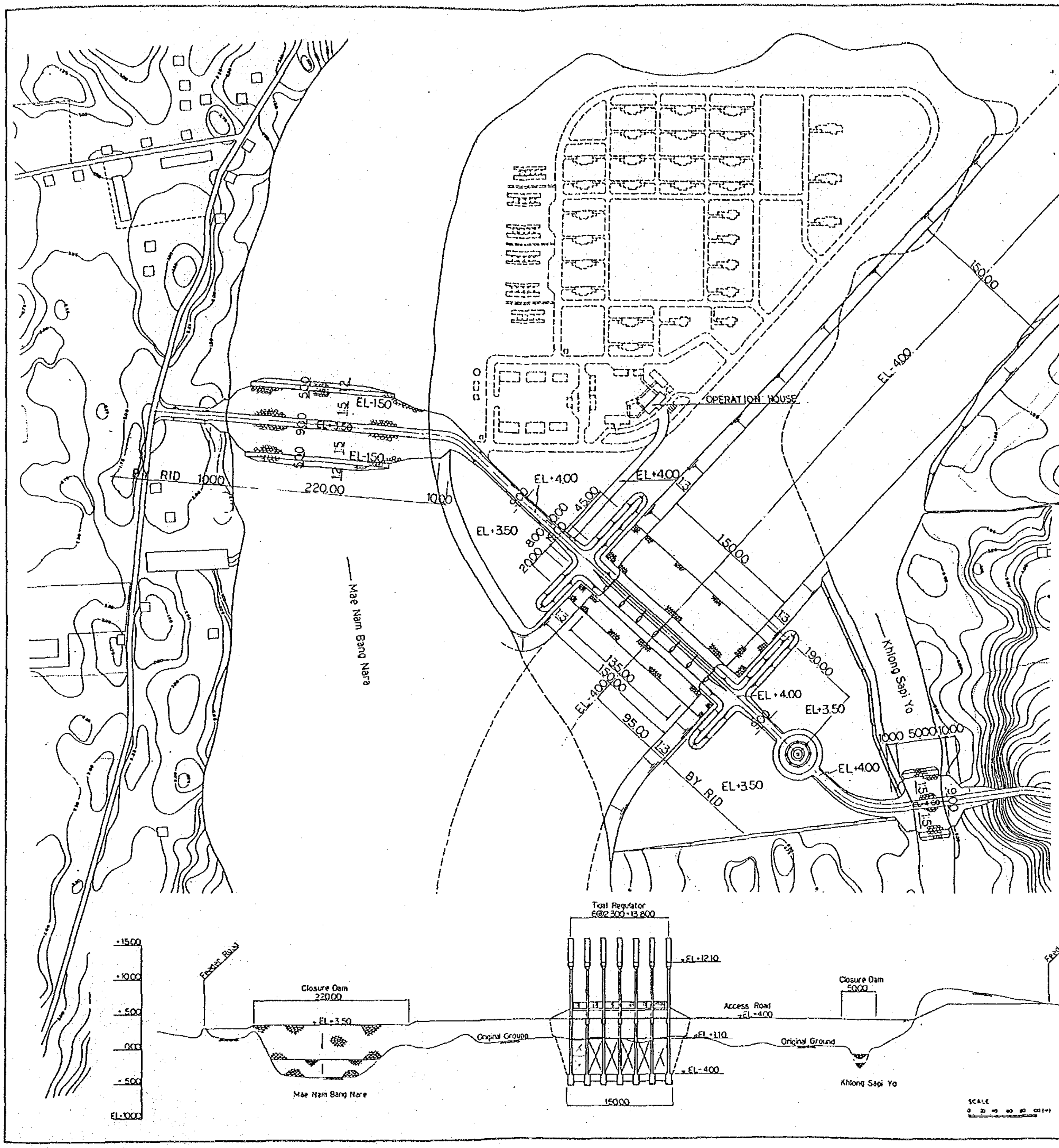
As a single story building will be sufficient for the size of the Operation and Maintenance Building, the structure of the building shall be planned to be suitble for a single story structure. Specifications for principal components of the building shall be as follows:

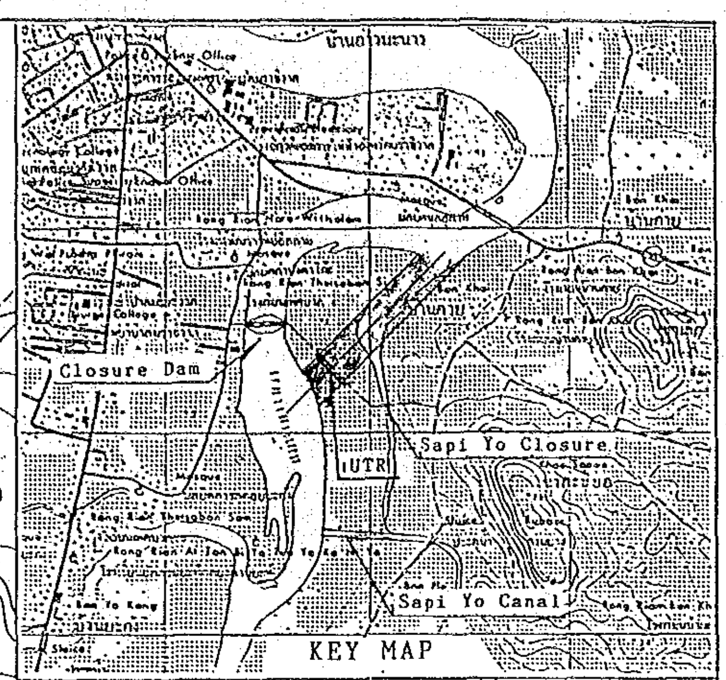
- Roof structure -- steel trussed frame structure
- Roof -- asbestors cement Roman tile roofing 0.50 m x 1.20 m, natural color
- Ceiling board -- cellocrete ceiling board shall be suspended from T-shaped aluminium frame, painted white.
- Column -- reinforced concrete column, 0.15m x 0.15 m
- Bean -- reinforced concrete beam
- Floor -- finished by placing reinforced concrete over compacted sand
  - * The operation room to be of cinder concrete finish (t = 10 cm) for wiring.
  - * Interior of offices shall be of metal trowel finish.

* Outdoor passages shall be of rough surface finish.
* Hot water heater room and toilet to be of mosaic finish with tile (2" x 2")

° Door -- prefabricated door (0.8 m x 2.0 m) made of teak plywood.

° Window -- transparent clear glass jalousies window in steel frame to be slide by means of gear roller.





Notes:

A. Scope of Work by Japanese Grant-Aid

The works to be undertaken by Japanese grant-aid cover the upper tidal regulator and its related structures below:

(1) A general plan for upper tidal regulator body is composed of piers, cut-off works, apron and riprap as well as foundation piles.

(2) The movable gate opening width of regulator is designed at 120 m long divided into 6 gates, and the water pressure conditions will be pressed by both the inside and outside pressures and overflow action at two leaf gates.

(3) Road bridge will be erected at the downstream side of the pier in relation to the maintenance and operation road to be connected to the existing roads.

(4) Connection channel will be constructed at the both sides of upstream and downstream related to the existing river after completion of the tidal regulator body.

(5) Closure dam in the Bang Nara river will be constructed after completion of the regulator body and connection channel.

(6) An operation house by means of a remote control room to be provided at inside of the house for the installation of equipment which configurated with a system as monitoring, remote operation of the gate, data-transmission, computation and communication.

B. Scope of Work by RID

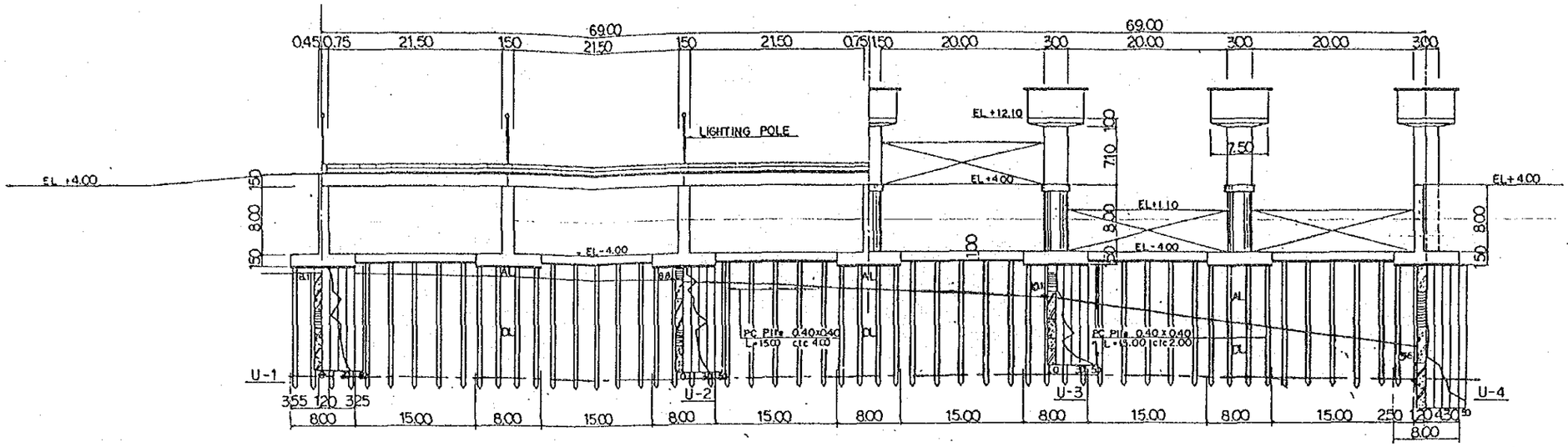
(1) O & M road at the right side of Bang Nara river and the both sides of Sapi Yo river will be constructed by RID, including Sapi Yo closure dam.

SCALE 0 20 40 60 80 100 150 200(m)

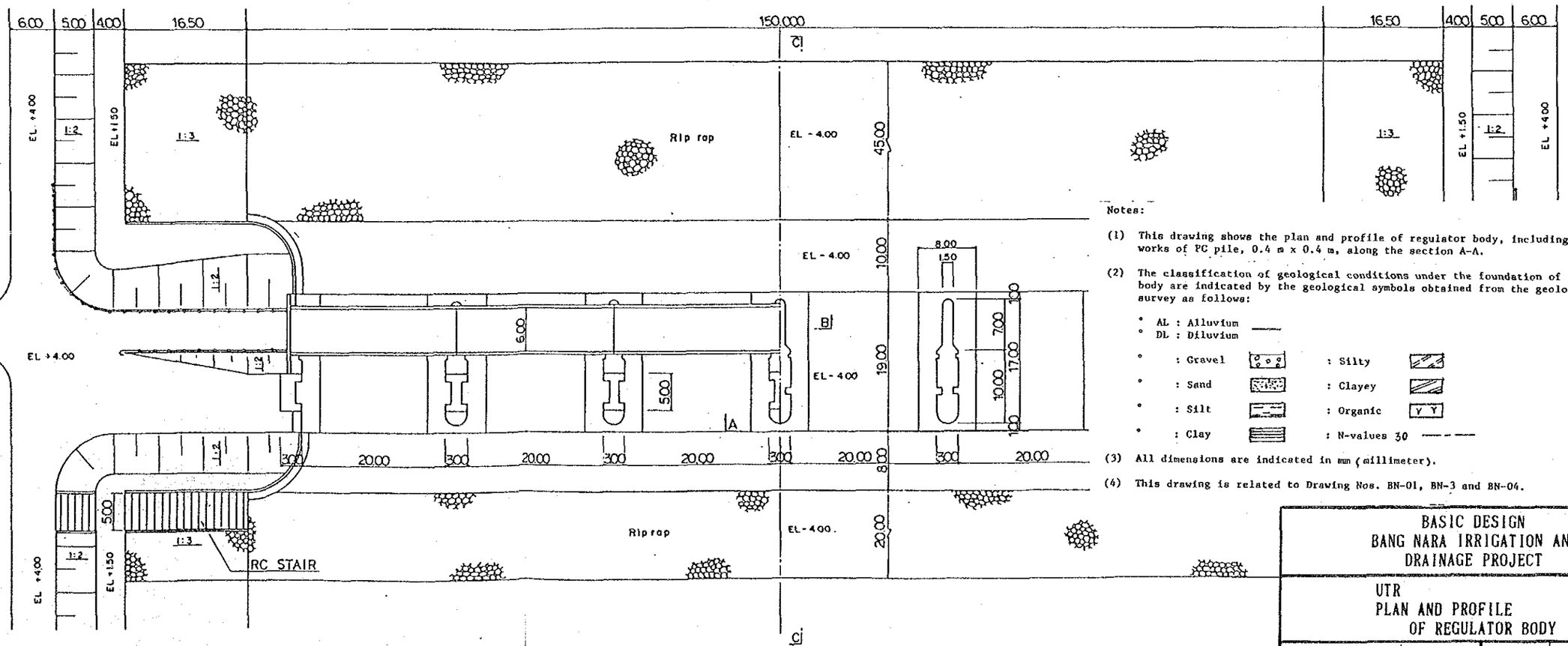
BASIC DESIGN BANG NARA IRRIGATION AND DRAINAGE PROJECT			
UTR GENERAL PLAN AND PROFILE			
DRAWING NO.	BN - 01	DATE	
JAPAN INTERNATIONAL COOPERATION AGENCY			

SECTION B-B

SECTION A-A



GENERAL PLAN



Notes:

(1) This drawing shows the plan and profile of regulator body, including foundation works of PC pile, 0.4 m x 0.4 m, along the section A-A.

(2) The classification of geological conditions under the foundation of the regulator body are indicated by the geological symbols obtained from the geological boring survey as follows:

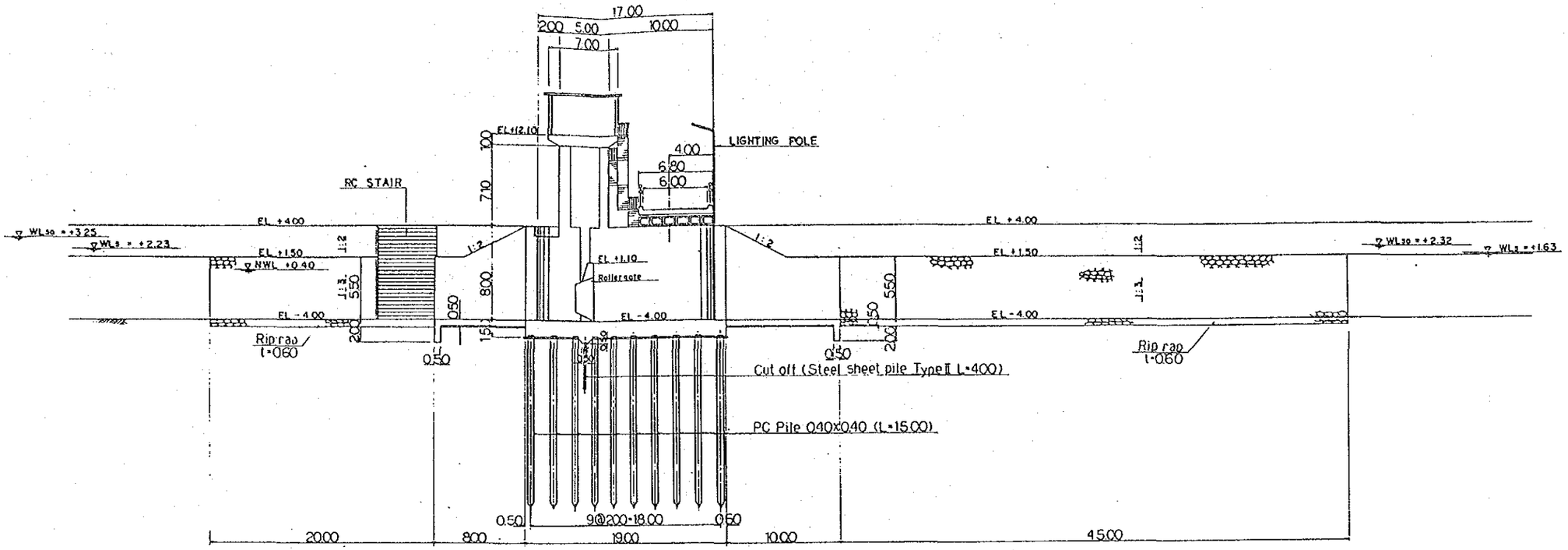
- AL : Alluvium
- DL : Diluvium
- : Gravel
- : Sand
- : Silt
- : Clay
- : Silty
- : Clayey
- : Organic
- : N-values 30

(3) All dimensions are indicated in mm (millimeter).

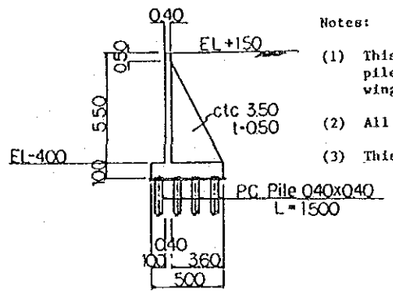
(4) This drawing is related to Drawing Nos. BN-01, BN-3 and BN-04.

BASIC DESIGN BANG NARA IRRIGATION AND DRAINAGE PROJECT
UTR PLAN AND PROFILE OF REGULATOR BODY
DRAWING NO. BN - 02 | DATE
JAPAN INTERNATIONAL COOPERATION AGENCY

SECTION C - C



WING WALL



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

Notes:

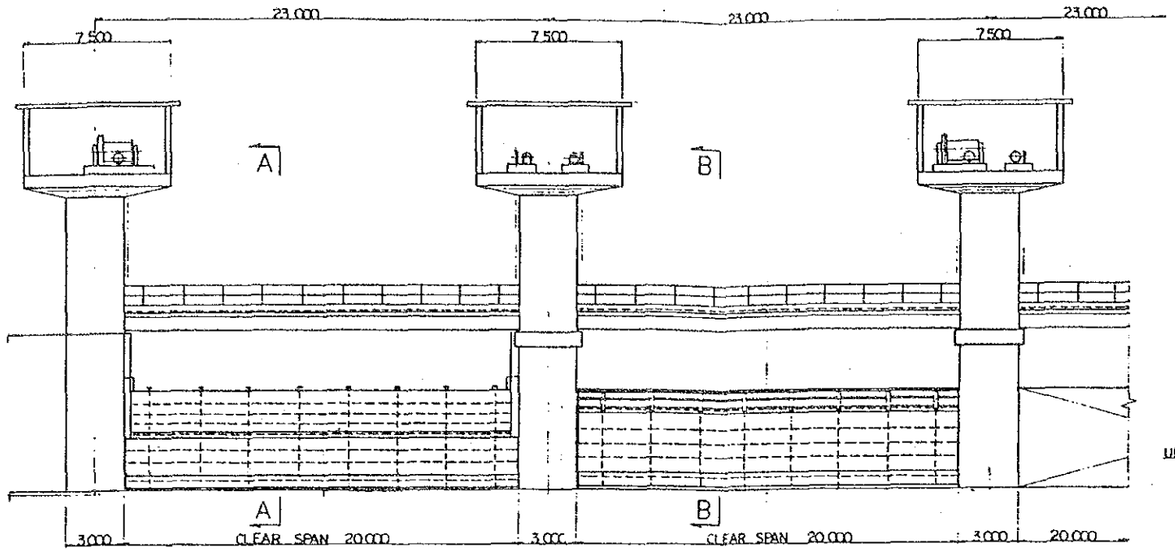
(1) This drawing shows the cross-section of regulator body, including cut-off, P.C pile in the foundation works and concrete body as well as concrete structure of wing wall at wings of both banks.

(2) All dimensions are indicated in mm (millimeter).

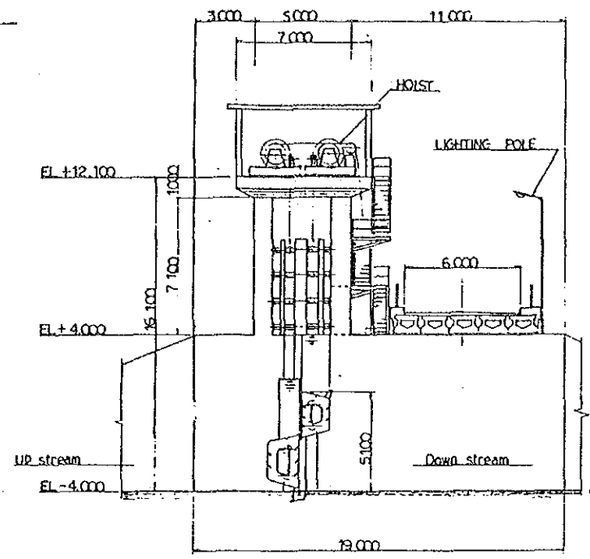
(3) This drawing is related to Drawing Nos. BN-01, BN-02, and BN-04.

BASIC DESIGN BANG NARA IRRIGATION AND DRAINAGE PROJECT			
UTR CLOSS SECTION OF REGULATOR BODY			
DRAWING NO.	BN - 03	DATE	
JAPAN INTERNATIONAL COOPERATION AGENCY			

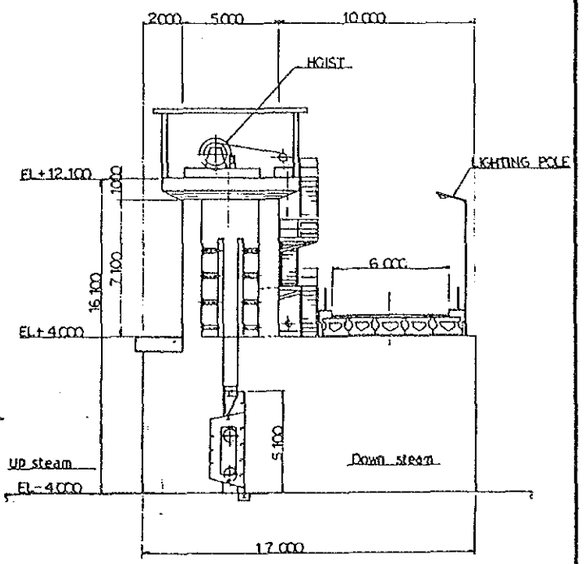
ELEVATION (UP STREAM VIEW)



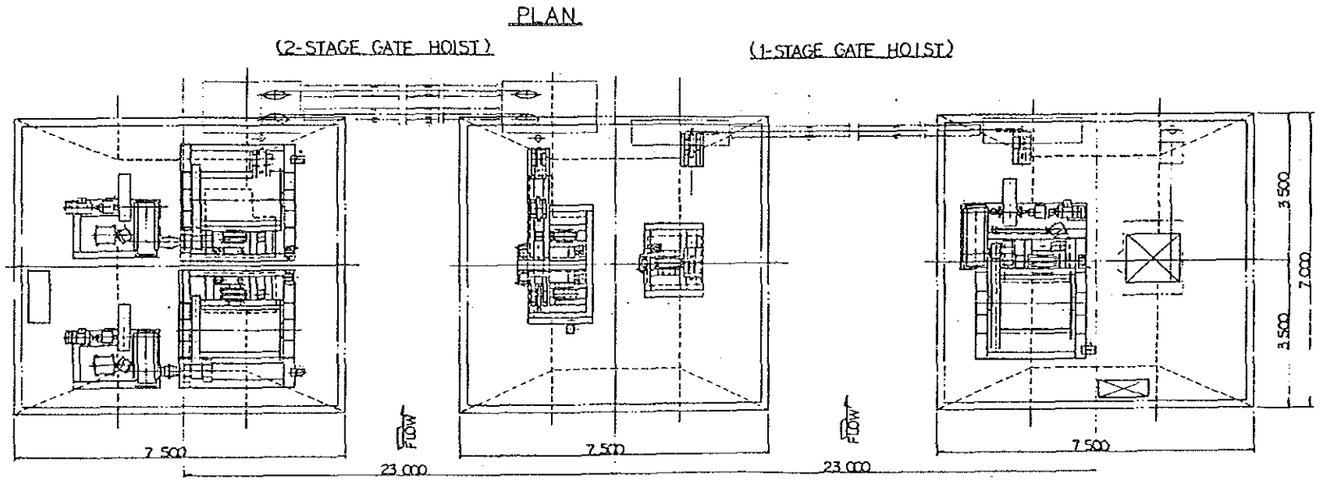
SECTION A - A
2 - STAGE GATE



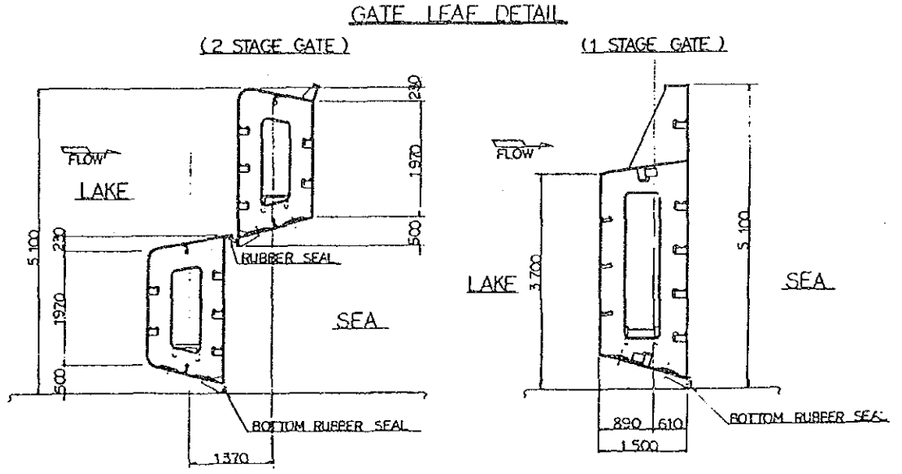
SECTION B - B
1 - STAGE GATE



PLAN

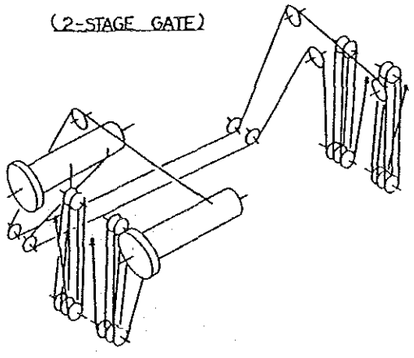


GATE LEAF DETAIL

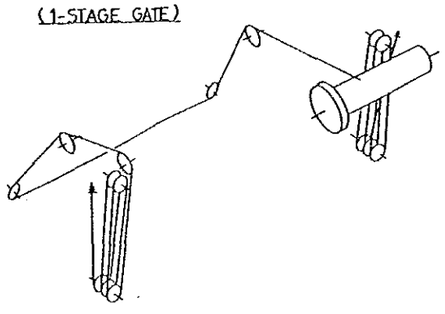


WIRING

(2-STAGE GATE)



(1-STAGE GATE)



Notes:

(1) This drawing shows the basic concept of the gate structures and its operation system at UTR, including gate body, wiring system and hoist equipment to be installed on top of pier.

(2) The gate body consists of two types of one-leaf gate for flood section and double leaf gate for discharge control section and the section of gate body is like shell formation.

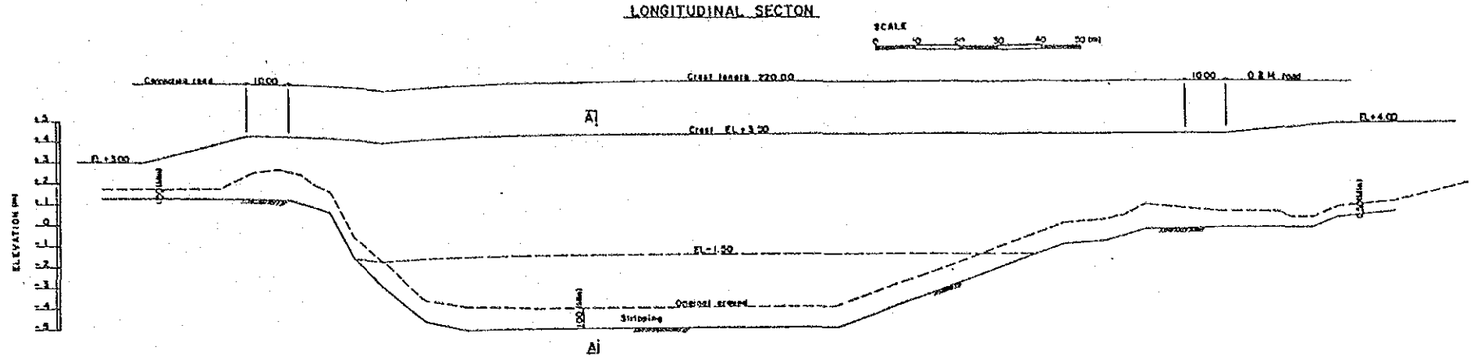
(3) Gate hoist machinery is wire rope winch type ones with one electric motor and one wiring drum, in cooperation with the installation of a gate operation panel at nearby hoist machinery.

(4) All dimensions and elevations are indicated in mm (millimeter).

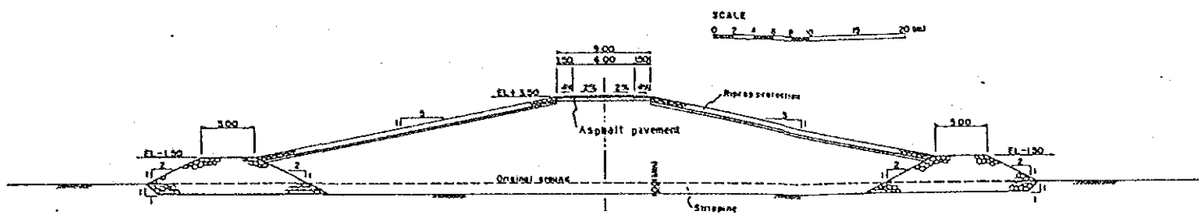
BASIC DESIGN BANG NARA IRRIGATION AND DRAINAGE PROJECT			
UTR OUTLINE OF GATE STRUCTURE			
DRAWING NO.	BN - 04	DATE	
JAPAN INTERNATIONAL COOPERATION AGENCY			

UPPER CLOSURE DAM

LONGITUDINAL SECTON

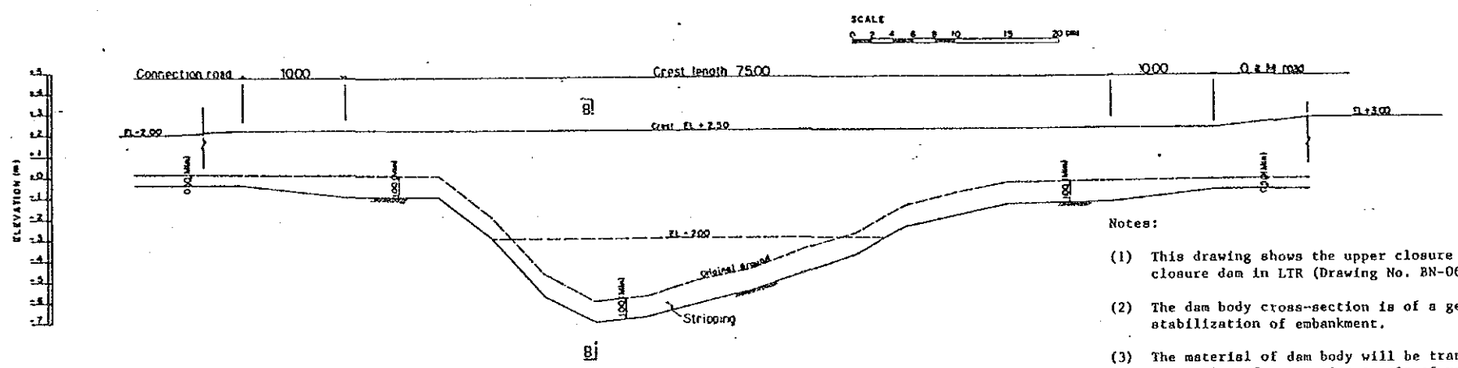


SECTION A - A

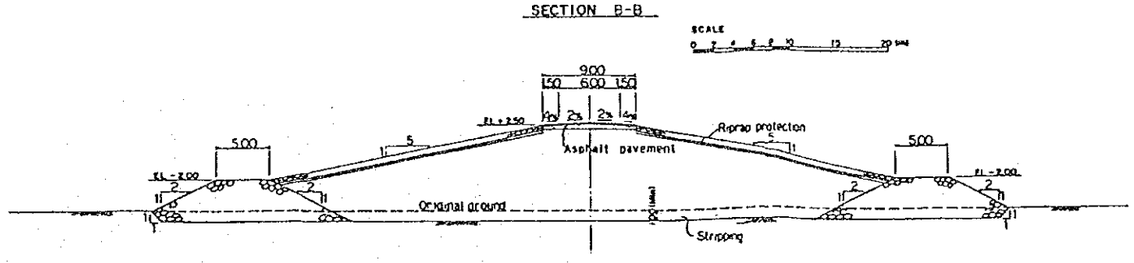


LOWER CLOSURE DAM

LONGITUDINAL SECTION



SECTION B-B



Notes:

(1) This drawing shows the upper closure dam in UTR (Drawing No. BN-01) and lower closure dam in LTR (Drawing No. BN-06), respectively.

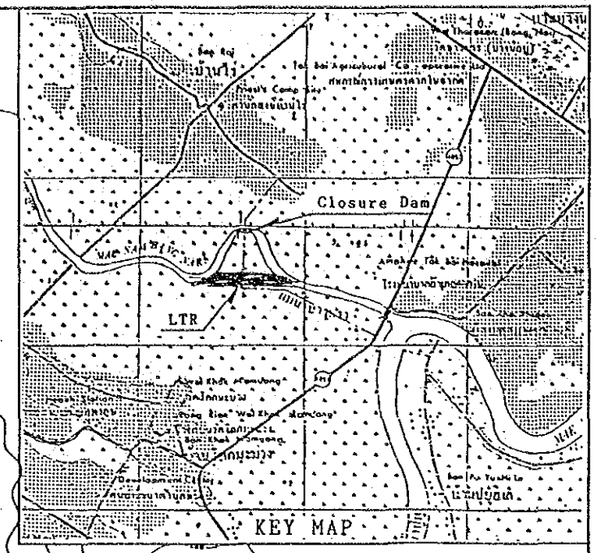
(2) The dam body cross-section is of a gentle slope embankment with 1:5 to realise the stabilization of embankment.

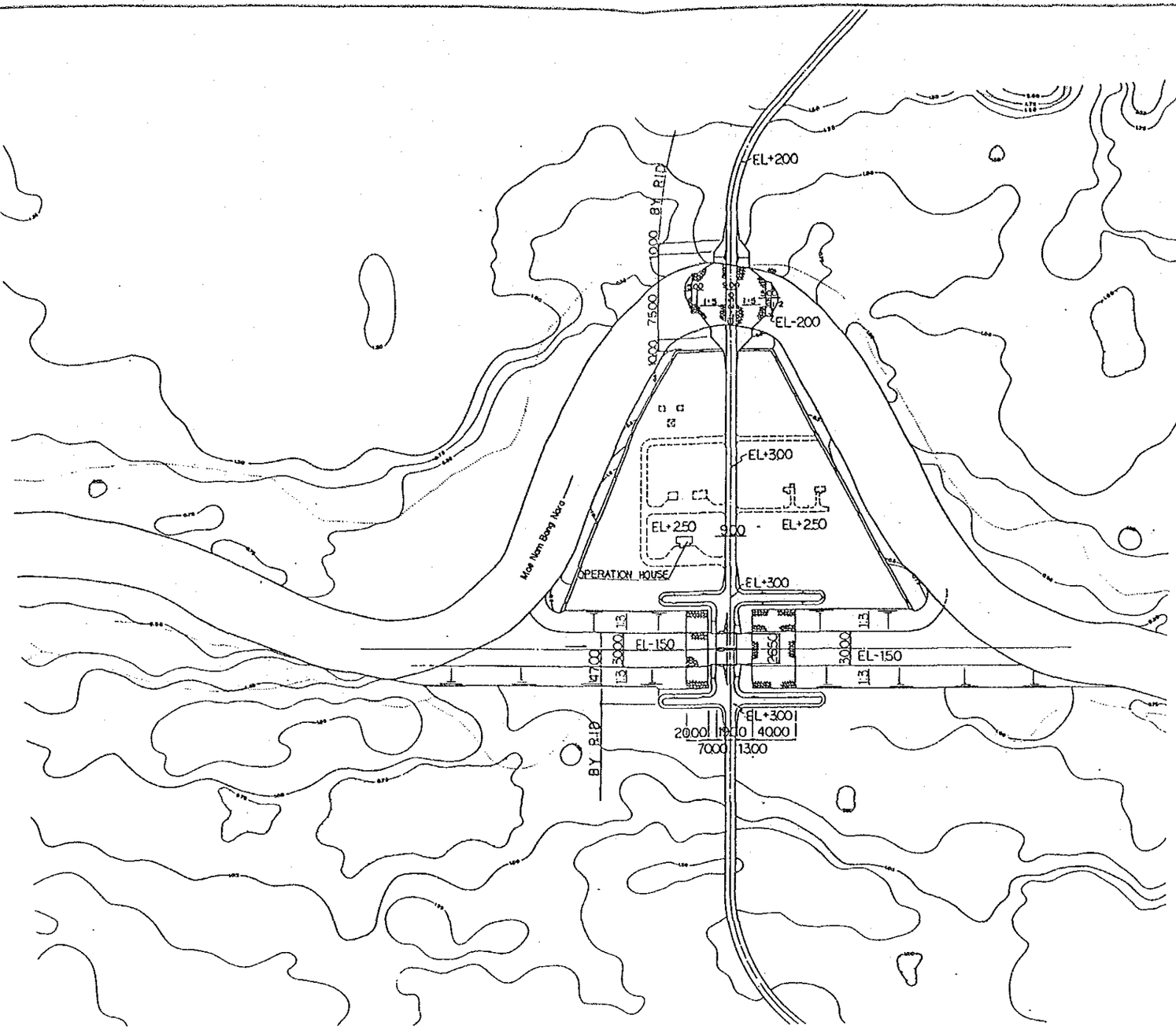
(3) The material of dam body will be transferred from the dredging sandy soil at the excavation of connection canals of upstream and downstream in the regulator body.

(4) All dimensions and elevations are indicated in mm (millimeter).

(5) This drawing is related to Drawing Nos. BN-01 and BN-06.

BASIC DESIGN BANG NARA IRRIGATION AND DRAINAGE PROJECT			
UTR, LTR CLOSURE DAMS			
DRAWING NO.	BN - 05	DATE	
JAPAN INTERNATIONAL COOPERATION AGENCY			





Notes:

A. Scope of Work by Japanese Grant-Aid

The works undertaken by Japanese grant-aid covers the lower tidal regulator and its related structures as follows:

(1) A general plan for lower tidal regulator body is composed of piers, cut-off works, apron and riprap as well as foundation piles.

(2) The movable gate opening width of regulator is designed at 24 m long cooperated with 2 gates, and the water pressure conditions will be worked by both the inside and outside pressures and overflow actions at two leaf gates.

(3) Road bridge will be erected at the downstream side of the pier in relation to the maintenance and operation road to be connected to the existing roads.

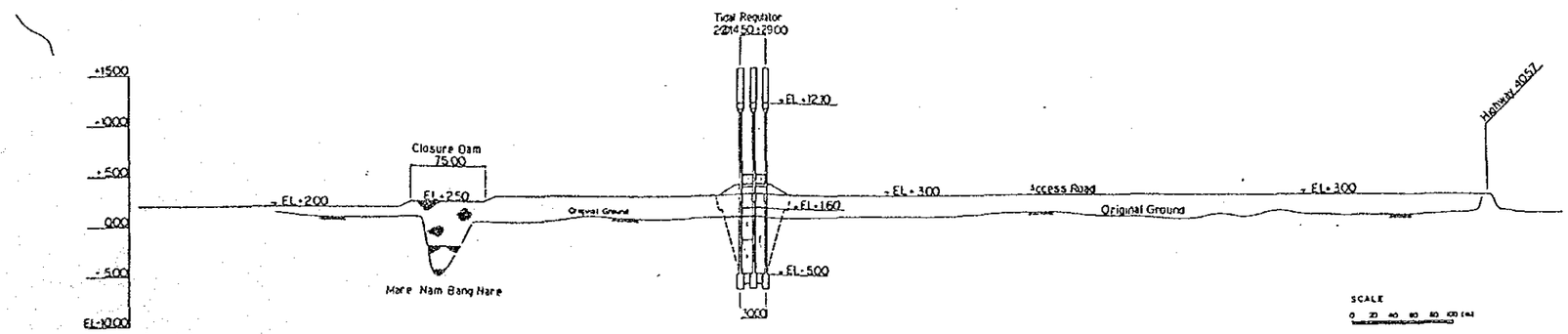
(4) Connection channel will be constructed at the both sides of upstream and downstream connecting to the existing river after completion of the tidal regulator body.

(5) Closure dam in the Bang Nara river will be constructed after completion for the regulator body and connection.

(6) An operation house by means of a remote control room to be provided inside the house for installation of equipment which configurated with a system as remote operation of the gate and communication.

B. Scope of Work by RID

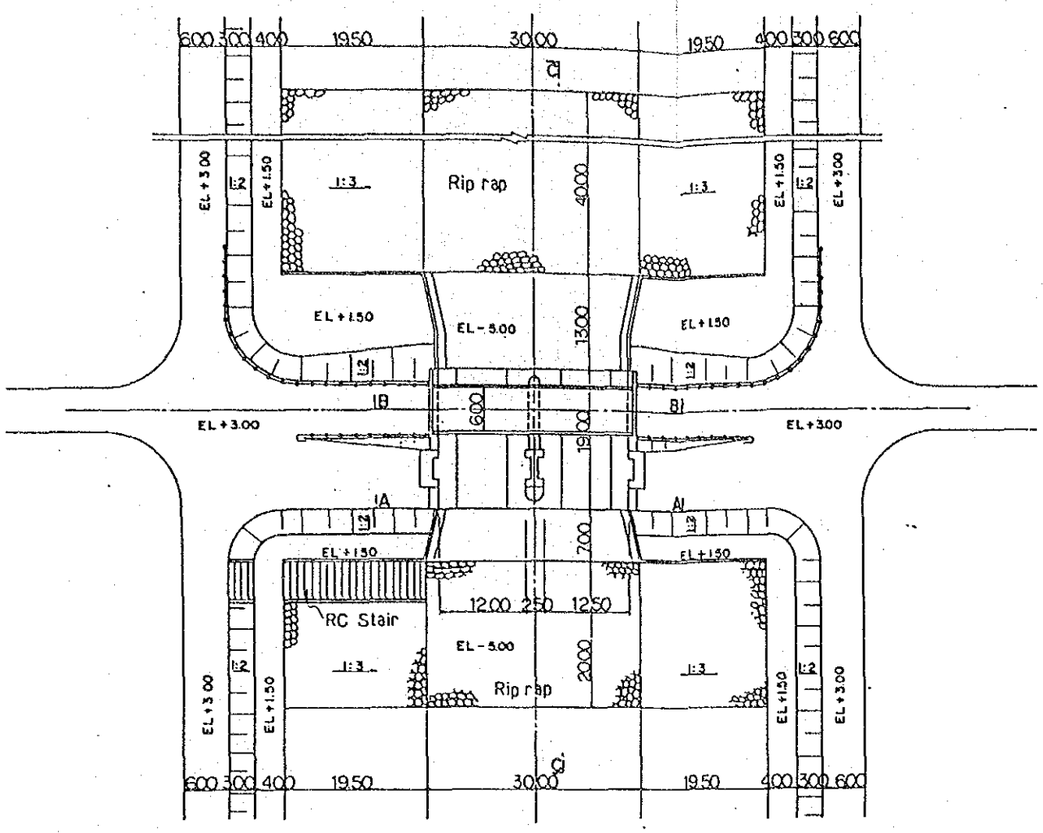
(1) O & M road at the both sides of the Bang Nara river will be constructed by RID; after its construction, O & M road will be connected with the existing roads as shown in the drawing.



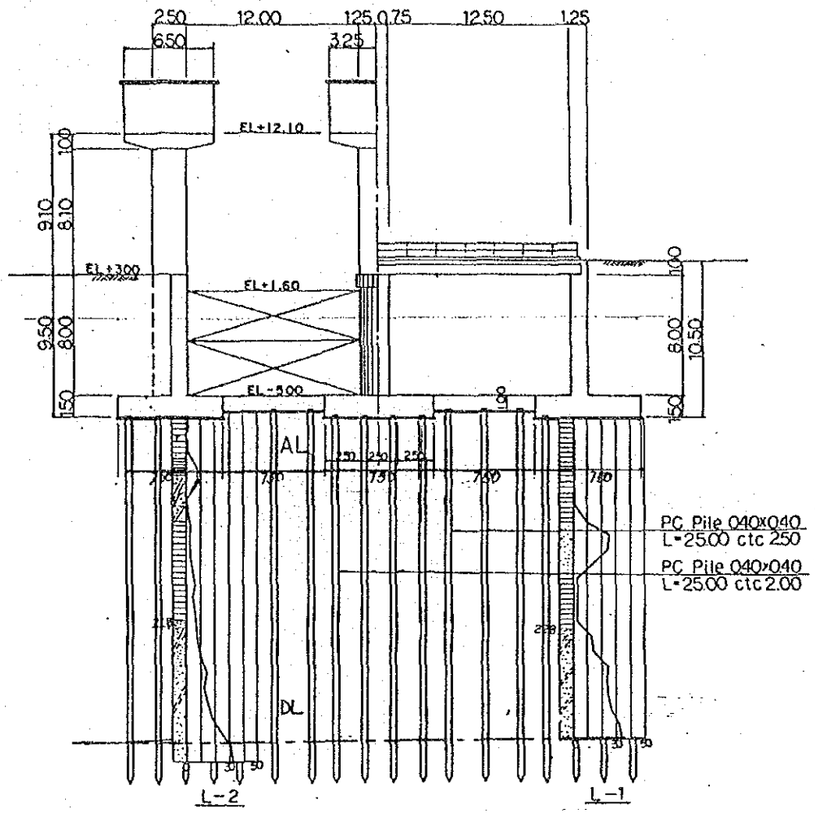
SCALE
0 20 40 60 80 100 150 200 (m)

BASIC DESIGN BANG NARA IRRIGATION AND DRAINAGE PROJECT			
LTR GENERAL PLAN AND PROFILE			
DRAWING NO.	BN - 06	DATE	
JAPAN INTERNATIONAL COOPERATION AGENCY			

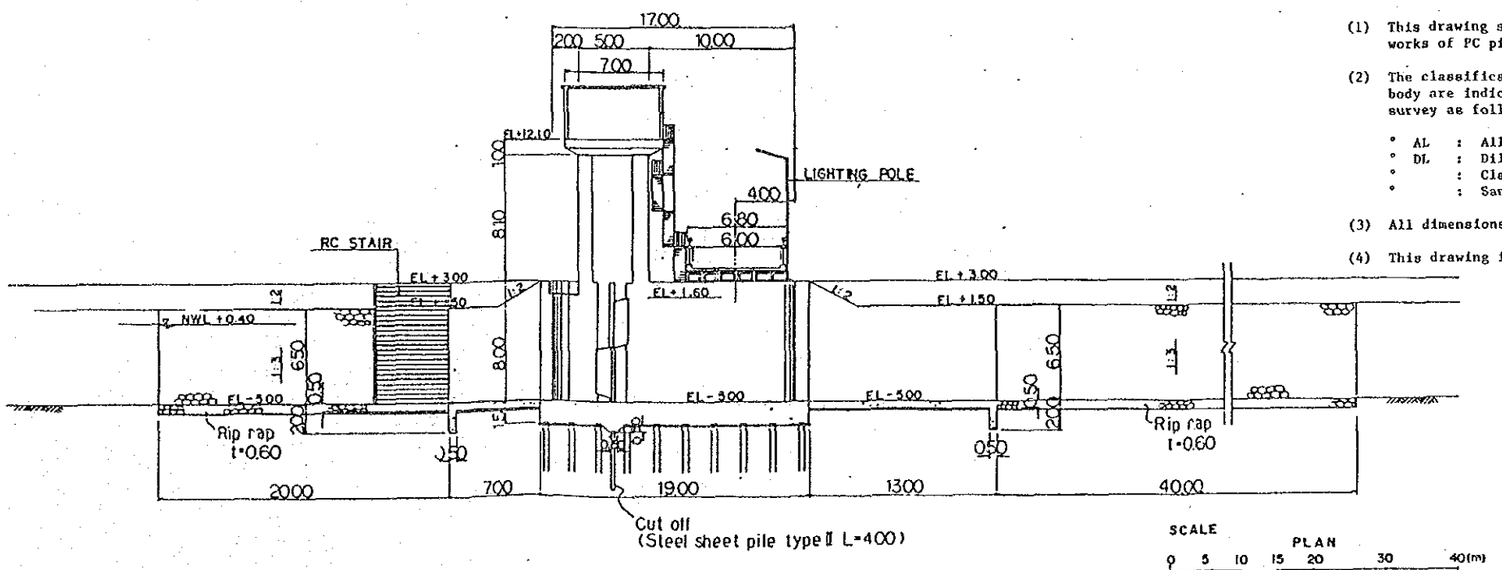
GENERAL PLAN



SECTION A-A SECTION B-B



SECTION C-C



Notes:

(1) This drawing shows the plan and profile of regulator body, including foundation works of PC pile, 0.4 m x 0.4 m, along the sections A-A and B-B.

(2) The classification for geological conditions under the foundation of the regulator body are indicated by the geological symbols obtained from the geological boring survey as follows:

- AL : Alluvium
- DL : Diluvium
- : Clay
- : Sand
- : Silty
- : N-values 30

(3) All dimensions are indicated in mm (millimeter).

(4) This drawing is related to Drawing Nos. BN-06, BN-08.

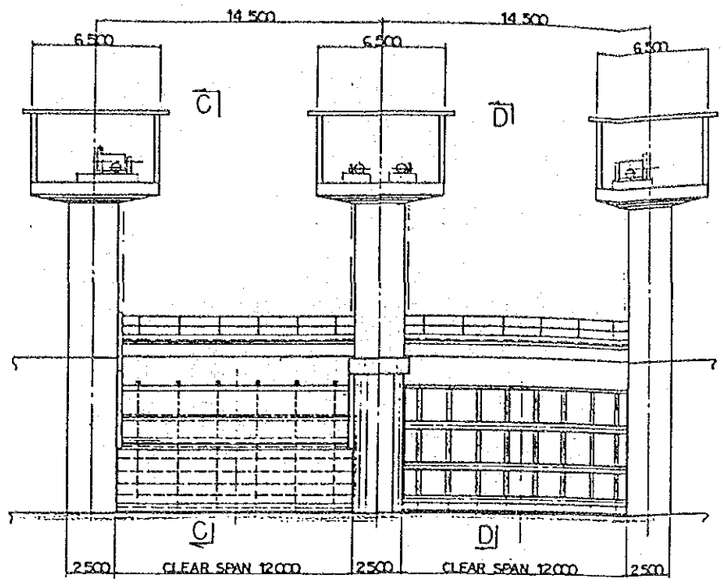
SCALE

PLAN 0 5 10 15 20 30 40(m)

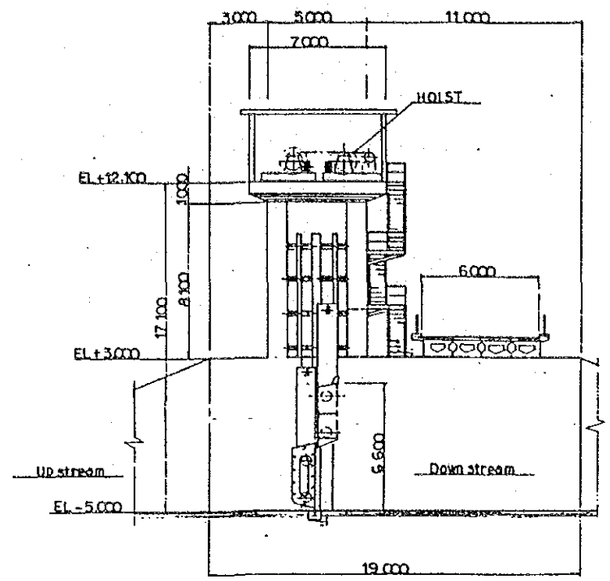
SECTION 0 2 4 6 8 10 15 20(m)

BASIC DESIGN BANG NARA IRRIGATION AND DRAINAGE PROJECT			
LTR PLAN AND PROFILE			
DRAWING NO.	BN - 07	DATE	
JAPAN INTERNATIONAL COOPERATION AGENCY			

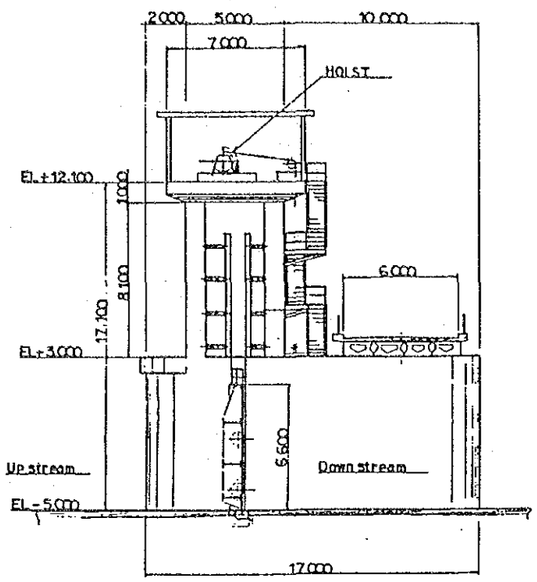
ELEVATION (UP STREAM VIEW)



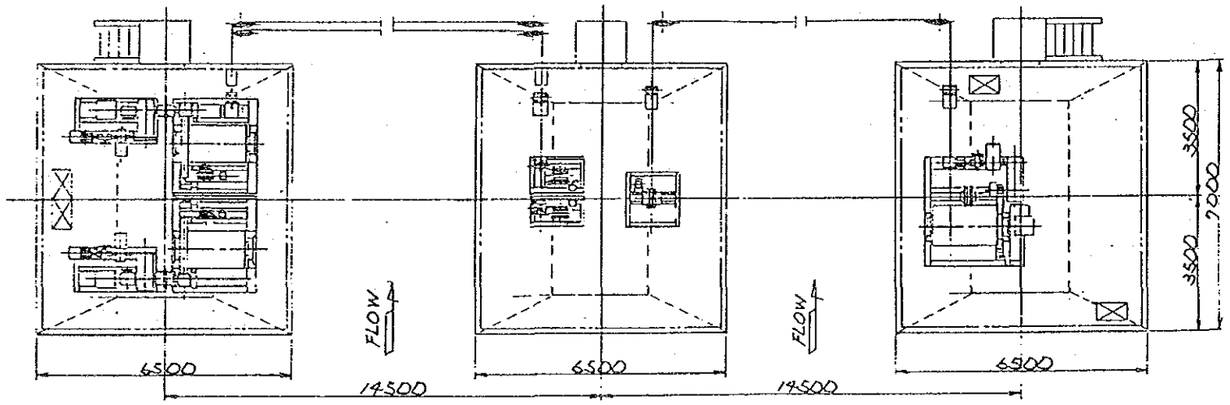
SECTION C - C
2-STAGE GATE



SECTION D - D
1-STAGE GATE

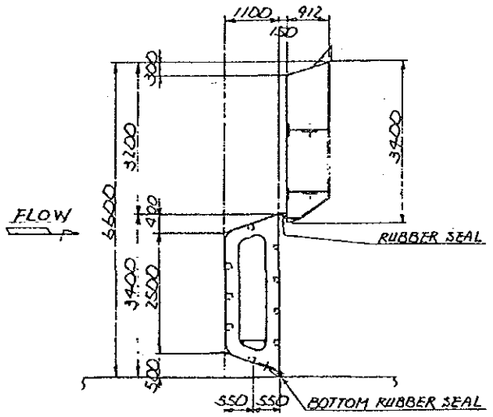


PLAN

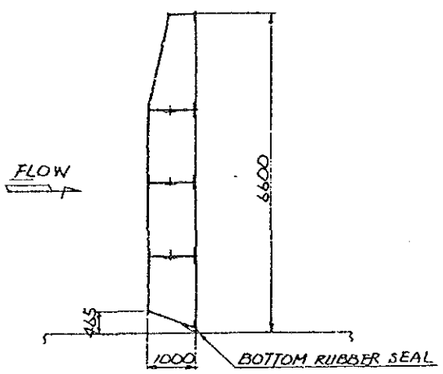


GATE LEAF DETAIL

(2-STAGE GATE)

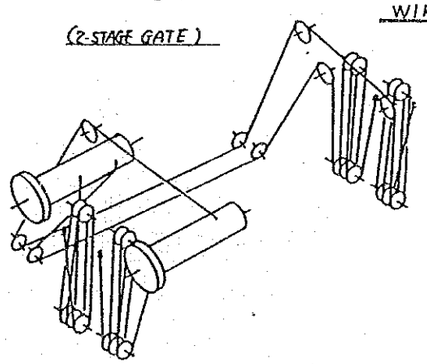


(1-STAGE GATE)

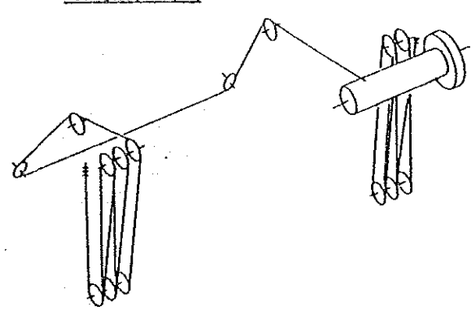


WIRING

(2-STAGE GATE)



(1-STAGE GATE)



Notes:

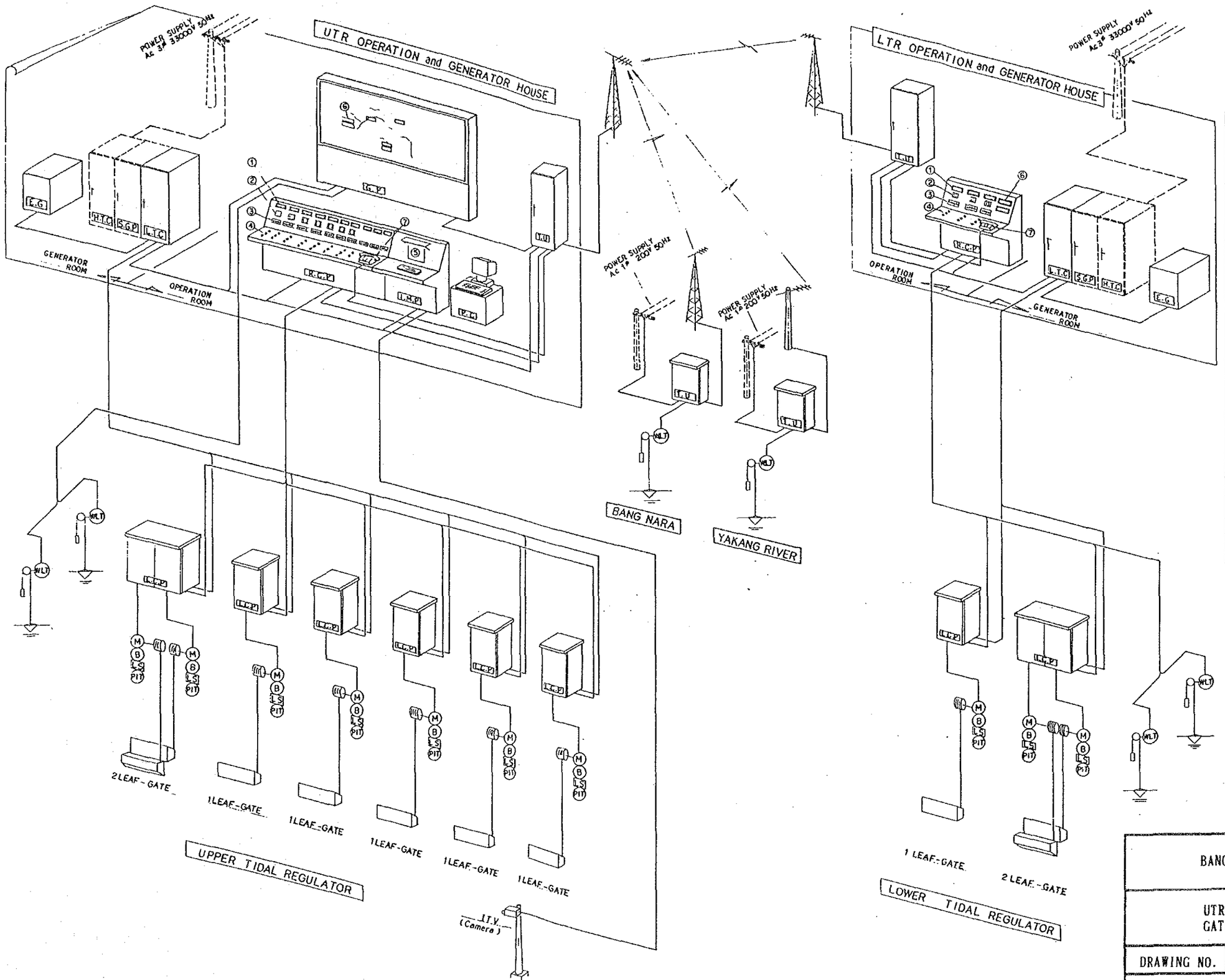
(1) This drawing shows the basic concept of the gate structures and its operation system at LTR, including gate body, wiring system and hoist equipment to be installed on a top of pier.

(2) The gate body consists of two types, as one-leaf gate for flood section and double leaf gate for discharge control section.

(3) Gate hoist machinery is wire rope winch type ones with one electric motor and one wiring drum, in cooperation with the installation of a gate operation panel at nearby hoist machinery.

(4) All dimensions and elevations are indicated in mm (millimeter).

BASIC DESIGN BANG NARA IRRIGATION AND DRAINAGE PROJECT			
LTR OUTLINE OF GATE STRUCTURE			
DRAWING NO.	BN - 08	DATE	
JAPAN INTERNATIONAL COOPERATION AGENCY			



LEGEND

H.T.C	HIGH TENSION CUBICLE
S.G.P	SWITCH GEAR PANEL
L.T.C	LOW TENSION CUBICLE
E.G	EMERGENCY GENERATOR
L.C.P	LOCAL CONTROL PANEL
R.C.P	REMOTE CONTROL PANEL
I.M.P	I T V MONITOR PANEL
G.P	GRAPHIC PANEL
T.U	TELEMETER UNIT
P.C	PERSONAL COMPUTER
M	MOTOR
B	BRAKE
L.S	LIMIT SWITCH
P.I.T	POSITION INDICATOR TRANSMITTER
W.L.T	WATER LEVEL TRANSMITTER
①	POSITION INDICATOR
②	AMMETER
③	INDICATING LAMP
④	PUSH BUTTON
⑤	I T V MONITOR
⑥	WATER LEVEL INDICATOR
⑦	TELEPHONE

—— SCOPE OF GATE CONTRACTOR
---- SCOPE OF OWNER

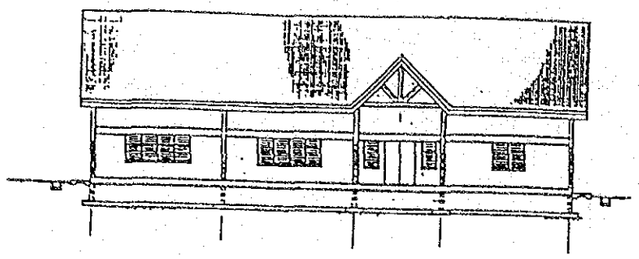
BASIC DESIGN
BANG NARA IRRIGATION AND DRAINAGE PROJECT

UTR, LTR
GATE OPERATION SYSTEM

DRAWING NO.	BN - 09	DATE	

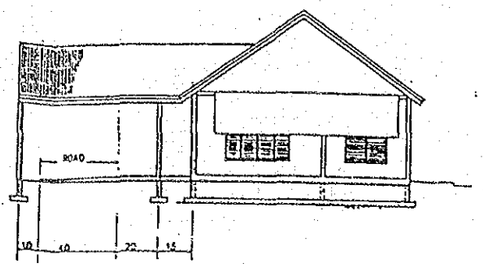
JAPAN INTERNATIONAL COOPERATION AGENCY

UTR



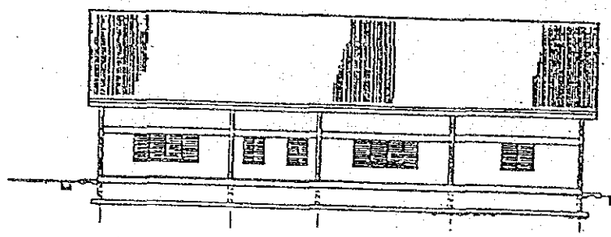
FRONT ELEVATION

SCALE 1:100



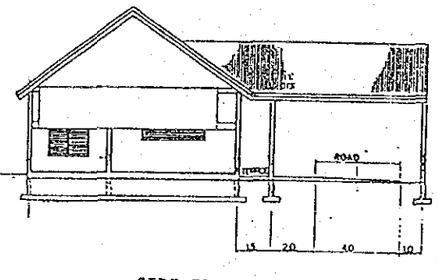
SIDE ELEVATION

SCALE 1:100



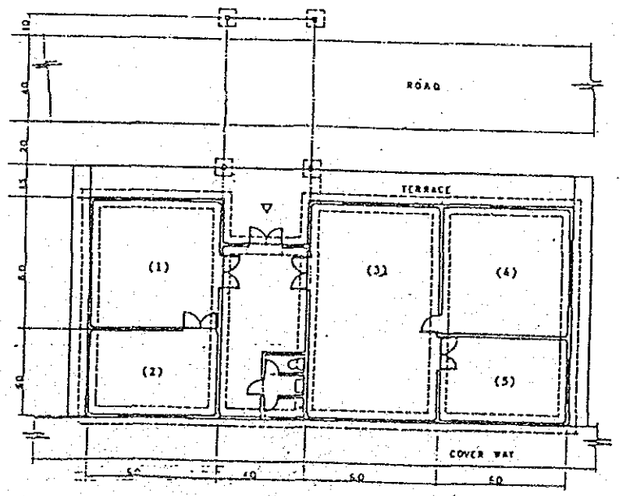
REAR ELEVATION

SCALE 1:100



SIDE ELEVATION

SCALE 1:100

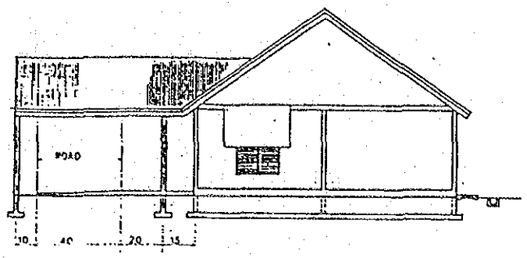


GROUND FLOOR PLAN

SCALE 1:100

Notes:
(1) : Office
(2) : Meeting Room
(3) : Operation Room
(4) : Generator Room
(5) : Reference Room

LTR



SIDE ELEVATION

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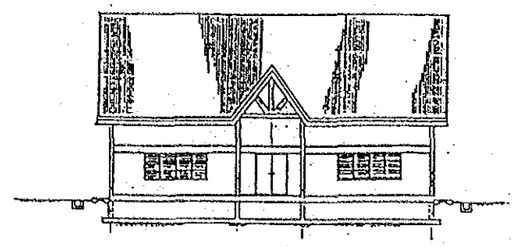
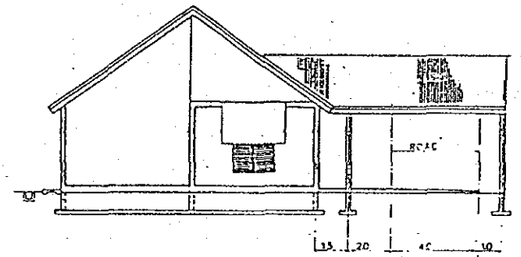


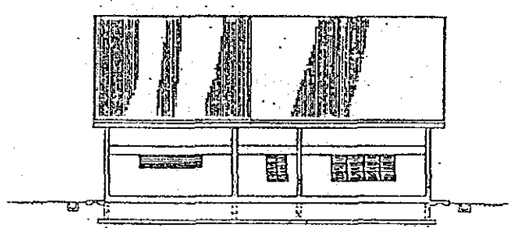
FRONT ELEVATION

SCALE 1:100



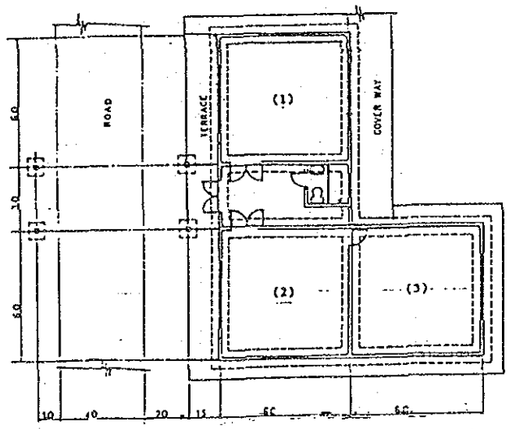
SIDE ELEVATION

SCALE 1:100



REAR ELEVATION

SCALE 1:100



GROUND FLOOR PLAN

SCALE 1:100

Notes:
(1) : Office
(2) : Operation Room
(3) : Generator Room

BASIC DESIGN
BANG NARA IRRIGATION AND DRAINAGE PROJECT

UTR, LTR
OPERATION HOUSES

DRAWING NO. | BN - 10 | DATE

JAPAN INTERNATIONAL COOPERATION AGENCY.

CHAPTER 6. PROJECT IMPLEMENTATION PROGRAMME

CHAPTER 6. PROJECT IMPLEMENTATION PROGRAMME

6-1. Implementing Organization

6-1-1. Project Implementing Body

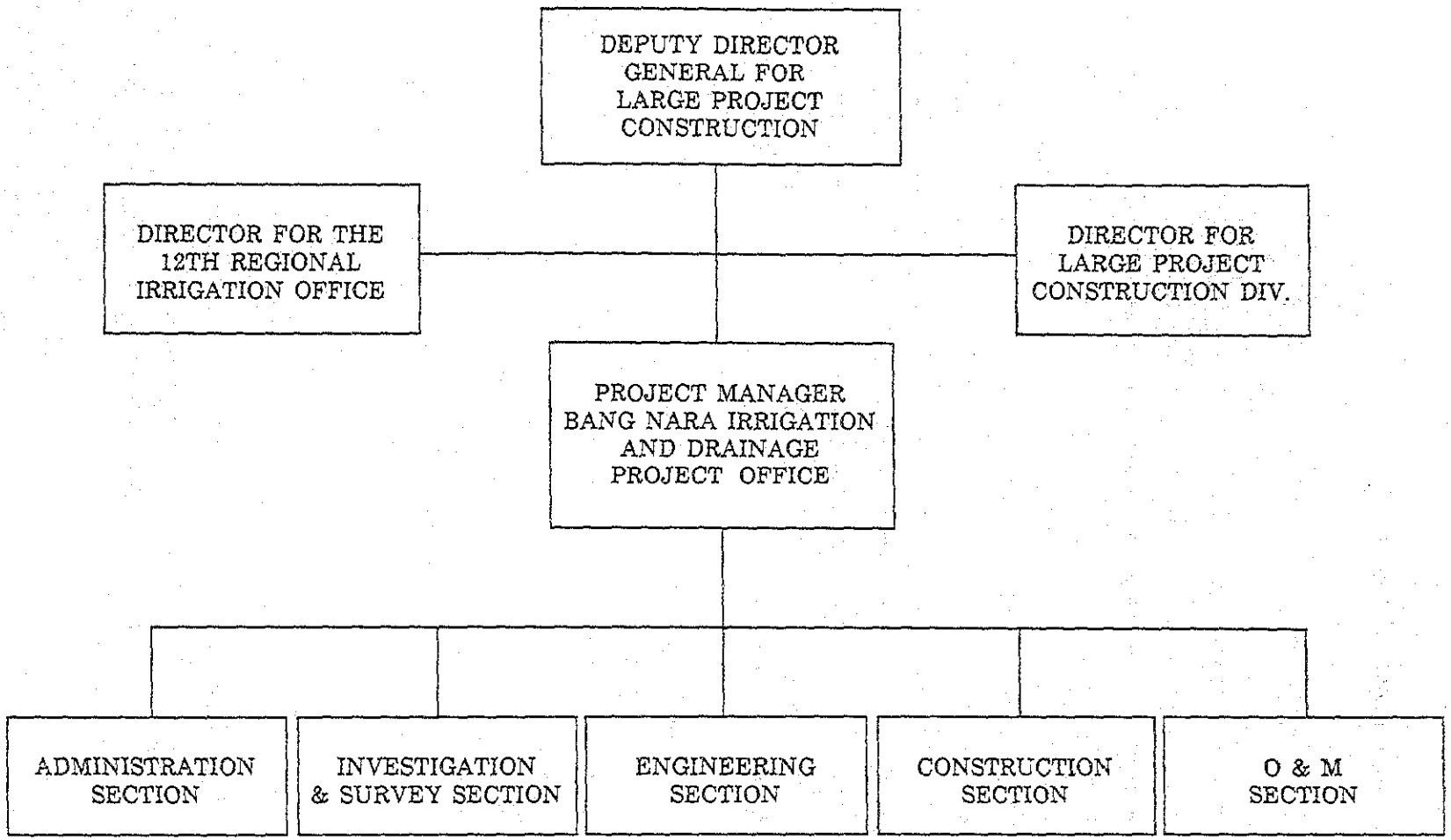
The Executing Agency of the Project Implementation would be the Royal Irrigation Department (RID) of the Ministry of Agriculture and Cooperatives. The Bang Nara Irrigation and Drainage Project Office, as shown in the organization chart in Chapter 4, 4-3, would be newly established at Narathiwat to promote the construction works directly at the project site. The large scale projects have been mainly implemented in cooperation with the foreign contractors, even though many similar projects in Thailand have been undertaken by the local contractors in either the direct management system or the contract system. The RID consists of the planning division, survey division and design division, mechnical engineering division and operation & maintenance division as a technical section.

For the on-going maintenance road construction at UTR, Mu No Project Office adjoining the project site has already managed those works as the representative of the planned new project office in cooperation with the above-mentioned technical sections in the RID. As the matter of fact, the staff of the RID and Mu No Project Office joined the technical field survey as the counterparts in the basic design team. The organization for construction works of the project is shown in Fig. 6-1.

6-1-2. Consultants

The consultants would undertake their works according to the consulting services contract to be made between the RID and consultants after the Exchange of Note for this project between the government of Thailand and Japan.

FIGURE 6-1 ORGANIZATION FOR CONSTRUCTION WORKS OF THE PROJECT



The consulting services would be divided into two stages; namely, the detail design stage and construction supervision stage.

(1) Detail Design Stage

The consulting contract would be made between the RID and the consultants after the Exchange of Note between both governments. The work period in the design stage would be four (4) months being shortened from six (6) months that were estimated in the F/S stage. Expected man-month would be the same as recommended in the F/S stage. Peculiarity to be carefully studied in the detail design of this project would be the poor foundation on which main structures are to be constructed, and in such conditions, the work items have varied such as civil, building, electric, communication, major equipment and so forth. Therefore, the experts who could properly finalize the detail design and necessary Bidding Documents and the specifications shall be required.

The whole works in this stage would be divided into two parts; the detail design works and preparation of the bid documents. The former would cover structural calculation, preparation of detail design drawings, construction planning and construction work schedule, and estimation of construction cost based on the approved and designated standards and conditions. Then the latter includes preparation of bid documents such as instruction to bidders, contract conditions (general and supplemental), technical specifications (general and particular), bill of quantities and bid drawings.

(2) Construction Supervision Stage

The consulting contract, as the same procedure as the former stage, would be made between the RID and the consultants after the Exchange of Note between both governments. The scope of works would consist of bidding works to select the most appropriate Japanese contractor that would undertake the construction of the tidal regulator, and

construction supervision during the construction work period. The work period and man-month would be almost the same as recommended in the F/S stage.

As mentioned above, whole works in this stage would be divided into two parts; namely, the pre-construction stage and the construction supervision stage. The first part covers invitation for bids, receiving questions and response by written form, and to attend the bidding conference. After opening of bids, then the consultants shall study the bids and prepare the evaluation reports in which technical evaluation shall be carefully made by detailed comparative study considering the bid price for the civil works and for installation of gates and other related equipment and facilities. On the other hand, the second part would be further divided into two; called, general construction supervision and site construction supervision. The general supervisors would stay at the office beside the site supervisors would stay at the site. They shall undertake the supervision of the civil works, manufacturing and installation of the gates and related equipments and facilities, check and approval of the documents concerning specifications, site tests, etc., and quality control of the construction works. Moreover, they shall conduct the preparation of monthly report, preparation of the O/M manuals, and operation training of the gates.

6-1-3. Contractors

Japanese contractor would conduct, after successful bidding and necessary procedure, the construction works and procurement of the required equipments under the grant-aid of this project. The construction of the tidal regulators and equipment to be granted under the grant-aid have been described in Chapter 4. The scope of the construction of the tidal regulator are as follows: civil works of the UTR and LTR, installation works of the gates and related equipment, conducting the various kinds of operation tests under presence of the persons concerned after completion of the construction works, and then to hand over to the RID. However, those equipment and facilities would

be finally accepted by the RID only after expiration of guarantee period.

On the other hand, the scope of procurement of the equipment, according to the specifications as the same as the above, would be to supply the equipment, then to transport up to the designated place where to be handed over. This contract would also be terminated after expiration of guarantee period.

6-2. Construction Planning

6-2-1. General

(1) Notes for implementation

The tidal regulator works are mainly divided into two kinds of works; namely, civil works at the sites as well as manufacturing, and installation works for the main gate body and related mechanical and electrical devices. The former will be carried out by Japanese contractor in cooperation with local sub-contractor. They will perform the works, involving local construction materials (cement, reinforcing bar, sand and aggregate) and equipment to be procured from near site and/or Bangkok. The local contractors must be a competent contractor and also experienced in similar irrigation project.

The latter works will be carried out at factories in Japan, such as material procurement, manufacturing and various tests due to complicated system among the mechanical and electrical equipment as well as data-transmission and measuring devices. The erection works at the sites will be carried out in cooperation with the local sub-contractors, however, a part of the major job at the site is to be immediately carried out by the Japanese engineers.

(2) Construction period

Major parts of the construction works are the tidal regulator and closure dam to be constructed on the soft foundation, and main works are the concrete work of the gate body, foundation work, earth work, dredging work of the channel, and manufacture and installation of the gates. Dredging would be used for the embankment material of the closure dam. These works shall be executed during the construction supervision.

The construction period would be two (2) years, however, the earth work may not be undertaken during four(4)-month rainy season. The civil work contract with the contractors is to be concluded two (2) months prior to the last month of the rainy season, when the construction works are to be commenced.

(3) Working time and others

- Working hour and day: 8 hours/day, 40 hrs/week, 5 days/week = 22 days/month
- National holiday: 18 days/year
- Labour accident compensation in Thailand has been classified into some ranks and would be applied to the project
- Emergency facilities: Narathiwat Central Hospital (General hospital under management of the local government) has surgical department, internal department, opthalmology department, dental department, dermatology department, etc. and 19 wards with 360 beds. Injured persons at the construction site could be possibly sent directly to the hospital as the distance between the project site and the hospital is only 5 kms. However, some emergency facilities are still to be supplied at both UTR and LTR.

6-2-2. Construction Work Schedule

(1) UTR

1) Temporary facilities and mobilization of construction machinery

a) Contractor's camp

The contractor's camp would be established in the area of 5,000 m^2 located on the hill at 400 m northeast from the tidal regulator site. The camp would include an administration house, accommodation facilities for office staff and labours, water supply facilities and relative facilities.

b) Concrete batching plant, motor pool, reinforcing bar working place and repairing workshop would be supplied in the area of 5,000 m^2 located beside the Bang Nara river right bank at 200 m south from the tidal regulator.

c) The construction machinery such as heavy machinery and general construction machinery would be mobilized from Bangkok and Changwat Narathiwat to the project site by trailers or trucks.

d) Sand, aggregate and stone would be obtained from the following places:

° Sand -- to be carried in from the borrow pit located beside the Yakkang River at 11 kms southwest from UTR.
° Aggregate -- Yala limestone would be utilized. Haul distance would be around 120 kms.
° Riprap stone -- to be carried in from the granite quarry site located at 3 kms from UTR.

2) Foundation works

Foundation excavation for the gate structure would start after the clearing and stumping works. Backhoes and dump trucks would be used for the first step excavation, then steel sheet piles would be driven in combination with further excavation and operation of well point by which the ground water table would be lowered. In this case, the excavation by machinery would be done until 30 cms above the planned final line, then the remaining would be excavated by labours. Then, the steel sheet piles would be driven by vibrating pile driver up to the designated level. After that, PC piles, which are to be manufactured at the PC pile factory at Songkhla, would be driven up to the designated bearing layer, then pile top finishing would be conducted. The well point method would be introduced for the dewatering work since K-value (coefficient of water permeability) of the sandy soil at the site, where is at only around 100 m distance from the river, is 8×10^{-3} cm/s, and to prevent from rising up the ground water table during the rainy season. The stone pitching would also be constructed on the slope to prevent the slope failure caused by heavy rainfall. Rain water would be collected through the drainage ditch constructed along the slope end, then drained by pumps.

3) Concrete Work of Pier and Apron

It is an important point for concrete work after earth foundation to complete concrete foundation, apron, and pier higher than the ground level before the succeeding rainy season. Consequently, concrete plant shall be prepared to fulfill the needs for these schedule. Concrete shall be carried to the site by agitator cars, and be put into a work through buckets of crawler crane, then be stabilized by vibrator.

4) Bridge

Bridge components shall be adopted ready-made box PC products by a factory in Songkhla. The bridge components shall be carried to the site by trailer trucks from the factory. As the component weighs 28 tons a piece, it is advisable to use truck crane in balanced lifting method. In addition, the road shall be paved with concrete.

5) Riprap and Rivetment

Rip rap shall be founded by concrete frames filled with rubble and broken stone, then be filled-up with concrete. On the other hand, rivetment shall be pitched in dry masonry after excavation and slope finishing.

6) Architecture

The site operation shed shall be completed after installation of gate operation devices and hoists. The remote operating shed shall be finished with reinforced concrete and brick wall, following the RID specifications. These shed shall be constructed in the order of foundation, columns, wall, roof, and interior/exterior.

7) Gate and Related Facilities

It is estimated eight (8) months to prepare/manufacture the relating machinery, such as the gates, motors, operating facilities, electric devices, etc. On the other hand, it needs two (2) months for marine transportaion between Japan and Thailand, customs clearance, and inland transportation. In addition, installation period at the site is six (6) months. Thus, it needs totally at least sixteen (16) months by test operation and transfer.

It is necessitated to consider safe and rational inland transportation/supervision taking into account of the maximum part weight of gates. Supervision of gate manufacturing, inspection, transportation, installation and test shall be undertaken in obedienct to the following procedure.

a) Manufacturing

Manufacturing of the gates and the related facilities shall be started after approval on the drawings and specifications. Each fastening shall generally be welded. Larger block parts are recommended considering transportation and installation. Welding shall follow the specifications and guideline which considers prevention of distortion/local stress. All surfaces of machinery except stainless surface, embedded surface under concrete, and mechanical finished surface shall be painted. Painting shall be started after approval on painting manual which is made following the specifications. Gates shall be painted under close supervision.

b) Inspection

Inspection shall follow the specifications and the following standards.

- Japanese Industrial Standard (JIS)
- Japan Electro-technical Committee (JEC)
- Japan Electric Mahine Industry Association (JEM)

Inspection plan and Inspection manual shall be submitted and approved, in advance. The following items shall be inspected by the RID.

- Inspection on materials
- Inspection on welding
- Inspection on temporary assembling
- Inspection on performance

c) Transportation

Packing of parts/blocks of the gates shall well be protected and reinforced for prevention of deformation and damage on the parts/blocks, taking into consideration of road conditions and local equipment in Thailand. Each part/block shall be coded for efficient work scheduling in Thailand.

d) Installation

Installation of both UTR and LTR shall follow below mentioned guidelines.

Gate Sheet :

- Bottom gate sheet shall be filled on bottom slot using protruded reinforcing steel bars for additional concrete and additional reinforcing steel bars, then secondary concrete shall be filled to embed the gate sheet.
- Side gate sheets shall be bolted on both ends of the bottom gate sheet, then side gate sheets shall be fixed on side slots using protruded additional reinforcing steel bars. Secondary concrete shall be filled to embed the gate sheets succeedingly.

Gate Leaf :

- Temporary pedestal shall be prepared on concrete slag.
- On-stage gate shall be lifted onto the temporary pedestal in the order of side block (in slot), lower middle block, upper middle block. Welding shall be done in sequence of assembling.
- Two-stage gate shall be started from the upper leaf. After assembling of the upper leaf, it shall be hoisted upto upper end, then the lower leaf shall be assembled.
- After inspection of welding, painting and assembling of water-tight rubber seal shall be fixed.

Hoist :

- Hoist shall be assembled all parts on chassis in factory. Hoist shall be lifted onto floor anchor of machine room using truck crane.
- Wiring between installed hoist and operating panel shall be done.
- Hoist shall be driven to wind up wirerope into gate leaves using temporary power source.
- After completion of assembling of gate leaves, water-tight rubber seal and limit switches shall be adjusted.
- Final test shall be done by remote operation after installation of the regular power source.
- Sheds of machine rooms shall be completed after installation of the hoists.

e) Inspection at the site

The following items shall be checked at the site.

- Check on size
- Check on welding

Also, the following test operation shall be done after confirmation of functions of gate leaves.

- Check on electric equipment
- Check on each function
- Test operation
- Other necessary checks/tests, if any.

Final inspection shall be held after test operation and adjustment. Construction is completed after approval by the RID and the Consultants.

8) Access Channel and Closure Dam

Rubber for closure dam shall be carried from quarry by barge to the site, then clamshell on platform shall put rubber into the necessitated points. Dredged soil is used for banking, and broken stone is used for slope protection compacted by bulldozer on both sides of the bank.

(2) Lower Tidal Gate

1) Foundation

Construction site has paddy fields, thus direct excavation of foundation is available. Soil type is silty-clay. Lenz-formed fine sand layer which is under pressure of confined aquifer lies on pier foundation surface. Considering condition of the clay, excavated slope shall have gentle slope, more than 1:2-3, for prevention of slope destruction.

Wet excavation is sheathed with H-piles and wooden sheet piles. Shalllow sump is adopted for drainage. Sand mats are laid above final ground level of foundation excavation.

2) Pier, Apron, and Other Constructions

Schedule of superstructure work which successes foundation work of LTR is similar to UTR schedule. Accordingly, almost the same equipment is availabe. Nevertheless, as construction period is limited, concrete batcher plant is needed not only for UTR but also for LTR. As for work schedule of heavy equipment, work schedule of UTR is taken into consideration.

Also, manufacturing, transportation, and installation of gates and related facilities of LTR are scheduled under consideration of UTR. Especially, schedule on dredger shall be as follows.

a) Dredger shall be carried in from the Narahiwat River mouth
b) Dredging of access channel at the Bang Nara River side, dredging of closure dam bottom, and dredging of access channel at seaside
c) Dredger shall move to UTR site through the Gulf of Thailand
d) Dredging of access channel at the Bang Nara River side, dredging of closure dam bottom, and dredging of access channel at the Kolok River side
e) Dredger shall be carried out to the sea through the Kolok River

6-3. Project Allotment

According to the guideline of Japanese grant-aid program, the coverage of Japanese grant-aid program on Tidal Regulator Construction and Equipment for the Bang Nara Irrigation and Drainage Project is confirmed by F/S in April, 1987.

And, further examination is made on grant schedule, its fundamental items, namely facility design and cost estimation, is shown in Chapter 5. Hereat, other project allotment between the nations are shown as follows.

6-3-1. Allotment of the Kingdom of Thailand

(1) General Item

1) Measure on tax exemption on unloading of the project related equipment at Bangkok
2) Safety assurance and smooth imigration/emigration procedure, etc. for the project related Japanese staff
3) Payment of bank commision

(2) Particular Item

1) Construction of pumping station, irrigatino/drainage canal, counter measure facilities against acid water, other pump equipment, and appurtenant structures. (These are excluded from Japanese grant-aid program.)
2) Land securing for construction of the Tidal regulator
3) Construction of power cable to the project site from existing power line
4) Construction of water supply pipeline for maintenance to the project site from existing water supply pipeline
5) Maintenance of completed facilities

6-3-2. Construction Work Alloted to the Japanese Side

(1) Construction of Tidal Regulators

1) Main body, gates and their related facilities
2) Closure dam
3) Access road
4) Gate operation office

(2) Procurement of Equipment and Materials

1) Survey Instrument
2) Concrete Test Instrument
3) Maintenance Equipment

(3) Consultancy Services

1) Detailed designing and preparation of detail drawing on the tide gate and its related equipment and materials
2) Preparation of tender documents (instruction to tenders, condition of contract (general and particular), specifications (general and particular), bill of quantities without unit price, programme and drawings)

3) Proxy for tendering and evaluation of tenderers
4) Witness and advice for negotiation, preparation of draft contract documents
5) Supervision of project implementation
6) Preparation and training of operation manual for the Bang Nara reservoir.

6-4. Procurement Schedule

The materials and equipment to be procured in this project are supplied by Japanese contractor on the basis of the materials produced in Japan and Thailand in compliance with the specifications prepared by the consultants. However, the materials required for the civil works are mainly procured in Thailand and the main body of gates and its related mechanical and electrical equipment are procured from Japan, including manufacturing, testing and transportation as well as installation works at the site. The outline of procurement schedule is as below.

(1) Construction equipment and Civil work's materials

As for the construction equipment, all equipment which are available in Thailand will be procured as mentioned in the construction planning, however, a dredger will be procured from Singapore since there is no dredger available in Thailand. All materials required for the civil works will be procured in Thailand, including cement, reinforcing bar, concrete aggregates, wood as well as materials for temporary construction works.

(2) Gate body and related devices

The main body of gate and mechanical and electrical equipment (gate, hoist, operation equipment, monitoring, computation, data-transmission and generator) will be procured after completion of various procedures (assemble, manufacturing, temporary erection, test and

packing) in Japan. These devices will be transported to Bangkok by ocean freight and then to site (about 1,200 km) by trailer.

6-5. Project Cost

(1) The project cost is roughly estimated at million yen in total.

(2) Government of Thailand

°	Construction of O & M road	:	10.2 Million ฿
°	Erection of Power and Water supply lines	:	3.1 "
°	Construction of Sa Pi Yo clousure dam	:	3.0 "
°	Land compensation	:	28.5 "
	Total		44.8 Million ฿

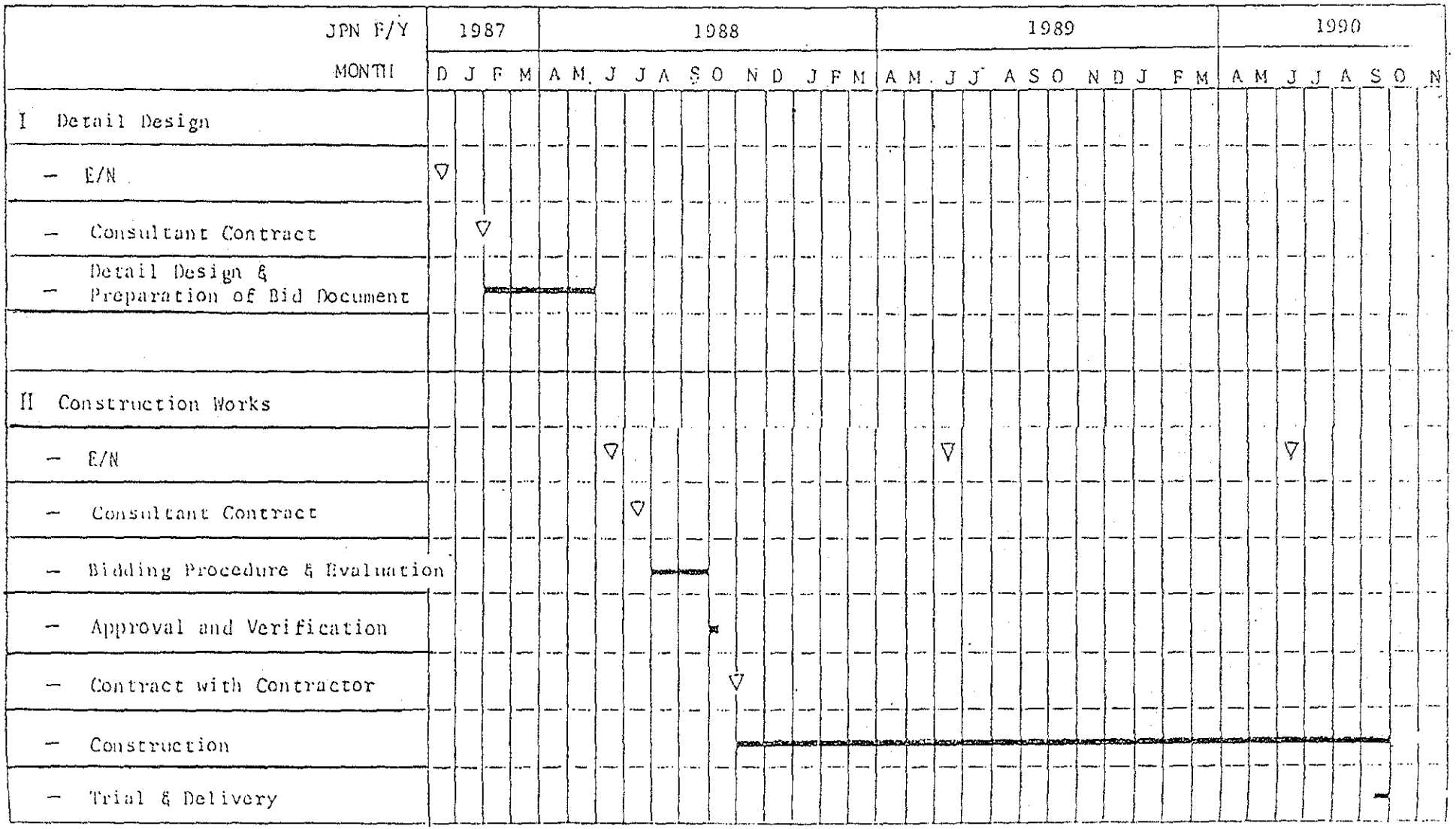
6-6. Project Implementation Schedule

Implementation of this project will commence after Exchange of Note (E/N) for grant-aid is signed between the Government of Japan and the Government of Thailand.

(1) Detailed Design

RID, an implementation agency of this project, will prepare the contract for detailed design with a consultant who bears Japanese nationality. The prospective consultant will undertake the detailed design and prepare tender documents for both construction work and procurement of equipment and materials.

FIGURE 6-2. IMPLEMENTATION SCHEDULE



(2) Tendering

RID will make a contract for tendering and supervising the construction work with a consultant who bears Japanese nationality soon after the Exchange of Note is signed. The prospective consultant will recommend the successful tender to RID, witness and advise to negitiation and contract. The construction contract will be enforced after approval of the Japanese government (JICA executes as proxy).

(3) Construction works

Contractor will commence main construction works followed by temporary works after the construction contract is enforced. The construction period will be 23 months after the contract is signed. Equipment and material will be furnished during the period of 23 months.

(4) Test operation and hand-over

Of the contracted construction period (23 months), a half of the last month will be spent to test operation of tide gate. Operation procedure of gates and their control equipment is explained to the Kingdom of Thailand. The tide gate will be handed over to the Kingdom of Thailand after operation test and final inspection is completed.

6-7. Operation and Maintenance Plan

6-7-1. Operation and Maintenance System

(1) Personnel

The whole facilities and their equipment and materials will be handed over to the Kingdom of Thailand after tidal regulators construction is completed. The Kingdom of Thailand will bear full responsibility for maintaining and operating those facilities. The Bang Nara maintenance office under the control of the regional irrigation office will actually perform operation and maintenance works.

(2) Monitoring System

Monitoring works will be done in the following three periods throughout the year:

- Dry period (mid-February - mid-June) ----- 8 hours monitoring
- Rainy period (mid-June - mid-October) --- 16 hours
- Flood period (mid-October - mid-February) --- 24 hours

In due consideration that a civil servant in Thailand normally works for 8 hours, monitoring personnel will be divided into a few groups and work in two or three working shifts.

(3) O & M Services

The tidal regulators will be composed with the multiple devices, including civil, machine, electricity, data-transmission, communication and computation/recording. The detailed O & M services for those devices will be conducted by the equipment supplier's to be prepared the specifications in relation to the monitorship in the following activities of the tidal regulators.

- Water level at upstream and downstream of the tide gate
- Opening of gate
- Performance of gate
- Overflow (by ITV)
- Water level in the Yakang (x 73)
- Water level in the Bang Nara (x 162)

The above-mentioned items will be monitored. Referring to pH, EC value measured once a day, the gate will be operated by using the gate operation manual, and measured values (water level, pH, EC, etc.) and released volume of water from each tide gate will be recorded.

6-7-2. Operation and Maintenance Cost

Operation and maintenance cost will be estimated at the time of cost estimate excluding price escalation.

1)	Personnel expenses	1,400
2)	O/M cost for gate and its control equipment	111
3)	O/M cost for vehicles	1,800
4)	General and administrative expenses	290
	Total	3,601 ฿/year