9.6.2 DETAILS OF BOTTOM OUTLET FACILITIES

One (1) set of Howel-bunger valve of 2.5 m diameter will be provided at the end of the end of the plug in the diversion Tunnel No.2. This size valve is considered to be the largest size to be possibly placed in a 9.2 m diameter tunnel.

The rating curve for the relationship between the reservoir water level and the discharge capacity of the valve is shown on Figure 9.6.1. As seen, up to a certain elevation the outlet capacity is controlled by the inflow capacity of the inlet tower. The valve has a discharge capacity similar to the basin average run-off and is sufficient to control reservoir water level and release riparian flow to downstream.

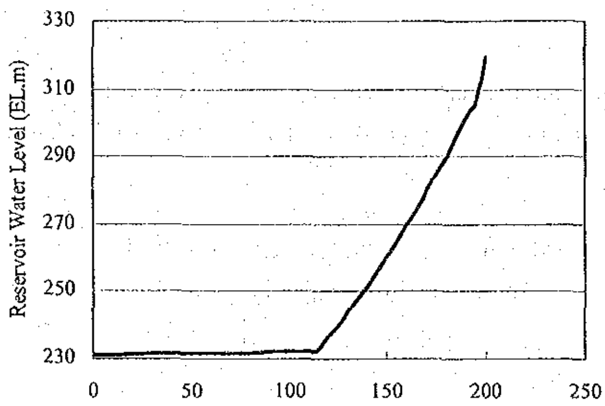


Figure 9.6.1 Rating Curve for Bottom Outlet Discharge

The required length of plug in the diversion tunnels is obtained at 45 m, assuming a safety factor for shear friction of 4.0. In addition to the Howel-bunger valve, one (1) set of emergency gate will be also provided.

9.7 INTAKE STRUCTURE AND POWER WATERWAY

9.7.1 GENERAL ARRANGEMENT

Power intakes, intake gate shafts, headrace tunnels, surge tanks and penstocks are located on the right abutment of the main dam.

The layout of these structures allows for the possibility of future extension of installed capacity from the initial 260 MW (16-hour peak) to 520 MW (8-hour peak), as the layout is shown on DWG.27. The intake structure and power waterway which is located on the mountain side is for the initial 260 MW while provision for expansion will be laid on the riverside.

Geometrical characteristics of the intake structure and power waterway are as follows:

- Inlet Sill Level: EL.263 m
- Length of Headrace Tunnel: 504 m
- Diameter of Headrace Tunnel: 9 m
- Surge Tank Diameter 12 m
- Surge Tank Shaft Height: 45 m
- Penstock Tunnel Length: 50 m
- Open Penstock Length: 243 m (horizontal)
- Penstock Diameter: 8.0 m (1 lane) and 6.4 to 4.0 m (2 lanes)
- Penstock End Level: EL.177.5 m

9.7.2 OPTIMUM WATERWAY PLAN

(1) Optimum Headrace Tunnel Diameter

Optimum diameter of the headrace tunnel is obtained through comparison of the sum of present value of construction cost for the headrace tunnel and power intake, maintenance cost and energy loss for alternative diameters ranging from 8.6 m to 9.4 m. Table 9.7.1 illustrates results of the comparison, which shows the lowest cost is for a diameter of 9.0 m.

Table 9.7.1 Comparison of Headrace Tunnel Diameter

Item	Unit	Alternative Diameter				
Diameter of Headrace Tunnel	m	8.6	8.8	9.0	9.2	9.4
Present Value of Cost	1,000 US$	6,861	7,116	7,288	7,629	7,894
Present Value of Energy Loss	1,000 US$	3,624	3,248	2,918	2,624	2,371
Total of Present Value	1,000 US$	10,485	10,364	10,206	10,253	10,265

(2) Optimum Penstock Diameter and Closing Time

Combination of optimum diameter of the penstock and closing time is obtained through comparison of the sum of present value of construction cost for penstock, turbine and generator, maintenance cost and energy loss for the alternative average diameters ranging from 5.2 m to 6.0 m and closing time ranging 5 sec and 7 sec. Table 9.7.2 illustrates results of the comparison, which shows the lowest cost for the diameter of 5.6 m with closing time of 6 sec.

Table 9.7.2 Comparison of Penstock Diameter and Closing Time

Item	Unit	Alternative Diameter				
Diameter of Penstock (in average)	m	5.2	5.4	5.6	5.8	6.0
Closing Time	sec	5	5	5	5	5
Pressure Rise	%	28.0	25.7	23.7	22.0	20.4
Present Value of Cost	1,000 US$	34,964	35,507	36,187	36,740	37,450
Present Value of Energy Loss	1,000 US$	11,451	10,274	9,351	8,619	8.026
Total of Present Value	1,000 US$	46,415	45,781	45,538	45,359	45,476
Closing Time	sec	6	6	6	6	6
Pressure Rise	%	22.9	21.0	19.4	18.0	16.7
Present Value of Cost	1,000 US$	34,781	35,222	35,879	36,643	37,248
Present Value of Energy Loss	1,000 US$	11,451	10,274	9,351	8,619	8,026
Total of Present Value	1,000 US$	46,232	45,496	45,230	45,262	45,274
Closing Time	sec	7	7	7	7	7
Pressure Rise	%	19.3	17.8	16.4	15.2	14.2
Present Value of Cost	1,000 US$	34,868	35,414	35,922	36,675	37,292
Present Value of Energy Loss	1,000 US$	11,451	10,274	9,351	8,619	8,026
Total of Present Value	1,000 US$	46,319	45,688	45,273	45,294	45,318

9.7.3 DETAILS OF WATERWAY STRUCTUES

(1) Power Intake

The power intake, of which sill elevation is EL.263 m, is located above the final sediment level, which is assumed for the Nam Ngiep-I to be EL.230 m for the projected lifetime of 100 years. In addition, the intake sill is located 2.5 x D (D: diameter of headrace tunnel) below the minimum operation level of the reservoir.

Dimensions of the power intake are determined to have a trashrack area sufficient for an inflow velocity less than 1 m/s so as to minimize the intake head loss.

(2) Headrace Tunnel

The headrace tunnel is designed as a single lane for the initial 260 MW. The tunnel will be mainly driven in the alternate geological formation of mudstone and sandstone. The length of the tunnel is 504 m and will have a circular cross section of 9.0 m internal diameter. In case of the future extension, another lane of the headrace tunnel will be laid at the river side so that the distance between the centerlines of the two tunnels becomes 40 m.

Lining thickness is set at 0.7 m, based on common practice at 0.05 x D +0.25 (D: diameter of headrace tunnel). The lining will be reinforced to resist internal water pressure. Backfill grouting at the crown and consolidation grouting around the whole perimeter of the tunnel will be carried out along its entire length.

(3) Surge Tank

The surge tank is of the restricted orifice type, which is commonly selected as the most economical option. The diameter of the main tank is set at 12 m, so as to satisfy Thoma's stability condition.

Main tank shaft top and bottom levels are set at EL. 333 m and 288 m, respectively, considering an allowance of 2 m against USWL.331 m and 1 m against DSWL.289 m. Thus, the main tank shaft height becomes 45 m. Below the main tank, a riser shaft of 5.5 m diameter and 16.8 m height connects to the headrace tunnel. A restricted orifice of 4.4 m diameter is equipped to the bottom of a riser shaft

(4) Penstock

At the downstream side of the surge tank, the penstock tunnel which accommodates a steel penstock of 8 m diameter will be driven for 50 m length. A bifurcation is provided at the outlet of the tunnel, and then two lanes of open penstock are laid for 243 m length down to the powerhouse. Diameter of the open penstock will vary from 6.4 m to 4.0 m. Total weight of the steel penstock is estimated at 2,100 ton.

9.8 POWER STATION FOR MAIN DAM

9.8.1 GENERAL ARRANGEMENT

The powerhouse will be located downstream of the main dam toe and constructed on ground surface at EL.195 m. This is higher by more than 2 m than the flood level for the 100-year recurrence flood with peak discharge of 3,290 m^3/s.

The powerhouse will accommodate two units of the vertical shaft Francis turbines at a setting level of EL 177.5 m which will ensure sufficient suction head for restricting turbine runner cavitation under single unit operation conditions.

The powerhouse design is based on the accommodation requirements of the hydraulic turbines, generators, auxiliary equipment such as cooling water supply pump, governor oil system, turbine control panels, generator exciter and switchgear for main generator circuit and station service power supply. A 245 kV GIS room will be arranged on the upstream side of the powerhouse.

The substructure of the powerhouse is sectioned in three floors for arranging the auxiliary equipment. The erection bay for turbine and generator assembly will be 20 cm higher than the ground level for easy access to the powerhouse. The generator floor will also house the generator switchgear, exciting cubicles and low tension switchgear. The turbine floor will accommodate the turbine control equipment such as air compressors, compressed air tank and governor control panels. The third floor will be used for cooling water supply pump with strainers and motor control center.

The main inlet valve connecting with penstock will be arranged on the bottom floor level. The governor oil sump tank for turbine will be also arranged in the same floor level. Drainage water from the powerhouse and drain water from the draft tube will be collected into the sump pit and drained to the tailrace by a drainage pump.

The control room for the generating equipment will be arranged in the first floor of the powerhouse annex building.

Main features of the power station for the main dam are as follows:

- Powerhouse Yard Level:	EL. 195 m
- Powerhouse Length:	70 m
- Powerhouse Width:	50 m
- Powerhouse Height	46 m
- Turbine Center Level:	EL. 177.5 m
- Tailwater Level:	EL. 181.4 m
- Full Supply Level:	EL. 320 m
- Minimum Operation Level:	EL. 296 m
- Rated Head:	127.7 m
- Rated Discharge:	230 m^3/s
- Rated Capacity:	260 MW

9.8.2 HYDRAULIC FEATURES FOR POWER GENERATION

(1) Tailwater Rating Curve

The tailwater rating curve for the power station for the main dam is obtained by a non-uniform flow computation for the stretch between the tailrace and the re-regulating weir, as shown in Figure 9.8.1.

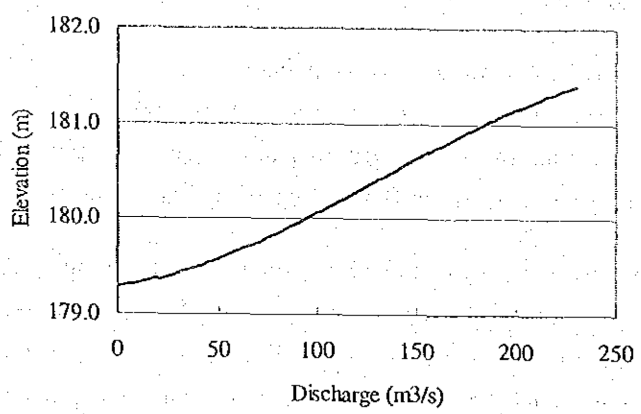


Figure 9.8.1 Taiwater Rating Curve for Power Station for Main Dam

(2) Headloss Rating Curve

The headloss rating curve for the main dam power station is obtained based on the waterway dimensions set out in this chapter, as shown in Figure 9.8.2.

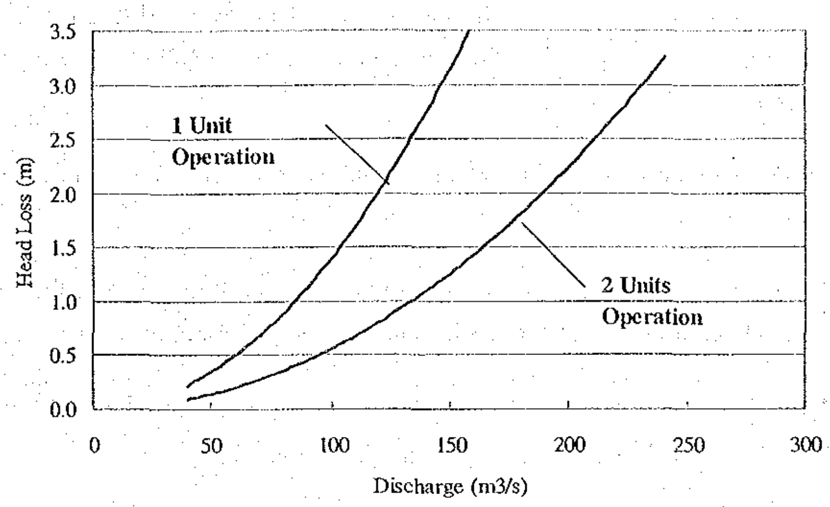


Figure 9.8.2 Headloss Rating Curve for Power Station for Main Dam

9.8.3 GENERATING EQUIPMENT

(1) Hydraulic Turbine and Auxiliary Equipment

The turbine output was calculated by the following head and water discharge.

- Maximum head: 138.3 m
- Rated head: 127.7 m
- Minimum head : 112.1 m
- Turbine discharge: 115 m^3/s

The turbines are designed as follows.

- Type: Vertical-shaft Francis type
- Output: 133.8 MW
- Speed: 214 rpm

Turbine type is selected from the applied head and speed was decided from limitation of specific speed and standard value which is calculated from the system frequency and generator pole numbers.

The spiral casing will be made of rolled steel plate with welded construction. The runner will be made of a low carbon stainless steel with 13% chromium and 4 % nickel. The draft tube liner is steel welded construction with a centre pier nose and extended with concrete liner to the outlet of the tailrace.

Turbine will be controlled by a microprocessor based PID digital governor. The solenoid control valves for turbine operation will be housed in the actuator panels.

A main inlet valve will be provided for each unit to shut off the water flow from the penstock line during the standstill time. The type of the inlet valve will be bi-plane butter-fly type operated with hydraulic servomotors.

A pressure oil system with air compressor and air-oil tank will be provided with each unit for turbine and main inlet valve operation.

A cooling water supply system is provided for each unit. The cooling water will be taken from the draft tube and supply to cooling system for bearings cooler and generator air coolers.

A drainage water and de-watering system for the powerhouse is to be provided to drain the collected water in the sump pit to the tailrace.

(2) Generators

The generators are designed as follows:

- Type: Three-phase synchronous (semi-umbrella type)
- Rated output : 144 MVA
- Power factor: 0.9
- Rated speed: 214 rpm
- Terminal voltage: 16 kV
- Insulation level: Class F
- Exciter : Static type

The generator will be connected to the main transformers through the 17.5 kV circuit breaker for synchronizing with power system. The main bus connection conductor will be isolated phase bus type considering its heavy current duty.

(3) Transformers

A main transformer for each unit is installed at the upstream side of the powerhouse to step up the generator voltage of 16kV to power system voltage of 230kV.

- Type: Single-phase, oil immersed, outdoor type
- Voltage ratio: 16/230 kV
- Rated capacity: 144MVA with delta-star connection (48MVA x 3 units)
- Cooling method: Forced oil and forced air cooled type

A neutral point of the transformer will be solidly grounded. Main transformer will be connected to the 245 kV Gas Insulated Switchgear (GIS) with a oil-gas bushing.

A local service power transformer of 50 MVA will be provisionary arranged for power supply to the station services including dam operation facilities. The local transformer will step down system voltage from 230kV to 20 kV for not only station power supply but also for the reactor required for light load transmission line voltage control. The required capacity of the reactor will be decided by the power system analysis at the time of the final design stage.

Water spray type fire fighting equipment will be provided for main transformers to extinguish fires and prevent fire flare.

(4) Medium and Low Voltage Switchgear

The single line diagram of the power plant is shown in Figure 9.8.3.

The generator switchgear will be arranged to connect the generator bus with main transformers and station service power transformer. The isolated phase bus (IPB) of 6000 A rating will be installed to carry the high current from the generator terminal to main transformer. The 17.5 kV SF6 gas insulated circuit breaker is provided for synchronizing the generator and power system. The required voltage and current transformers are enclosed in the cubicles for measuring and equipment protection purpose. The current limiting reactor will be arranged on a branch circuit of the unit station service transformer from the generator bus to suppress the short circuit current.

20 kV indoor switchgear will be arranged for the station power supply to be fed from the 50 MVA local service transformer and power supply for main dam facilities.

A three-phase four wire 400/230 V low-voltage switchgear installation will distribute the station power to auxiliary equipment of generating equipment. All low voltage switchgear equipment will be housed in the cubicle.

110V DC battery and battery charger will be arranged for power plant control system and initial charging of the generator exciter.

(5) Control and Protection System

The microprocessor based control and integrated protective system including the main transformer will be provided for the generating equipment. The turbine and generator will be controlled manually or automatically either at the local unit control panel or at the supervisory control system in the main control room via the SCADA system. An independent controller for unit operation, switchgear and station service will be interconnected with a high speed LAN net work by optical fiber cables. The supervisory control and data acquisition system (SCADA) will be provided to control and monitor the system operation from the load dispatching center or control room.

Transmission line protective relay will be digital distance type with carrier protective equipment

(6) Ancillary Equipment

Two (2) sets of overhead traveling crane with 160 tons main hoist will be provided for turbine and generator erection.

500kVA emergency diesel engine generator will be provided for black out start of generating equipment and powerhouse security in case of power system failure.

Telephone and paging system for operation and maintenance purpose will be provided for the powerhouse, outdoor and main intake control house.

(7) 230 kV Switchgear

Selection of the type of high voltage switchgear was made after considering several factors including the total cost of the applicable switchgear equipment, operation and maintenance costs, likelihood of further expansion and available land area for switchgear installation.

The cost of conventional switchgear is approximately 30% lower than that of Gas Insulated Switchgear (GIS) including erection cost. However, a conventional switchyard design will require a land area of approximately 100 m x 100 m near the powerhouse and increase work quantity of associated civil work and miscellaneous work.

In this project, possibility of future expansion of the plant capacity is considered so as to allow change of power demand pattern from 16 hours peak power supply to 8 hours supply and twice the initial 260MW capacity. Expansion using conventional switchgear requires twice the initial area that is not available around the powerhouse. Consequently the outdoor switchyard would have to be shifted to about 1.5 km downstream. In this case, the construction cost for conventional type will be mostly comparable to GIS construction.

While, the Gas Insulation Switchgear is more advantageous than that of conventional type considering the easiness of future extension and difficulty of construction expansion space for conventional type switchgear surrounding the power station area. Accordingly, GIS will be adopted for high 230kV switchgear in this project.

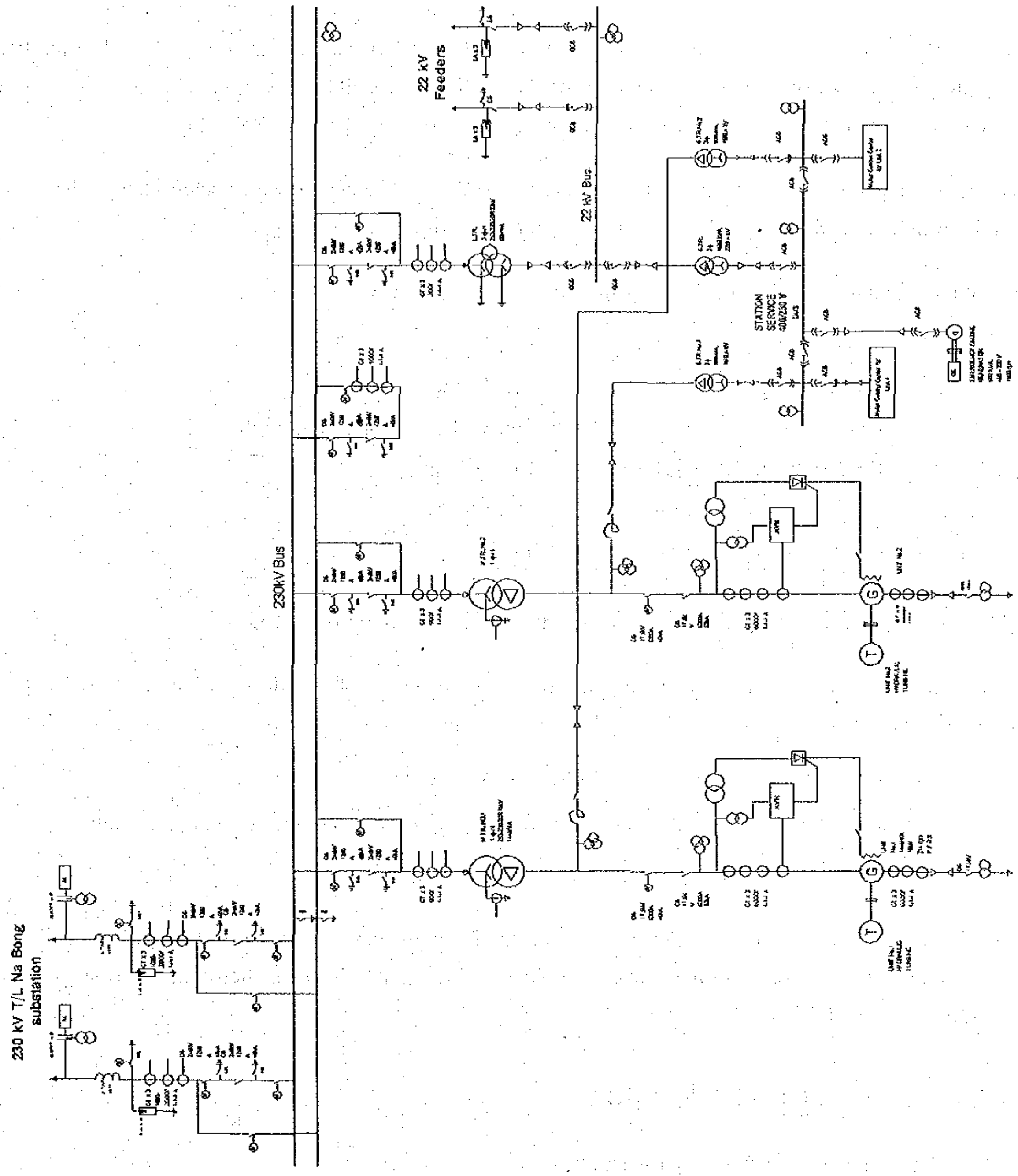


Figure 9.8.3 Single Line Diagram for Power Station for Main Dam

9.9 RE-REGULATING WEIR

9.9.1 GENERAL ARRANGEMENT

The re-regulating weir will be located about 5 km downstream of the proposed dam site. The facility is mainly composed of a concrete face rockfill dam (CFRD), a spillway with gated overflow portion and a surface type powerhouse. Proposed layout is shown on Figure 9.9.1(DWG.23).

As the river course curves to the left direction at this site, the powerhouse is positioned at the right bank. A diversion channel will be constructed on a small hill on the left bank.

Geometrical characteristics for the re-regulating weir are as follows:

- Weir Crest Level:	EL. 184 m
- Overflow Crest Level:	EL. 172 m
- Gated Weir:	5 nos., 12m wide x 9.5m high
- Stilling Basin Bottom Level:	EL. 163 m
- Stilling Basin Length:	40 m
- Crest Length of CFRD	110 m

9.9.2 REQUIRED CAPACITY FOR RE-REGULATING POND

The required capacity for re-regulating pond is calculated at 4.5 mil.m^3 approximately by the following equation:

Capacity Vr = (230 m^3/s – 153 m^3/s) x 3600 sec x 16 hours

where, 230m^3/s: Peak discharge for 16-hour operation from power plant at the dam

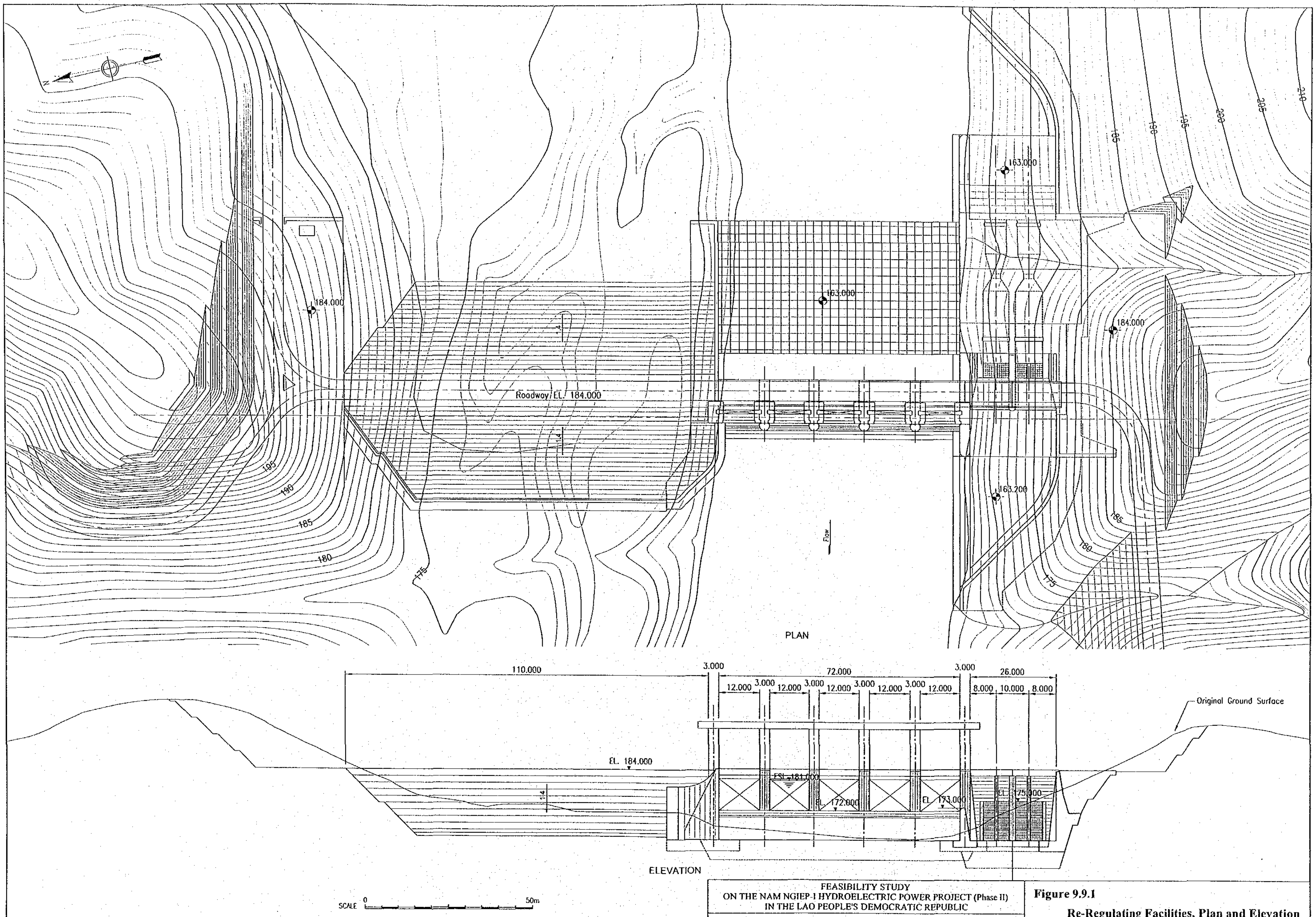
153m^3/s: Release from the re-regulating pond

The full supply level is set at EL.181 m, so as not to affect substantially the tailwater level of the main dam's powerhouse. The minimum operation level is set at EL. 176 m, that enables to secure an effective storage of 4.7 mil.m^3.

9.9.3 DETAILS OF STRUCTURES

(1) *River Diversion during Construction*

The river diversion is designed as to the 5-year recurrence probable flood of 1,590 m^3/s. A trapezoidal open channel with bottom width of 50 m will be excavated for 500 m length along the low hills on the left bank. Sill levels at the inlet and outlet of the channel are set at EL.164 m and EL. 163.5 m, respectively.



FEASIBILITY STUDY
ON THE NAM NGIEP-1 HYDROELECTRIC POWER PROJECT (Phase II)
IN THE LAO PEOPLE'S DEMOCRATIC REPUBLIC

JAPAN INTERNATIONAL COOPERATION AGENCY

Figure 9.9.1

Re-Regulating Facilities, Plan and Elevation

While the river water is diverted through this channel, the overflow section of the weir and the powerhouse on the right bank will be constructed. After these structures are installed, the river water will be diverted through the overflow section, then the remaining non-overflow section will be constructed. The plan of the river diversion is shown on DWG.22.

(2) Overflow Section

The overflow section is designed to have five (5) 12 m wide and 9.5 m high gates. This overflow weir with a crest level at EL. 172 m discharges the peak of the 100-year recurrence probable flood of 3,290 m^3/s at FSL 181 m at full gate opening.

The length of the stilling basin is set at 40 m, and the bottom level at EL.163 m.

(3) Non-overflow Section

End of the spillway will be connected to the abutment with CFRD non-overflow weir section. The crest level of the non-overflow sections is set at EL.184 m, which is about 3 m above the full supply level.

(4) Dykes

Impervious fill type non-overflow dykes are to be constructed across the four (4) branch valleys on the river banks. Length and height of these dykes are as follows.

Table 9.9.1 Dykes at Re-regulating Pond

No.	River Bank	Length	Height
1	Right	400	8
2	Right	50	10
3	Left	50	10
4	Left	30	5

9.10 POWER STATION FOR RE-REGULATING WEIR

9.10.1 GENERAL ARRANGEMENT

The powerhouse will have two bulb type turbine units, at a setting level of EL 161 m after considering the effects of turbine runner cavitation under single unit operation conditions.

The powerhouse is designed based on the size of the hydraulic turbines, generators, auxiliary equipment such as cooling water supply pump, governor oil system, turbine control panels, generator exciter and switchgear for generator circuit and station service power supply. 115kV outdoor switchgear will be arranged to connect to the transmission line for domestic power supply.

Main features of the power station for the re-regulating weir are as follows:

- Powerhouse Yard Level: EL. 184 m
- Powerhouse Length: 49 m
- Powerhouse Width: 26 m
- Powerhouse Height 30 m
- Turbine Center Level: EL. 161.0 m
- Tailwater Level: EL. 167.3 m
- Full Supply Level: EL. 181.0 m
- Minimum Operation Level: EL. 176.0 m
- Rated Head: 12 m
- Rated Discharge: 160 m^3/s
- Rated Capacity: 16.8 MW

9.10.2 HYDRAULIC FEATURES FOR POWER GENERATION

The tailwater rating curve for the power station at the re-regulating weir is obtained by a non-uniform flow computation for the stretch between the tailrace and the gauging station at B.Hatkham, as shown in Figure 9.10.1. Meanwhile, the head loss is not considered as it is negligibly small.

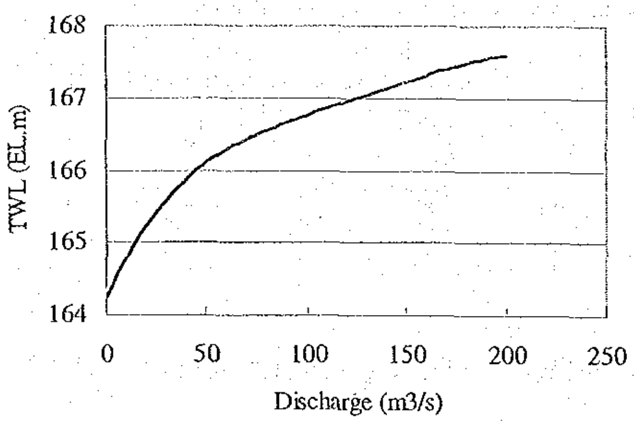


Figure 9.10.1 Taiwater Rating Curve for Power Station for Re-regulating Weir

9.10.3 GENERATING EQUIPMENT

(1) Hydraulic Turbine and Auxiliary Equipment

The turbine output was calculated by the following head and water discharge.

- Maximum head: 14.5 m
- Rated head: 12.0 m

- Minimum head : 8.7 m
- Turbine discharge: 80 m^3/s

The turbines are designed as follows.

- Type: Bulb type
- Output: 8.7 MW
- Speed: 187.5 rpm

The turbine type was determined from the applied head and the speed was calculated according to practical limitations and standard values relating to system frequency and generator pole numbers.

The bulb casing will be made of rolled steel plate with welded construction. The runner will be made of a low carbon stainless steel with 13% chromium and 4 % nickel.

The turbine will be controlled by the microprocessor based PID digital governor. The solenoid control valves for turbine operation will be housed in the actuator panels. The pressure oil system with air compressor and air-oil tank will be provided with each unit for turbine operation. A cooling water supply system is provided for each unit.

A drainage water and de-watering system for the powerhouse is to be provided to drain the collected water in sump pit to the tailrace.

(2) Generators

The generators are designed as follows:

- Type: Three-phase synchronous type
- Rated output : 9.3 MVA
- Power factor: 0.9
- Rated speed: 187.5 rpm
- Terminal voltage: 6.6 kV
- Insulation level: Class F
- Exciter : Static type

The generator will be connected with a 6.6 kV single bus through a 7.2 kV circuit breaker for synchronizing with power system and connected with main transformer together with 2 units.

(3) Transformers

A main transformer for each unit will be installed at the upstream side of the powerhouse to step up the generator voltage of 6.6 kV to power system voltage of 115kV.

- Type: Single-phase, oil immersed type
- Voltage ratio: 6.6/115 kV

- Rated capacity: 19MVA with delta-star connection
- Cooling method: Natural air cooled type

A local transformer of 1 MVA rating will be provided to step up the system voltage from 6.6 kV to 20 kV for local power supply and interconnection with main dam power station.

(4) *Medium and Low Voltage Switchgear*

The single line diagram of the power plant is shown in Figure 9.10.2.

The generator switchgear will be arranged to connect the 6.6 kV bus to the main transformers and station service power transformer. 20 kV indoor switchgear will be arranged for local power supply.

A three-phase four wire installation of 400/230 V low-voltage switchgear will be provided to distribute the station power to auxiliary equipment for power plant. All low voltage switchgear equipment will be housed in the cubicle.

110V DC battery and battery charger will be arranged for control system of power plant and initial charging of the generator exciter.

(5) Control and Protection System

A unit control and protective system will be provided for the generating equipment. The turbine and generator will be controlled manually or automatically either at local unit control panel or at supervisory control system in the main control room via a SCADA system. The supervisory control and data acquit ion system(SCADA) will be provided so as to control and monitor the system operation from the load dispatching center or control room.

Unit protection system with digital type relay will be provided for the generator. Transmission line protective relay will be digital distance type with carrier protective equipment

(6) Ancillary Equipment

One (1) set of overhead traveling crane with 40 tons main hoist will be provided for turbine and generator erection. 100 kVA emergency diesel engine generator will be also provided for black out starting of generating equipment and powerhouse security in case of power system failure.

(7) 115 kV Switchgear

Conventional type 123kV rating switchgear equipment will be provided for connecting the 115kV transmission line from the power station to the Paxsan substation.

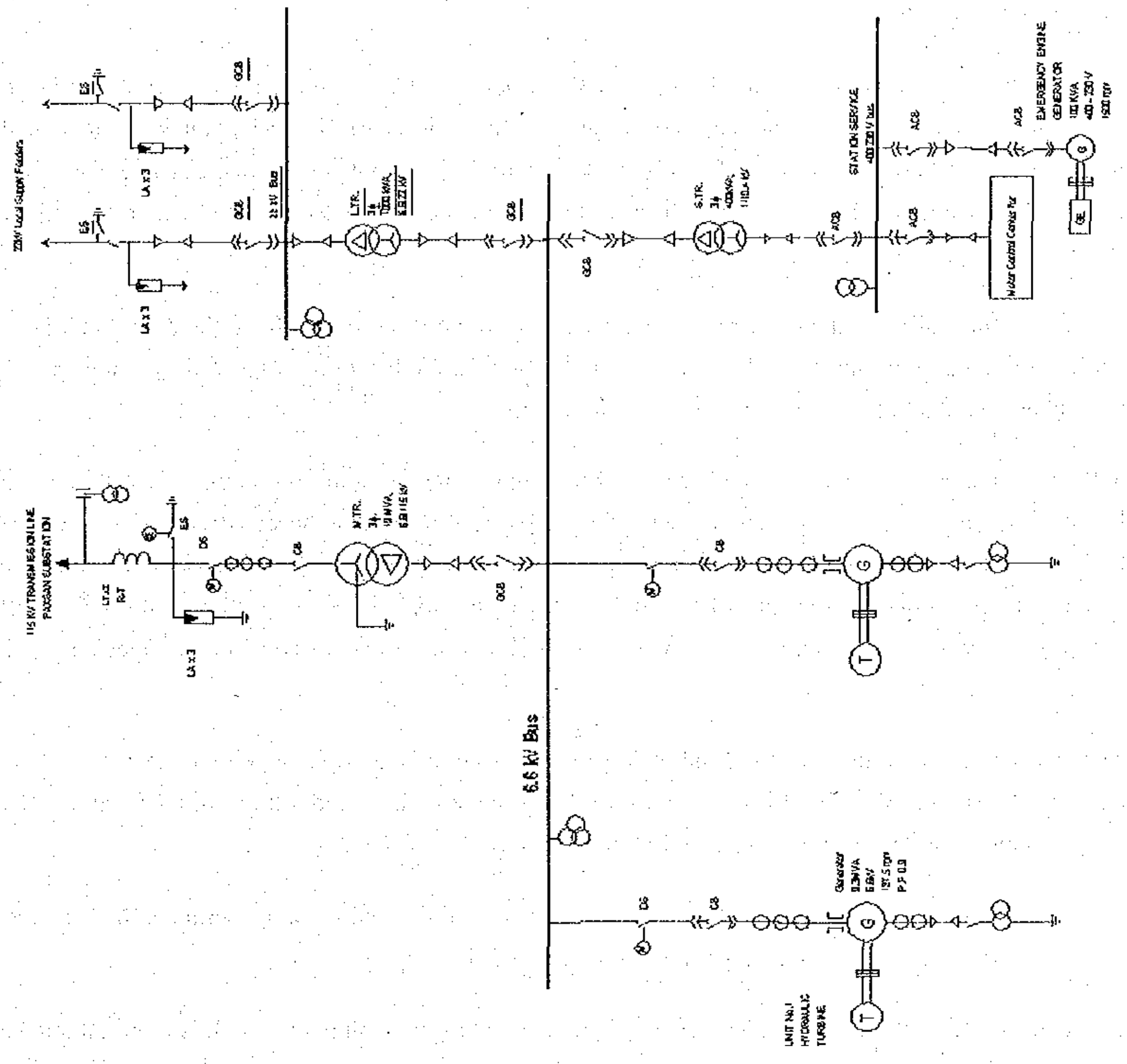


Figure 9.10.2 Single Line Diagram for Power Station for Re-regulating Weir

9.11 TRANSMISSION LINE AND SUBSTATION

9.11.1 MAIN TRANSMISSION LINE AND SUBSTATION

(1) Transmission Line

The generated power at Nam Ngiep-I project will be mainly exported to Thailand to contribute to the increasing power demand of the Thai power grid. Since the Nam Ngiep-I plant is located in the northern part of Pakxan and approximately 40 km from the national border of Laos and Thailand, a number of transmission line routes have been examined, including those associated with other existing IPP hydropower projects in the central region.

At 115 kV transmission line has already been extended to the Pakxan area from the Nam Leuk power station and interconnected with the Thai system at Bungkan substation. This transmission line has been constructed to meet local power demand in Paxsan area.

MIH has already conducted a feasibility study on a high voltage system in conjunction with the Num Ngum-3 hydropower development project. The study recommended the construction of a 500 kV trunk line interconnecting three regions for exporting the power generated therein to the neighbouring countries. The proposed location of the high voltage substation is Nabong where power from IPP projects in northern and central regions will be routed, and the transmission line voltage stepped up from 230 kV to 500 kV.

The transmission line route for the Nam Ngiep-I power station is also planned to connect with Nabon collector substation which will is located 45 km from the Vientiane and 125.2 km far from the Nam Ngiep-I power station. The transmission line route is shown on DWG.25.

The transmission line for the Nam Ngiep-I power station will be double circuit with ACSR conductor of 1,297,000 MCM and galvanized steel ground wire of 3/8".

The collector substation will be constructed by the National Grid Company which is to be established for managing the integrated power system in the whole of Laos and provide an efficient power system operation for the export generated power by IPP projects.

The final transmission line route will be decided by considering the final construction plan of 230kV transmission line and collector substation for Nam Ngum -2 and 3 hydropower projects, which precede the Nam Ngiep-I project.

(2) Substation

As discussed above, the collector substation will be constructed at Nabong as part of the associated project for Num Ngum-2 and 3 hydroelectric projects. By the time the Nam Ngiep-I project is completed, the main structure of the collector substation would have been in operation for some time, connected to the Thai power system. The Nam Ngiep-I project will therefore bear the cost of the extension bay for the 230 kV transmission line, including switchgear equipment with associated control and line protective equipment and civil work.

(3) 22 kV Transmission Line for Local Power Supply

The project will also construct the local power supply lines for supplying power for the project facilities and interconnection of the regulating power station.

9.11.2 DOMESTIC TRANSMISSION LINE AND SUBSTATION

(1) Transmission Line

The generated power from the regulating weir power station will be exclusively used for domestic power supply.

At present, Pakxan substation is the nearest substation and is 40km distant. There are two alternative transmission line option to connect the power station with Paxsan substation, one at 22 kV and a second at 115kV. However, after considering the generated output of the power station of 19MVA, the 115kV transmission line will be recommended since the voltage drop of a 22 kV transmission line with double circuits of 240 mm^2 will exceed more than 13 % at Paxsan substation under maximum current flow.

The transmission line route is shown on DWG.26. The transmission line will be single circuit with ACSR conductor of 150 mm^2 and galvanized steel ground wire of 3/8".

(2) Substation

As discussed above, the project will bear cost of the extension bay for 115 kV transmission line at Pakxan, including the switchgear equipment with associated control and line protective equipment, and civil work.

(3) 22kV Distribution Line for Local Power Supply

THE PROJECT WILL ALSO CONSTRUCT THE 22KV LOCAL POWER SUPPLY LINE IN THE VICINITY.

10. CONSTRUCTION PLAN AND COST ESTIMATE

10.1 GENERAL

This chapter describes the construction plan and cost estimate, both of which are based on the preliminary design and recent updated information.

The construction plan is to be utilized as a guide not only to the implementation of the construction works but to assist with the preparation of the project cost estimate. The Plan examines: (i) the outlines of the practical construction method, (ii) the specifications for the construction equipment/ plant required, (iii) the hauling distances of several materials, based on the layout of access road and temporary facilities, and (iv) the detailed construction schedule.

The cost estimate uses the unit price estimate method in principle. The project cost consists of construction cost comprising civil works and metal & electrical works, environmental cost, operation cost for SPC, and price contingency.

10.2 CONSTRUCTION PLAN AND SCHEDULE

10.2.1 BASIC CONDITIONS

(1) Workable Days

The annual rainfall in the construction site area ranges from 1,900 mm to 3,700 mm (about 2,900 mm on average), according to daily rainfall data that has been recorded during the ten-years period from 1991 to 2000 at Muong Kao rainfall station located near the dam site. The summary of rainfall record is shown in Table 10.2.1.

Table 10.2.1 Summary of Rainfall Record at Muong Kao Rainfall Station (Unit : mm)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1991	0	0	45	9	87	416	545	637	319	6	0	23	2,087
1992	25	52	7	19	238	683	461	373	50	0	0	30	1,939
1993	2	24	140	164	407	876	901	662	499	45	0	0	3,718
1994	0	88	108	61	288	756	656	613	272	52	0	14	2,908
1995	1	0	0	29	316	831	747	865	235	52	0	0	3,076
1996	0	124	82	193	173	417	659	747	347	60	58	0	2,860
1997	15	12	69	180	333	456	1,020	376	465	17	0	0	2,942

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1998	0	15	51	50	179	527	1,012	649	123	48	0	0	2,654
1999	0	0	156	257	795	821	598	589	333	59	31	0	3,640
2000	0	45	39	208	393	956	667	504	339	46	0	0	3,197
Mean	4	36	70	117	321	674	727	601	298	39	9	7	2,902

From the rainfall record above, intensive rainfall is observed in the period between May and September, and the total rainfall during this period accounts for about 90 % of the annual rainfall.

Workable days for major construction work comprising excavation work, embankment work, concrete work, and grouting work can be assessed from the above daily rainfall data. The monthly mean rainy day on each rainfall range are computed as below:

Table 10.2.2 Monthly Mean Rainy Day (Unit : day)

Daily Rainfall Range (mm)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
=0	30.1	25.4	27.4	23.1	18.2	9.1	8.9	11.7	17.9	27.9	29.4	30.5	259.6
0<x<=5	0.7	0.7	1.4	1.3	2.1	1.8	2.6	2.1	1.5	1.5	0.0	0.2	15.9
5<x<=10	0.1	0.7	0.4	1.4	1.4	2.9	2.7	3.3	2.2	0.6	0.3	0.0	16.0
10<x<=20	0.1	0.5	0.7	2.7	3.2	3.5	4.7	3.2	3.2	0.3	0.1	0.2	22.4
20<x<=30	0.0	0.2	0.3	0.2	1.8	3.2	3.0	3.3	1.8	0.1	0.1	0.0	14.0
30<x<=40	0.0	0.5	0.4	0.7	1.8	3.0	2.2	2.2	0.8	0.4	0.1	0.1	12.2
40<	0.0	0.0	0.4	0.6	2.5	6.5	6.9	5.2	2.6	0.2	0.0	0.0	24.9
Total	31.0	28.0	31.0	30.0	31.0	30.0	31.0	31.0	30.0	31.0	30.0	31.0	365.0

The suspended days due to rainfall for major construction work are assumed as below:

Table 10.2.3 Criteria of Work Suspended Days (Unit : day)

Daily Rainfall Range (mm)	Excavation	Embankment	Concrete	Grouting
0<x<=5	0	0	0	0
5<x<=10	0	0	0	0
10<x<=20	0	0.5	0	0
20<x<=30	0	0.5	1.0	0
30<x<=40	1.0	1.0	1.0	1.0
40<	1.0	1.0	1.0	1.0

Based on the above data, the monthly workable days for major construction work can be estimated as follows:

Table 10.2.4 Monthly Workable Days (Unit : day)

1. Excavation	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Holiday	0.0	0.0	0.0	3.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	5.0
Sunday	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	51.6
Rain	0.0	0.5	0.8	1.3	4.3	9.5	9.1	7.4	3.4	0.6	0.1	0.1	37.1
Overrap	0.0	0.1	0.1	0.6	0.8	1.4	1.3	1.1	0.5	0.1	0.0	0.2	6.0
Total of Suspended	4.3	4.7	5.0	8.0	8.8	12.4	12.1	10.6	7.2	4.8	4.4	5.2	87.7
Workable	26.7	23.3	26.0	22.0	22.2	17.6	18.9	20.4	22.8	26.2	25.6	25.8	277.3
2. Embankment	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Holiday	0.0	0.0	0.0	3.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	5.0
Sunday	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	51.6
Rain	0.1	0.9	1.3	2.8	6.8	12.9	13.0	10.7	5.9	0.8	0.2	0.2	55.3
Overrap	0.0	0.1	0.2	0.8	1.1	1.8	1.9	1.5	0.8	0.1	0.0	0.2	8.6
Total of Suspended	4.3	5.0	5.4	9.2	11.0	15.3	15.4	13.4	9.4	5.0	4.5	5.3	103.3
Workable	26.7	23.0	25.6	20.8	20.0	14.7	15.6	17.6	20.6	26.0	25.5	25.7	261.7

3. Concrete	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Holiday	0.0	0.0	0.0	3.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	5.0
Sunday	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	51.6
Rain	0.0	0.7	1.1	1.5	6.1	12.7	12.1	10.7	5.2	0.7	0.2	0.1	51.1
Overrap	0.0	0.1	0.2	0.6	1.0	1.8	1.7	1.5	0.7	0.1	0.0	0.2	8.0
Total of Suspended	4.3	4.9	5.2	8.2	10.4	15.2	14.7	13.5	8.8	4.9	4.5	5.2	99.7
Workable	26.7	23.1	25.8	21.8	20.6	14.8	16.3	17.5	21.2	26.1	25.5	25.8	265.3
4. Grouting	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Holiday	0.0	0.0	0.0	3.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	5.0
Sunday	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	51.6
Rain	0.0	0.5	0.8	1.3	4.3	9.5	9.1	7.4	3.4	0.6	0.1	0.1	37.1
Overrap	0.0	0.1	0.1	0.6	0.8	1.4	1.3	1.1	0.5	0.1	0.0	0.2	6.0
Total of Suspended	4.3	4.7	5.0	8.0	8.8	12.4	12.1	10.6	7.2	4.8	4.4	5.2	87.7
Workable	26.7	23.3	26.0	22.0	22.2	17.6	18.9	20.4	22.8	26.2	25.6	25.8	277.3

As a result, the annual total and monthly mean workable days for each work are summarized as below:

Table 10.2.5 Annual Total and Monthly Mean Workable Days (Unit : day)

Work Items	Annual Total	Monthly Mean
Excavation	277	23
Embankment	262	22
Concrete	265	22
Grouting	277	23

For the underground works, 25 workable days per month can be applied through a year.

(2) Construction Materials

Major construction materials required will be procured in the following way.

(i) Aggregate materials

Aggregate materials consisting of coarse and fine aggregate will be obtained through development of the proposed quarry site located about 23.7 km upstream of the dam site on the left bank.

(ii) Rock materials for the dam

Rock materials will be obtained from the sandstone quarry identified within 1 km of the dam axis. In addition, re-use rock material will be selected from excavated rock from the spillway.

(iii) Cement

The cement will be imported from Thailand.

(iv) Reinforcement bar

Vientiane Steel Industry Co Ltd., which was incorporated in September 1994 as a joint venture between Lao PDR and foreign partners, is one and the first company in Lao PDR to manufacture and supply steel product. The company is capable of producing deformed and round bar in accordance with international standards. Reinforcement bar imported from Thailand is also available for this project.

(v) Fuel

Fuel comprising diesel oil and gasoline can be purchased at the domestic market price from the Lao government.

(vi) Explosives

Explosives and detonators required for the rock blasting work will be imported from Thailand.

(vii) Wooden materials

Wooden materials such as plywood and timber are available in Lao PDR.

(3) Temporary Facilities

The temporary facilities for the construction works mainly consist of 1) Stockpile and concrete batching plant/ aggregate crushing plant, 2) Contractor's camp, 3) Engineer's site office, and 4) Spoil bank. As shown in the attached DWG.02, each of the temporary facilities can be located on the flat lands dotted between the dam site and re-regulation weir site downstream of the dam site.

10.2.2 CONSTRUCTION METHOD

(1) River Diversion Scheme

(i) Diversion tunnel

The diversion tunnel method will be used during the construction of the main dam works. Two diversion tunnels (9.2 m in finished diameter) are planned in the right bank of the dam site. The diversion tunnels are about 1,180 m and 1,070 m in length respectively. Both of the diversion tunnels will be driven by top heading and bottom bench cut methods, using 3-boom hydraulic wheel jumbo, 1.9 m^3 side dump wheel loader, and 10 ton dump truck. Since the construction of the diversion tunnels is critical path work, both of the tunnels will be excavated from both inlet and outlet portals. The monthly progress of tunnel excavation is expected to be 110 m/month as a result of the cycle time analysis. The temporary supporting of the tunnel will be achieved by shotcrete and rock bolts, and then the lining concrete will be placed using 10.5m-long circular traveling steel forms, 100 m^3/h concrete pump car, and 4.5 m^3 agitator truck. The average hauling distances for each work are estimated as below based on the layout of access roads and temporary facilities.

Table 10.2.6 Hauling Distance for River Diversion Work (Unit : km)

Work Item	Hauling Distance	Remarks
Tunnel excavation	5.5	From dam axis to spoil bank
Tunnel lining concrete	1.5	From plant yard to dam axis

The total construction period of the diversion tunnel works is assumed to be about 20 months from January 2006 to August 2007, provided the mobilization can be completed by the end of December 2005.

(ii) River diversion work

Following the completion of the diversion tunnels, primary upstream and downstream cofferdam will be constructed to divert the existing river flow into the diversion tunnels. It is generally recommended that the river diversion work be carried out during the dry season. In our schedule the river diversion is scheduled be achieved in the beginning of October 2007 when the dry season starts. After the river diversion, the upstream cofferdam that is planned to be of CFRD type will be constructed.

(2) Main Dam

(i) Foundation excavation

The excavation of the foundation zone can be executed starting from the highest point on both abutments. The excavation, common mainly for the rock's foundation will be carried out using 44 ton bulldozer with ripper, 10.3 m^3 wheel loader, and 46 ton dump truck. The excavation of rock to form the plinth foundation will be carried out by the low bench cut method with a bench height of less than 3 m. The drilling of blast holes will be carried out by 150 kg crawler drill and the breaking of rock will be carried out by 7.5 kg pick hammer. Most of the abutment excavation can be completed before the river is diverted, while the riverbed excavation can be commenced after the river is diverted. The average hauling distance for foundation excavation work is estimated as below.

Table 10.2.7 *Hauling Distance for Foundation Excavation Work (Unit : km)*

Work Item	Hauling Distance	Remarks
Open excavation	5.5	From dam axis to spoil bank

The total construction period of the foundation excavation works is assumed to be about 15 months from November 2006 to January 2008, provided the river diversion can be achieved in the beginning of October 2007.

(ii) Quarry for rock materials

The excavation of rock from the quarry will be carried out using the bench cut method with a bench height of 8 m, using 180 kg crawler drill, 32 ton bulldozer, 44 ton bulldozer, 10.3 m^3 wheel loader, and 46 ton dump truck. The average hauling distance for rock materials is estimated as below.

Table 10.2.8 Hauling Distance for Rockfill Materials (Unit : km)

Work Item	Hauling Distance	Remarks
Rockfill materials	1.0	From quarry site to dam axis

(iii) Dam embankment

The embankment volume required is estimated at 7,268,000 m^3 in total. The embankment materials will be obtained from the quarry sites as well as the re-used rock from the spillway excavation. The proportion of the materials from the quarry and the re-used rock materials from spillway in the dam embankment is outlined below.

Table 10.2.9 Proportion of the Embankment Materials (Unit : m3)

Material Source	Quantity	Proportion
Re-used rock materials from spillway	4,288,880	59%
Rock materials from quarry	2,979,120	41%
Total	7,268,000	100%

The above quantity of re-used rock materials from spillway is the quantity converted from 3,063,486 m^3 in bank measurement mentioned in the next section (3) Spillway into the compacted measurement, using the soil conversion factor (Bank : Compacted = 1:1.4).

The embankment work will be carried out using 32 ton bulldozer for spreading, and 15 - 18 ton vibrating roller for compaction. The compaction work will be specified with layer thickness of 0.4 - 0.8 m and compaction of six layers at a time.

The total construction period of the dam embankment works is assumed to be about 21 months from February 2008 to October 2009, after completion of the dam foundation excavation. The monthly progress of dam embankment is expected to be 350,000 m^3 on average.

(iv) Concrete works for plinth and slab

The construction of the plinth can be carried out prior to dam embankment in general. Following the excavation of the plinth foundation area on both abutments and a detailed survey, the construction of the plinth can be executed starting in those areas. The construction of the plinth in riverbed section can be commenced after completion of the riverbed excavation. The placement work will be carried out using 100 m^3/h concrete pump car and 4.5 m^3 agitator truck.

The construction of the face slab will be carried out in 2 stages. The construction of the first stage can be commenced once the dam embankment has reached the middle height of the dam. The second stage can be commenced once the dam embankment has been completed. The placement work will be carried out using 15 m wide slip form, concrete chute, and 4.5 m^3 agitator truck. The average hauling distance for the plinth and slab concrete is estimated as below.

Table 10.2.10 Hauling Distance for Plinth and Slab Concrete (Unit : km)

Work Item	Hauling Distance	Remarks
Plinth and slab concrete	4.0	From plant yard to dam crest

A concrete batching plant with the following specifications will be required for the construction works of the plinth and slab, in consideration of the total concrete volume and placement period.

Table 10.2.11 Specifications for Concrete Batching Plant

Item	Specification
Plant type	Tilting drum
Mixing capacity per unit	1.5 m^3
Nos. of mixer	3 units
Mixing time	2.5 min.
Plant capacity	97.2 m^3/h
Operation hour	7 hrs

Item	Specification
Daily production	680 m^3/day
Cement silo	600 ton

The construction period of the plinth concrete works is assumed to be about 12 months from May 2007 to April 2008, provided the river diversion can be achieved in the beginning of October 2007. The construction periods of the slab concrete works in two stages are assumed to be about 6 months from October 2008 to March 2009 and 6 months from November 2009 to April 2010 respectively.

(v) Quarry for aggregate materials

The excavation of rock at the qurry will be carried out by the bench cut method with a bench height of 8 m, using 180 kg crawler drill, 32 ton bulldozer, 1.2 m^3 backhoe, and 10 ton dump truck. The average hauling distance for aggregate materials is estimated as below.

Table 10.2.12 Hauling Distance for Aggregate Materials (Unit : km)

Work Item	Hauling Distance	Remarks
Aggregate materials	27.5	From quarry site to plant yard

An aggregate crushing plant will be installed to produce both fine and coarse aggregate at the site. The required capacity of the aggregate crushing plant is planned based on the peak concrete volume requirement that can be assumed from the production capacity of the concrete batching plant. Two concrete batching plants will be required with the daily production capacity of 680 m^3/day, which will be utilized for the plinth/ slab construction and for the spillway construction respectively. From the mixture proportions of the plinth and slab concrete, comprising portland cement of 307 kg, fine aggregate of 722 kg, and coarse aggregate of 1,122 kg, assumed referring to some similar projects, the capacity of the aggregate crushing plant can be roughly computed as follows.

(a) The capacity of the crushing plant comprising rod mill, classifier etc. for fine aggregate production is determined at about 70 ton/h by the following equation:

Capacity $Cs = Q \times f / (T \times E)$

Where, Q : Peak production volume (680 m^3/day x 2 nos. x 0.722 ton/m^3 = 982 ton/day)

f : Allowance factor for loss in fine aggregate production process (1.15)

T : Net operating hours per day at peak (24 hr)

E : Operation factor (0.7)

(b) The capacity of the secondary plant comprising cone crusher etc. is determined at about 180 ton/h by the following equation:

Capacity $C = C1 + C2$

Where, C1 : The capacity required for fine aggregate production (Cs x 1.15 = 80.5 ton/h)

C2 : The capacity required for coarse aggregate production

Where, $C2 = Q2 \times f2 / (T \times E)$ = 97.6 ton/h

Q2 : Peak production volume (680 m^3/day x 2 nos. x 1.122 ton/m^3 = 1,527 ton/day)

f2 : Allowance factor for loss in secondary plant production process (1.15)

T2 : Net operating hours per day at peak (24 hr)

E2 : Operation factor (0.75)

(c) The capacity of the primary plant comprising jaw crusher etc. is determined at about 250 ton/h by the following equation:

Capacity C = C' x f3 x f4/ (E1 x T1/ E2 x T2)

Where, C' : The capacity of the secondary plant (180 ton/h)

f3 : Allowance factor for loss in primary plant production process (1.15)

f4 : Allowance factor for unbalanced crude stone feed (1.1)

E1 : Operation factor of primary plant (0.7)

E2 : Operation factor of secondary plant (0.75)

T1 : Net operating hours per day at peak for primary plant (24 hr)

T2 : Net operating hours per day at peak for secondary plant (24 hr)

(vi) Foundation treatment

Both consolidation grouting and curtain grouting can be executed in parallel with the plinth construction. The consolidation grout will be drilled with 150 kg crawler drill and 5.5 kW rotary boring machines. The curtain grout will be drilled with 150 kg crawler drill, 5.5 kW and 11 kW rotary boring machines. The cement grout will be mixed at the central plant equipped with 200 lit x 2 grout mixer, and 7.5 kW and 11 kW grout pumps.

The construction period of the consolidation grout works is assumed to be about 12 months from July 2007 to June 2008, while the construction period of the curtain grout works is assumed to be about 16 months from July 2007 to October 2008.

(3) Spillway

(i) Open excavation

The excavation of common material will be carried out using 44 ton bulldozer with ripper, 10.3 m^3 wheel loader, and 46 ton dump truck in parallel with the foundation excavation of the main dam. The excavation of rock will be carried out by the bench cut method with a bench height of 5 m, using crawler drill with 150 kg drifter, 32 ton bulldozer, 1.2 m^3 backhoe, and 10 ton dump truck. The rock materials excavated from the spillway will be screened and divided into two groups; 1) re-used rock which can be utilized as a rockfill material for the dam, and 2) the other rock which are hauled to the spoil bank. According to the geological judgement, conglomerate and sandstone are expected to be of rockfill material. Therefore the quantity of re-used rock material can be computed as below, using the distribution rate of conglomerate and sandstone by each geological formation at the spillway.

Table 10.2.13 Quantity of Re-used Rock Material (Unit : m3)

Formation	Rock Excavation	Rate(%)	Re-used Rock Material
Ss + Ms	173,934	50	86,967
Formation 5	2,026,136	95	1,924,829
Formation 4	566,107	30	169,832
Formation 3	912,267	85	775,427
Formation 2	212,862	50	106,431
Total	3,891,306		3,063,486

The average hauling distances for each excavation work are estimated as below.

Table 10.2.14 Hauling Distance for Spillway Excavation (Unit : km)

Work Item	Hauling Distance	Remarks
Re-used rock materials	0.5	Within the dam site
The other excavation materials	5.5	From dam axis to spoil bank

The total construction period of the spillway excavation works is assumed to be about 26 months from January 2006 to February 2008, provided the mobilization and the river diversion can be achieved by the end of December 2005 and in the beginning of October 2007 respectively.

(ii) Concrete works

The fixed type tower crane of 13.5 ton with self climbing (bucket capacity: 4.5 m^3, max. working radius: 75 m) will be employed for the placement work of the upper portion of the spillway. Placement work on the lower portion of spillway will be carried out using 50 ton crawler crane (bucket capacity: 3.0 m^3) and 100 m^3/h concrete pump car. The mixed concrete will be hauled by 4.5 m^3 agitator truck. The average hauling distance for the spillway concrete is estimated as below.

Table 10.2.15 Hauling Distance for Spillway Concrete (Unit : km)

Work Item	Hauling Distance	Remarks
Spillway concrete	4.0	From plant yard to dam crest

The concrete batching plant with the daily production capacity of 680 m^3/day, which is the same capacity as the other one, will be required to cope with the total concrete volume and placement period.

The total construction period of the spillway concrete works is assumed to be about 18 months from May 2007 to October 2008, provided the river diversion can be achieved in the beginning of October 2007.

Installation of spillway gates will be carried out using 30 ton truck crane to be stationed at upstream of spillway crest after completion of concrete works of spillway crest. The installation will be started from gate anchor parts which will be embedded into spillway piers. The arms, gate leaves and hoisting equipment will be installed after completion of concrete works for spillway piers. The total construction period of the spillway gates is assumed to be 6 months from August 2008 to January 2009.

(4) Power Intake

The excavation of common material will be carried out using 44 ton bulldozer with ripper, 10.3 m^3 wheel loader, and 46 ton dump truck. The excavation of rock will be carried out by the low bench cut method with a bench height of less than 3 m. The shaft excavation will be carried out by the sinking method with shotcrete and rock bolt supports.

The open concrete works will be carried out using 30 ton crawler crane (bucket capacity: 1.0 m^3) and 100 m^3/h concrete pump car. The shaft lining concreting will be carried out using 100 m^3/h concrete pump car.

All of the construction works mentioned above can be executed in parallel with the foundation excavation works of main dam. The total construction period is assumed to be about 9 months from November 2006 to July 2007.

(5) Waterway

The waterway consists of 3 sections; 1) headrace tunnel with 504 m in length and 9.0 m in finished diameter, 2) surge tank with 12.0 m in finished diameter, and 3) penstock line comprising tunnel part with 50 m in length and open penstock part with 243 m in length.

Both the headrace tunnel and penstock tunnel sections will be driven by top heading and bottom bench cut method, using 3-boom hydraulic wheel jumbo, 1.9 m^3 side dump wheel loader, and 10 ton dump truck. The monthly progress of tunnel excavation is expected to be 55 m/month as a result of the cycle time analysis. The temporary supporting of the tunnel will be achieved by shotcrete and rock bolts, and then the lining concrete will be placed using 10.5m-long circular traveling steel forms, 100 m^3/h concrete pump car, and 4.5 m^3 agitator truck.

The surge tank shaft will be excavated by sinking method with shotcrete and rock bolt supports. The shaft lining concrete will be placed using 100 m^3/h concrete pump car.

The average hauling distances for each work are estimated as below.

Table 10.2.16 Hauling Distance for Waterway Works (Unit : km)

Work Item	Hauling Distance	Remarks
Tunnel excavation	5.5	From dam axis to spoil bank
Tunnel lining concrete	1.5	From plant yard to dam axis

The headrace tunnel will be excavated starting at the inlet after completion of the diversion tunnel No.2 excavation, using the same equipment fleet as the diversion tunnel No.2 excavation. The construction period of the headrace tunnel excavation is assumed to be about 10 months from December 2006 to September 2007. The penstock tunnel will be excavated starting from its outlet, using the same equipment fleet as the headrace tunnel after completion of the open excavation in its outlet area. The construction period of the penstock tunnel excavation is assumed to be about 2 months from December 2007 to January 2008. As a result, the total construction period of the waterway works except pipe installation is assumed to be about 17 months from December 2006 to April 2008. An eight month period from May 2008 will be required for the pipe installation.

Installation of penstock will be carried out using 30 ton truck crane, 30 ton capacity winch, unloading wagon with rail, man cage for welding and paint works, etc. after completion of excavation of the penstock tunnel. The total construction period of the penstock is assumed to be 8 months from May 2008 to December 2008.

(6) Powerhouse

The excavation works can be commenced after the river is diverted. The excavation of common material will be carried out using 44 ton bulldozer with ripper, 10.3 m^3 wheel loader, and 46 ton dump truck. The excavation of rock will be carried out by the low bench cut method with a bench height of less than 3 m. Following the excavation works, the open concrete works will be carried out using 30 ton crawler crane (bucket capacity: 1.0 m^3) and 100 m^3/h concrete pump car.

The construction period of the civil works above is assumed to be about 10 months from October 2007 to July 2008, provided the river diversion can be achieved in the beginning of October 2007.

The architectural works comprising building, utilities, and electrical works will be carried out after completion of the concrete works. The installation works for overhead travelling crane, draft tube, and turbine will be carried out in parallel with the concrete and architectural works.

Erection of major generating equipment is as follows.

The erection of draft tube will be executed by lifting winch or tower crane for the powerhouse construction before installation of the overhead traveling crane. The draft tube to be delivered with some sections will be assembled and welded at draft tube pit. Following by the secondary concrete of the draft tube and casing foundation, a spiral casing with upper draft tube will be assembled by welding and pressure test will be carried out with 1.5 times of maximum pressure for 1 minute to confirm the safety of spiral case construction. After centering and leveling of the spiral case, secondary concrete will be placed. With construction of the casing, the associate piping system will also be arranged. Turbine assembly including setting runner will be performed during curing time of the secondary concrete. Turbine pit will be formed by steel liner to be used as concrete form of generator barrel foundation by bottom of generator lower bracket. After completion of the barrel foundation, final centering of turbine will be checked for proceed the generator assembling works. The generator stator will be placed on the generator pit using two overhead traveling cranes. The generator rotor will be assembled at erection bay and inserted to the generator stator. Auxiliary equipment of the generator will be installed in parallel with assembly works.

Single phase main transformer will be unloaded on respective transformer foundations by sliding method from the lower platform type trailer.

245 kV GIS will be delivered with unit bays and unloaded by truck crane on embedded steel foundation in the GIS room. Assembly work of the small component will be carried out using 5 tons overhead traveling crane.

Installation and test period of generating is assumed to be 22 months from beginning of January 2009.

(7) Bottom Outlet and Plug for Diversion Tunnel

The bottom outlet facilities installed in the diversion tunnel No.2 consist of valve, emergency gate, and intake screen. These installation works will be carried out under dry working condition in the tunnel. Since the gate closure of the diversion tunnel No.1 will be carried out on the first of May 2010 after completion of the main dam works, the installation period of the bottom outlet including the temporary plug works is assumed to be about 7 months from October 2009 to April 2010.

The reservoir impounding can be commenced from the first of May 2010, after the gate closure of the diversion tunnel No.1. The commercial operations of generating unit 1 and unit 2 are expected to start from the first of October 2010 and the first of November 2010 respectively.

(8) Re-regulating Facilities

The re-regulating facilities comprise weir of overflow and no-overflow sections, powerhouse, switchyard and dykes. The river diversion works will be achieved using the open diversion canal excavated in the left bank terrace. After the river diversion, the foundation excavation of the weir (overflow section) will proceed. The concrete works of the weir (overflow section) will be carried out using 30 ton crawler crane (bucket capacity: 1.0 m^3) and 100 m^3/h concrete pump car. After completion of the concrete works of the weir (overflow section), the river flow will be transferred back to the original river course and then the foundation excavation of the weir (no-overflow section) will proceed. The weir (no-overflow section) that is of CFRD type will be constructed in the same manner as the main dam.

The total construction period of the weir is assumed to be about 10 months from November 2008 to August 2009.

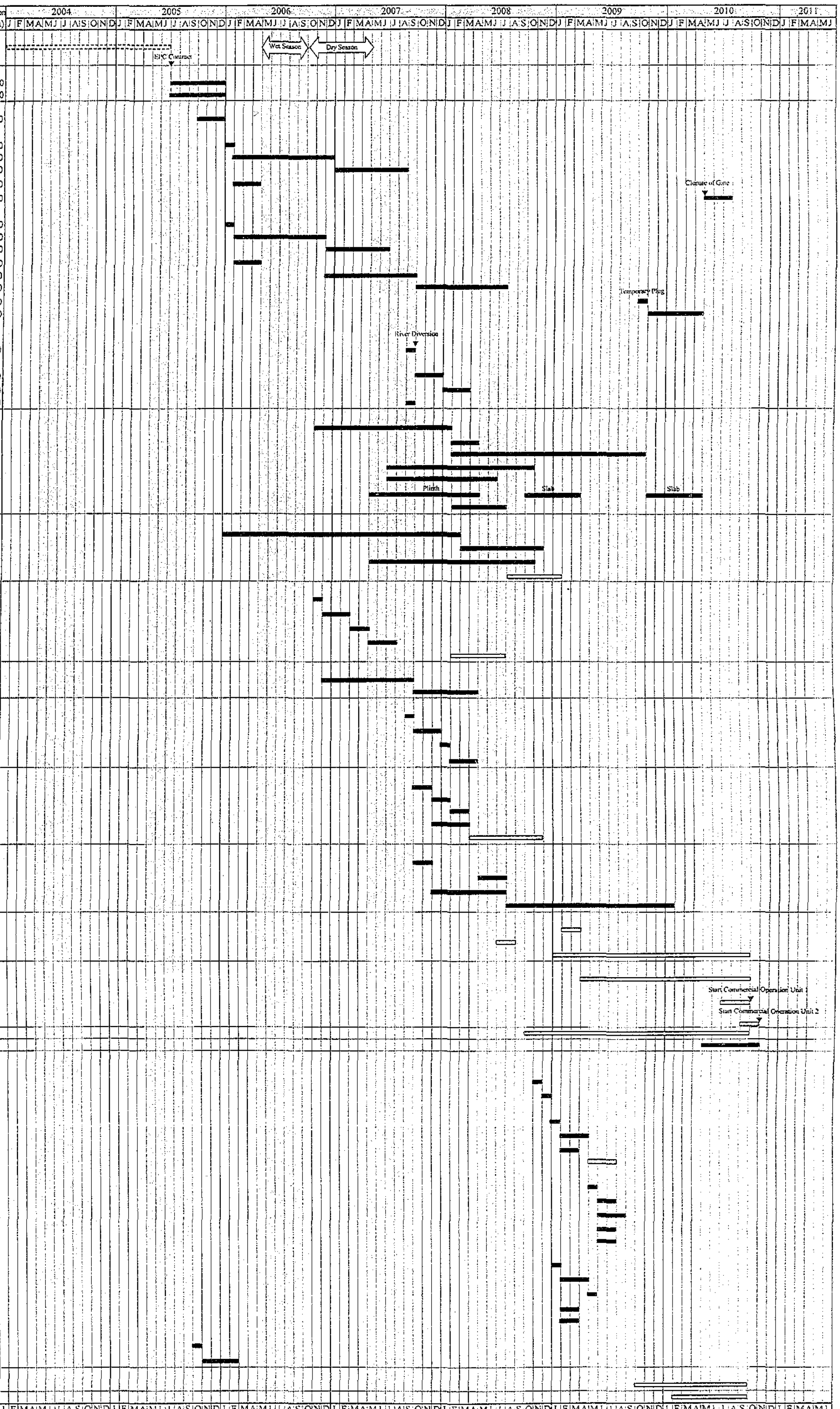
Installation of re-regulating gates will be carried out using 30 ton truck crane to be stationed at upstream of overflow section of weir after completion of concrete works of such section. The total construction period of the penstock is assumed to be 3 months from May 2009 to July 2009.

10.2.3 CONSTRUCTION SCHEDULE

The construction schedule is prepared, provided the EPC contract can be made in the end of June 2005. The construction schedule, together with pre-construction schedule, is shown in Figure 10.2.1.

Table 10.2.1 Overall Construction Schedule for the Nam Ngiep-I Hydroelectric Power Project

Work Item	Work Quantity	Duration (month)
Pre-construction		
Site Investigation and Tender Design		
EPC Contract		
Temporary Facilities		
Permanent/ Temporary Access Road		6.0
Base Camp		6.0
River Diversion Scheme		
Mobilization & Installation		3.0
Diversion Tunnel No.1		
Open Excavation	176,500 m³	1.0
Tunnel Excavation	1,180 m	11.0
Tunnel Lining Concrete	1,180 m	8.0
Open Concrete Works	9,450 m³	3.0
Plug concrete	3,450 m³	3.0
Diversion Tunnel No.2		
Open Excavation	176,500 m³	1.0
Tunnel Excavation	1,080 m	10.0
Tunnel Lining Concrete	1,080 m	7.0
Open-concrete Works	9,450 m³	3.0
Tunnel Excavation for Access Gallery	410 m	10.0
Tunnel Lining Concrete for A/Gallery	410 m	10.0
Plug concrete	3,450 m³	1.0
Valve Installation		6.0
River Diversion Work		
River Divertion		
Primary Cofferdam		1.0
Upstream Cofferdam		
Embankment	409,000 m³	3.0
Concrete Works for Slab	4,200 m³	3.0
Downstream Cofferdam		1.0
Main Dam		
Open Excavation	1,650,000 m³	15.0
Tunnel Excavation for Crest Gallery	130 m	3.0
Main Dam Embankment	7,268,000 m³	21.0
Curtain Grouting	47,000 m	16.0
Consolidation Grouting	4,000 m	12.0
Concrete Works for Slab and Plinth	41,000 m³	24.0
Mass Concrete	35,000 m³	6.0
Spillway		
Open Excavation	5,827,000 m³	26.0
Backfill	62,000 m³	9.0
Open Concrete Works	135,000 m³	18.0
Gate Installation		6.0
Power Intake		
Open Excavation	74,000 m³	1.0
Shaft Excavation	4,500 m³	3.0
Open Concrete Works	6,500 m³	2.0
Shaft Lining Concrete	3,200 m³	3.0
Gate Installation		6.0
Headrace Tunnel		
Tunnel Excavation	504 m	10.0
Tunnel Lining Concrete	504 m	7.0
Surge Tank		
Open Excavation	46,000 m³	1.0
Shaft Excavation	4,800 m³	3.0
Open Concrete Works	800 m³	1.0
Shaft Lining Concrete	1,500 m³	3.0
Penstock Line		
Open Excavation	190,000 m³	2.0
Tunnel Excavation	50 m	2.0
Tunnel Lining Concrete	50 m	2.0
Open Concrete Works	13,000 m³	4.0
Pipe Installation		8.0
Powerhouse and Architectural Works		
Open Excavation	99,000 m³	2.0
Backfill	135,000 m³	3.0
Open Concrete Works	26,000 m³	8.0
Architectural Works		18.0
Turbines and Auxiliaries		
OHT Crane Installation	2 nos.	2.0
Draft tube	2 nos.	2.0
Turbine	2 nos.	21.0
Generators and Auxiliaries		
Generator Installation	2 nos.	18.0
Test and Comissioning		
Unit 1		2.0
Unit 2		2.0
Transmission Line and Substation (230 k	125 km	24.0
Impounding to RWL		6.0
Re-regulating Facilities		
River Diversion Work		
Open Excavation	240,000 m³	1.0
U/S and D/S Cofferdam	128,000 m³	1.0
Weir (Overflow Section)		
Open Excavation	22,000 m³	1.0
Open Concrete Works	38,000 m³	3.0
Curtain Grouting	300 m	2.0
Gate Installation		3.0
Weir (Non-Overflow Section)		
Open Excavation	88,000 m³	1.0
Dam Embankment	84,000 m³	2.0
Open Concrete Works	1,000 m³	3.0
Curtain Grouting	600 m	2.0
Consolidation Grouting	300 m	2.0
Powerhouse & Switchyard		
Open Excavation	94,000 m³	1.0
Open Concrete Works	43,000 m³	3.0
Backfill	11,000 m³	1.0
Curtain Grouting	200 m	2.0
Consolidation Grouting	100 m	2.0
Dyke		
Open Excavation	65,000 m³	1.0
Dam Embankment	247,000 m³	4.0
Generators and Auxiliaries (Re-regulating Wier)		
Generator Installation	2 nos.	12.0
Transmission Line and Substation (115 k	40 km	8.0
Work Item	Work Quantity	Duration (month)



The following activities are on the critical path in the overall construction schedule.

Table 10.2.17 Critical Path in Overall Construction Schedule

No.	Work/Event	Schedule
1.	Site investigation and tender design	2003
2.	EPC contract	End of Jun., 2005
3.	Permanent/temporary access road construction	End of Jun., 2005
4.	Diversion tunnel construction	End of Jan., 2006
5.	River diversion	End of Sep., 2007
6.	Main dam construction	End of Sep., 2008
7.	Reservoir impounding	End of Apr., 2010
8.	Wet test of generating equipment	End of Jun., 2010
9.	Commissioning of generating unit 1	End of Sep., 2010
10.	Commissioning of generating unit 2	End of Oct., 2010

10.3 COST ESTIMATE

10.3.1 BASIC CONDITIONS AND ASSUMPTIONS

The base cost comprises i) Construction cost, ii) Environmental cost, iii) Operation cost for SPC, and iv) Price contingency. The basic conditions and assumption of the cost estimate are as follow:

(i) The price level of the cost estimate is July 2002 when site investigation works was carried out.

(ii) Since almost all the cost components such as labor, materials, and equipment will be obtained from abroad, the project cost is expressed in US dollar (US$) only.

(iii) The construction cost is estimated with the unit price estimate method in principle. Each of the work quantities is computed from the preliminary design.

(iv) Each of the unit prices of major civil works is developed by a breakdown of unit price. The costs of metal works, generating equipment, transmission line, and substation are estimated from the data obtained from manufacturers and from the recent bidding unit prices of similar projects in Asian countries.

(v) Price contingency is estimated with the assumed price escalation rate of 1.3 % per annum (referring to current USA consumer price index movements).

(vi) All kinds of tax are excluded from the cost estimate.

10.3.2 COST ESTIMATE METHOD

The cost estimates for each work category are made by the following procedure.

(1) Temporary Facilities and Permanent Access Road

The temporary facilities comprise temporary road (L=33.6 km), telecommunication line (L=51.0 km), power distribution line (L=31.0 km), base camp, and other miscellaneous (mobilization, etc.). The permanent access road comprises permanent access road to the dam site (L=12.1 km), existing road betterment (L=21.0 km), and bridge installation (three). Of these work items, the costs for the temporary/ permanent access road construction are estimated based on the detailed work quantities and the unit prices. Costs for the other works are estimated on a length measure or square measure basis.

(2) Civil Works

The construction cost for each civil work is estimated by multiplying work quantity and unit price in principle. The unit prices of major civil works are determined by making a breakdown of each unit price as described in the preceding section. The cost components of the breakdown of unit price comprise labor, materials, equipment, and contractor's indirect cost. Each cost component is explained as below.

(i) Labor wage

Almost all the skilled and semi-skilled will be employed from Thailand. Labor wage is based on the basic daily wages in 8-hour per shift for each kind of labor. Each labor wage is shown below.

Table 10.3.1 Labor Wage (Unit : US$)

Labor	Unit	Wage
Foreman	day	21.00
Operator	day	18.00
Driver for dump truck	day	10.00
Concrete worker	day	11.00
Carpenter	day	11.00
Plumber	day	11.00
Mechanic	day	13.00
Electrician	day	13.00
Welder	day	13.00
Skilled labor	day	8.00
Common labor	day	6.00

(ii) Material cost

As described in the preceding section 10.2 Construction Plan and Schedule, almost all the materials except fuel and wooden materials will be obtained from abroad. The aggregate materials including fine aggregate will be produced at the quarry site. Both coarse aggregate and fine aggregate therefore are estimated based on the quarry development cost, production cost at the aggregate crushing plant, and hauling charge to the site. Each material cost is shown below.

Table 10.3.2 Material Cost (Unit : US$)

Materials	Unit	Unit Price
Light oil	liter	0.31
Gasoline	liter	0.36
Portland cement	ton	73.00
Deformed bar	ton	345.00
Timber for formwork	m^3	157.56
Plywood for formwork	m^3	136.55
Dynamite	kg	2.90
Electric power	kWh	0.05
Coarse aggregate	ton	7.85
Fine aggregate	ton	10.22

(iii) Equipment cost

The equipment cost comprises depreciation cost, repair and maintenance cost, and annual administration cost. The equipment cost on hourly or daily basis is estimated, referring to authorized guideline used in Japan to determine the life time, rate of repair, maintenance and administration expenses.

(iv) Contractor's indirect cost

Overhead expenses and profits are contributed to the unit rates of each work item. These expenses are estimated at 25 percent of the direct cost comprising labor wage, material cost, and equipment cost.

(v) Unit prices of major civil works

Each of the unit prices of major civil works except foundation grouting is made using the above base costs and the production rates of equipment and labor, based on the construction plan. Each unit price is shown below, while each breakdown of the unit prices is shown in the supporting report.

Table 10.3.3 Unit Prices of Major Civil Works (Unit : US$)

Work Item	Unit	Unit Price
Open excavation, common	m^3	4.8
Open excavation, rock	m^3	10.0
Tunnel excavation [a)]	m^3	46.8
Dam embankment	m^3	3.3
Open structural concrete [b)]	m^3	79.6
Tunnel lining concrete [b)]	m^3	92.0
Reinforcement bar	ton	584.3
Foundation grouting [c)]	m	114.1

Note;
a) Unit price of tunnel excavation includes costs for all kinds of tunnel support.
b) Unit price of concrete works includes cost for fromwork.
c) This unit price was determined with the average contract unit price of 7 similar projects.

(3) Metal Works

The cost for metal works comprises the CIF price at Bangkok, inland transportation charge, and installation cost. The unit price per weight of respective type of structure is determined, referring to the recent bidding data of similar works. Each unit price is shown below.

Table10.3.4 Unit Prices of Metal Works (Unit : US$)

Type of Structure	Unit	Unit Price
Slide gate leaf and stoplog leaf	ton	5,000
Guide frame	ton	6,000
Diversion gate guide frame	ton	5,000
Radial and fixed wheel gate leaves	ton	6,000
Hoist, gantry crane, high pressure gate and valve	ton	8,000
Radial gate anchorage	ton	5,000
Trashrack	ton	3,000
Steel penstock and outlet pipe	ton	4,000
Hydraulic unit	ton	12,000

(4) Generating Equipment

The cost for generating equipment comprises the CIF price at Bangkok, inland transportation charge, and installation cost. The lump sum estimating method is applied to components of generating equipment. The cost of respective components is determined by referring to the recent bidding data of similar works.

(5) Transmission Line and Substation

The cost for tower materials, conductors and substation equipment comprises the CIF price at Bangkok, inland transportation charge, and installation cost. The civil works such as site clearance, earthwork, and foundation treatment are included in the transmission line cost. The cost for transmission line is estimated with unit price estimating method, while the cost for substation is estimated as a lump sum. The cost of respective components is determined, referring to the recent bidding data of similar works.

(6) Environmental Cost

The environmental cost consists of the environmental monitoring and planning, and resettlement cost. These costs are estimated by taking into account the results of the environmental impact study in this feasibility study.

(7) Operation Cost for SPC

The operation cost for SPC consists of the site investigation and tender design, and administration of SPC. The lump sum estimating method is applied to the site investigation, while the man/month basis estimating method is applied to the tender design. The administration of SPC is assumed at 2 % of the total of the construction and environmental costs.

(8) Price Contingency

Price contingency is estimated with the assumed price escalation rate of 1.3 % per annum which is produced as an average escalation rate from the year 2001 USA CPI (Consumer Price Index) escalation of 1.6 % and an escalation of 1.1 % between June 2001 to June 2002.

10.3.3 BASE COST

Base cost in total is estimated at about US$ 343.7 x 10^6 as summarized below and detailed in Table 10.3.7 and 10.3.8.

Table10.3.5 Total Project Cost (Unit : US$)

Particular	Draft Final
1. Construction Cost	
1.1 Civil Works	178,411,440
1.2 Metal Works	20,287,000
1.3 Generating Equipment	59,137,400
1.4 Transmission Line and Substation	33,946,000
Sub-total (1.1 to 1.4)	291,781,840
2. Environmental Cost	
2.1 Environmental Monitoring and Planning	9,669,000
2.2 Resettlement Cost	6,804,260
Sub-total (2.1 to 2.2)	16,473,260
3. Operation Cost for SPC	
3.1 Site Investigations and Tender Design	4,125,000
3.2 Administration for SPC	6,165,100
Sub-total (3.1 to 3.2)	10,290,100
Sub-total (1 to 3)	318,545,200
4. Price Contingency	25,167,410
Base Cost	**343,712,610**

10.3.4 ANNUAL DISBURSEMENT SCHEDULE

The annual disbursement schedule is made in accordance with the base cost and the construction schedule as summarized below and detailed in Table 10.3.9.

Table10.3.6 Annual Disbursement Schedule (Unit : US$)

Year	Amount
2005	26,481.9
2006	23,007.0
2007	83,929.6
2008	86,533.4
2009	72,418.4
2010	51,342.3
Total	343,712.6

Table 10.3.7 Summary of Project Cost

Unit: US$

Particular	Draft Final
C1. Temporary Facilities	8,674,000
C2. Permanent Access Road	8,052,000
C3. River Diversion Works	22,459,610
C4. Main Dam	47,060,350
C5. Spillway	63,400,860
C6. Bottom Outlet and Plug for Diversion Tunnel	1,414,010
C7. Power Intake	1,849,650
C8. Headrace Tunnel	3,893,340
C9. Surge Tank	808,320
C10. Penstock Line	2,918,490
C11. Power Station (Main Dam)	4,886,220
C12. Re-regulating Weir and Dykes	8,047,580
C13. Power Station (Re-regulating Weir)	4,947,010
Sub-total for Civil Works (C1 to C13)	178,411,440
C14. Metal Works for Power Station (Main Dam)	19,594,000
C15. Metal Works for Power Station (Re-regulating Weir)	693,000
C16. Generating Equipment for Power Station (Main Dam)	46,968,900
C17. Generating Equipment for Power Station (Re-regulating Weir)	12,168,500
C18. Transmission Line and Substation for Power Station (Main Dam)	31,146,000
C19. Transmission Line and Substation for Power Station (Re-regulating Weir)	2,800,000
Sub-total for M & E Works (C14 to C19)	113,370,400
Total Construction Cost (C1 to C19)	**291,781,840**
E1. Environmental Monitoring and Planning	9,669,000
E2. Resettlement Cost	6,804,260
Total Environmental Cost (E1 to E3)	**16,473,260**
O1. Site Investigation and Tender Design	4,125,000
O2. Administration of SPC	6,165,100
Total Operation Cost for SPC (O1 to O2)	**10,290,100**
Total Project Cost (w/o Price Contingency)	**318,545,200**

Table10.3.8 Breakdown of Project Cost (1/3)

Particular	Unit	Unit Price (US$)	Qty	Amount (US$)	Draft Final
C1. Temporary Facilities					8,674,000
Temporary Road to Dam Site (L=9.9km)	LS			1,955,000	
Temporary Road to Quarry Site (L=23.7km)	LS			4,589,000	
Telecommunication Line	km	10,000	51	510,000	
Power Distribution Line	km	20,000	31	620,000	
Base Camp	m^2	50.0	10,000	500,000	
Other miscellaneous (Mobilization, etc.)	LS			500,000	
C2. Permanent Access Road					8,052,000
Permanent Access Road to Dam Site (L=12.1km)	LS			5,452,000	
Existing Road Betterment	km	100,000	21	2,100,000	
Bridge Installation (3 nos.)	m^2	1,000	500	500,000	
C3. River Diversion Works					22,459,610
Open Excavation in Common	m^3	4.8	316,000	1,516,800	
Open Excavation in Rock	m^3	10.0	37,000	370,000	
Cofferdam Embankment	m^3	3.3	409,000	1,349,700	
Open-Concrete Works for Inlet and Outlet	m^3	79.6	18,900	1,504,440	
Open Concrete Works for Cofferdam Slab	m^3	79.6	4,200	334,320	
Tunnel Excavation	m^3	46.8	206,000	9,640,800	
Tunnel Lining Concrete	m^3	92.0	56,100	5,161,200	
Re-bar	ton	584.3	3,300	1,928,190	
Other miscellaneous	-	3.0%		654,160	
C4. Main Dam					47,060,350
Open Excavation in Common	m^3	4.8	1,650,000	7,920,000	
Main Dam Embankment	m^3	3.3	7,268,000	23,984,400	
Tunnel Excavation	m^3	46.8	1,000	46,800	
Curtain Grouting	m	114.1	47,000	5,362,700	
Consolidation Grouting	m	114.1	4,000	456,400	
Open Concrete Works for Slab and Plinth	m^3	79.6	41,000	3,263,600	
Mass Concrete	m^3	79.6	35,000	2,786,000	
Re-bar	ton	584.3	3,200	1,869,760	
Other miscellaneous (measuring apparatus, etc.)	-	3.0%		1,370,690	
C5. Spillway					63,400,860
Open Excavation in Common	m^3	4.8	1,935,000	9,288,000	
Open Excavation in Rock	m^3	10.0	3,892,000	38,920,000	
Backfill	m^3	3.3	62,000	204,600	
Open Concrete Works	m^3	79.6	135,000	10,746,000	
Re-bar	ton	584.3	4,100	2,395,630	
Other miscellaneous (slope protection, etc.)	-	3.0%		1,846,630	
C6. Bottom Outlet and Plug for Diversion Tunnel					1,414,010
Plug Concrete	m^3	92.0	6,900	634,800	
Tunnel Excavation for Access Gallery	m^3	46.8	10,000	468,000	
Tunnel Lining Concrete for Access Gallery	m^3	92.0	2,300	211,600	
Re-bar for Access Gallery	ton	584.3	100	58,430	
Other miscellaneous	-	3.0%		41,180	
C7. Power Intake					1,849,650
Open Excavation in Common	m^3	4.8	61,000	292,800	
Open Excavation in Rock	m^3	10.0	13,000	130,000	
Shaft Excavation	m^3	46.8	4,500	210,600	
Open Concrete Works	m^3	79.6	6,500	517,400	
Shaft Concrete	m^3	92.0	3,200	294,400	
Re-bar	ton	584.3	600	350,580	
Other miscellaneous	-	3.0%		53,870	
C8. Headrace Tunnel					3,893,340
Tunnel Excavation	m^3	46.8	44,300	2,073,240	
Tunnel Lining Concrete	m^3	92.0	12,200	1,122,400	
Re-bar	ton	584.3	1,000	584,300	
Other miscellaneous	-	3.0%		113,400	
C9. Surge Tank					808,320
Open Excavation in Common	m^3	4.8	42,000	201,600	
Open Excavation in Rock	m^3	10.0	4,000	40,000	
Shaft Excavation	m^3	46.8	4,800	224,640	
Open Concrete Works	m^3	79.6	800	63,680	
Shaft Lining Concrete	m^3	92.0	1,500	138,000	
Re-bar	ton	584.3	200	116,860	
Other miscellaneous	-	3.0%		23,540	
C10. Penstock Line					2,918,490
Open Excavation in Common	m^3	4.8	150,000	720,000	
Open Excavation in Rock	m^3	10.0	40,000	400,000	
Tunnel Excavation	m^3	46.8	3,600	168,480	
Tunnel lining Concrete	m^3	92.0	1,100	101,200	
Open Concrete Works	m^3	79.6	13,000	1,034,800	

Table10.3.8 Breakdown of Project Cost (2/3)

Particular	Unit	Unit Price (US$)	Qty	Amount (US$)	Draft Final
Re-bar	ton	584.3	700	409,010	
Other miscellaneous	-	3.0%		85,000	
C11. Power Station (Main Dam)					**4,886,220**
Open Excavation in Common	m^3	4.8	87,000	417,600	
Open Excavation in Rock	m^3	10.0	12,000	120,000	
Backfill	m^3	3.3	135,000	445,500	
Open Concrete Works	m^3	79.6	26,000	2,069,600	
Re-bar	ton	584.3	1,000	584,300	
Building, Utilities, and Electrical Works	LS	50% of P/H substructure		1,106,900	
Other miscellaneous	-	3.0%		142,320	
C12. Re-regulating Weir and Dykes					**8,047,580**
Open Excavation in Common	m^3	4.8	345,000	1,656,000	
Open Excavation in Rock	m^3	10.0	70,000	700,000	
Embankment	m^3	3.3	459,000	1,514,700	
Open-Concrete Works	m^3	79.6	39,000	3,104,400	
Curtain Grouting	m	114.1	900	102,690	
Consolidation Grouting	m	114.1	300	34,230	
Re-bar	ton	584.3	1,200	701,160	
Other miscellaneous	-	3.0%		234,400	
C13. Power Station (Re-regulating Weir)					**4,947,010**
Open Excavation in Common	m^3	4.8	75,000	360,000	
Open Excavation in Rock	m^3	10.0	19,000	190,000	
Embankment	m^3	3.3	11,000	36,300	
Open-Concrete Works	m^3	79.6	43,000	3,422,800	
Curtain Grouting	m	114.1	200	22,820	
Consolidation Grouting	m	114.1	100	11,410	
Re-bar	ton	584.3	1,300	759,590	
Other miscellaneous	-	3.0%		144,090	
Sub-total for Civil Works (C1 to C13)				**178,411,440**	**178,411,440**
C14. Metal Works for Power Station (Main Dam)					**19,594,000**
Diversion Tunnel Gates					
Gate leaf	ton	5,000	110	550,000	
Guide frame	ton	5,000	32	160,000	
Spillway Stoplogs					
Stoplog leaf	ton	5,000	90	450,000	
Guide frame	ton	6,000	40	240,000	
Gantry crane	ton	8,000	30	240,000	
Spillway Gates					
Gate leaf	ton	6,000	360	2,160,000	
Guide frame	ton	6,000	30	180,000	
Hoist	ton	8,000	90	720,000	
Anchorage	ton	5,000	110	550,000	
Intake Bulkhead Gates					
Gate leaf	ton	6,000	70	420,000	
Guide frame	ton	6,000	20	120,000	
Hoist	ton	8,000	18	144,000	
Intake Screen	ton	3,000	68	204,000	
Bottom Outlet, Howell-bunger Valve					
Howell-bunger valve	ton	8,000	40	320,000	
Hydraulic unit	ton	12,000	10	120,000	
Bottom Outlet, Emergency Gate					
High pressure gate	ton	8,000	75	600,000	
Outlet pipe	ton	4,000	110	440,000	
Bottom Outlet Intake Screen	ton	3,000	90	270,000	
Penstock Steel	ton	4,000	2,100	8,400,000	
Tailrace Gates					
Gate leaf	ton	5,000	30	150,000	
Guide frame	ton	6,000	18	108,000	
Gantry crane	ton	8,000	9	72,000	
Re-Regulating Weir, Stoplog for Check Gates					
Stoplog leaf	ton	5,000	40	200,000	
Guide frame	ton	6,000	40	240,000	
Monorail hoist	ton	8,000	12	96,000	
Re-Regulating Weir, Check Gates					
Gate leaf	ton	6,000	265	1,590,000	
Guide frame	ton	6,000	55	330,000	
Hoist	ton	8,000	65	520,000	
Other miscellaneous	-			0	
C15. Metal Works for Power Station (Re-regulating Weir)					**693,000**

Table10.3.8 Breakdown of Project Cost (3/3)

Particular	Unit	Unit Price (US$)	Qty	Amount (US$)	Draft Final
Trashrack	ton	3,000	52	156,000	
Inlet Gate					
Gate leaf	ton	5,000	48	240,000	
Guide frame	ton	6,000	20	120,000	
Outlet Gate					
Gate leaf	ton	5,000	13	65,000	
Guide frame	ton	6,000	8	48,000	
Gantry crane	ton	8,000	8	64,000	
Other miscellaneous	-			0	
C16. Generating Equipment for Power Station (Main Dam)					**46,968,900**
Hydraulic Turbines and Auxiliary Equipment	LS			14,669,000	
Generators and Associated Equipment	LS			13,545,000	
Transformers	LS			6,035,700	
Switchgears and Control Equipment	LS			8,145,800	
Associated Equipment and Materials	LS			4,573,400	
Other miscellaneous	-			0	
C17. Generating Equipment for Power Station (Re-regulating Weir)					**12,168,500**
Hydraulic Turbines and Auxiliary Equipment	LS			5,872,800	
Generators and Associated Equipment	LS			3,947,400	
Transformers	LS			403,000	
Switchgears and Control Equipment	LS			973,500	
Associated Equipment and Materials	LS			971,800	
Other miscellaneous	-			0	
C18. Transmission Line and Substation for Power Station (Main Dam)					**31,146,000**
Transmission Line	km	230,000	125.2	28,796,000	
Substation	LS			2,350,000	
Other miscellaneous	-			0	
C19. Transmission Line and Substation for Power Station (Re-regulating Weir)					***2,800,000***
Transmission Line	km	50,000	40	2,000,000	
Substation	LS			800,000	
Other miscellaneous	-			0	
Sub-total for M & E Works (C14 to C19)				**113,370,400**	**113,370,400**
Total Construction Cost (C1 to C19)				**291,781,840**	**291,781,840**
E1. Environmental Monitoring and Planning					***9,669,000***
Completion of EIA Study to International Standards				726,000	
Completion of Resettlement Action Plan(RAP) & Social Action Plan(SAP)				825,000	
Organization of Environmental Management Unit (EMU) and Committee				500,000	
Measures during Construction Phase (5 years)				5,230,000	
Measures during Reservoir Filling Phase				510,000	
Measures during Initial Operation Phase (year 1-5)				579,000	
Measures during Concession Period (year 6-25)				420,000	
Other miscellaneous	-	10%		879,000	
E2. Resettlement Cost					**6,804,260**
Resettlemnt				975,000	
Livelihood Component				2,159,000	
Community Development & Management				1,624,220	
Possible Population Growth (30% of Total)				1,427,470	
Other miscellaneous	-	10%		618,570	
Total Environmental Cost (E1 to E3)				**16,473,260**	**16,473,260**
O1. Site Investigation and Tender Design					**4,125,000**
Site Investigation	LS			1,500,000	
Tender Design	M/M	15,000	150	2,250,000	
Other miscellaneous	-	10%		375,000	
O2. Administration of SPC during Construction					**6,165,100**
Administrarion of SPC during Construction	-	2% of C & E		6,165,100	
Total Operation Cost for SPC (O1 to O2)				**10,290,100**	**10,290,100**
Total Project Cost (w/o Price Contingency)				**318,545,200**	**318,545,200**

Table 10.3.9 Breakdown of Annual Disbursement Schedule

(Unit: US$)

Description	Amount	Year									Total
		2002	2003	2004	2005	2006	2007	2008	2009	2010	
1. Temporary Facilities/ Permanent Access Road	16,726,000				16,726,000						16,726,000
2. Civil Works											
2.1 : River Diversion Works	22,459,610					11,229,805	11,229,805				22,459,610
2.2 : Main Civil Works	139,225,830					6,961,292	41,767,749	48,729,041	34,806,458	6,961,292	139,225,830
3. Metal Works	20,287,000						4,057,400	5,071,750	5,071,750	6,086,100	20,287,000
4. Generating Equipment	59,137,400						11,827,480	14,784,350	14,784,350	17,741,220	59,137,400
5. Transmission Line and Substation	33,946,000						6,789,200	8,486,500	8,486,500	10,183,800	33,946,000
Sub-total (1 to 5)	291,781,840				16,726,000	18,191,097	75,671,634	77,071,641	63,149,058	40,972,412	291,781,840
6. Environmental Monitoring and Planning	9,669,000				2,030,490	1,063,590	1,063,590	1,063,590	1,063,590	3,384,150	9,669,000
7. Resettlement Cost	6,804,260				1,360,852	1,360,852	1,020,639	1,020,639	1,020,639	1,020,639	6,804,260
8. Site Investigation and Tender Design	4,125,000				4,125,000						4,125,000
9. Administration of SPC	6,165,100				1,233,020	1,233,020	924,765	924,765	924,765	924,765	6,165,100
Sub-total (1 to 8)	318,545,200				25,475,362	21,848,559	78,680,628	80,080,635	66,158,052	46,301,966	318,545,200
10. Price Contingency	25,167,410				1,006,511	1,158,472	5,248,951	6,452,847	6,260,331	5,040,295	25,167,410
Total project cost	343,712,610				26,481,873	23,007,031	83,929,579	86,533,482	72,418,383	51,342,261	343,712,610