15. Construction Plan and Construction Schedule

15. Construction Plan and Construction Schedule

		Page
15.1	Outline	15- 1
15.1.1	Selected Three Projects	15- 1
15.1.2	Basis in Formulating Construction Plan and Construction Schedule	15- 2
15.2	Se Kong No. 4 Project	15- 6
15.2.1	Construction Plan	15- 6
15.2.2	Construction Schedule	15-12
15.3	Xe Kaman No. 1 Project	15-15
15.3.1	Construction Plan	15-15
15.3.2	Construction Schedule	15-20
15.4	Xe Namnoy Project	15-23
15.4.1	Xe Namnoy Midstream Project	15-23
15.4.2	Xe Namnoy Midstream and Xe Namnoy Downstream	15-33

List of Tables

Table	Description
Table 15.1-1	Summary Table of Construction Road

List of Figures

Figures	Description
Fig. 15.2-1	Construction Schedule of Se Kong No. 4 Project
Fig. 15.3-1	Construction Schedule of Xe Kaman No. 1 Project
Fig. 15.4-1	Construction Schedule of Xe Namnoy Midstream Project
Fig. 15.4-2	Construction Schedule of Xe Namnoy Midstream and Downstream Project

15. Construction Plan and Construction Schedule

15.1 Outline

15.1.1 Selected Three Projects

In this chapter, construction plans and construction schedules for three projects listed below are studied on the basis of preliminary design described in Chapter 14.
Outlines of each project are briefly explained below.

(1) Se Kong No.4 Project

This project has; total reservoir capacity: $7{,}776\times10^6$ m^3, catchment area: 5,400 km^2, concrete-faced rock-fill dam of 164 m high and 14,400,000 m^3 in volume, and powerhouse at the foot of the dam. Maximum output of power generation is 443 MW. The construction period is estimated to be eight years and three months (99 months).

(2) Xe Kaman No.1 Project

This project has; total reservoir capacity: $16{,}208\times10^6$ m^3, catchment area: 3,800 km^2, R.C.C. concrete gravity dam of 143 m high and 1,670,000 m^3 in volume, and a power-house at the downstream end of short waterway. Maximum output is 256 MW. The construction period is estimated to be six years and two and a half months (74.5 months).

(3) Xe Namnoy Project

(3-1) Xe Namnoy Midstream Project

In this project, discharge for power generation is diverted from Xe Pian River which is close to the reservoir at Se Namnoy River for higher generation capacity. The scheme has; total reservoir capacity: 323 x 10^6 m^3 , catchment area: 749 km^2, zoned type rock fill dam of 69 m high and 1,253,000 m^3 in volume, and a powerhouse at the downstream end of waterway. Maximum output is 238 MW. The construction period is estimated to be four years and eleven months (59 months).

(3-2) Xe Namnoy Midstream and Downstream Project

This project is a combined plan consists of the above mentioned Xe Namnoy Midstream Project and another power station development scheme with daily regulating pond, called Downstream Project, located downstream of Xe Namnoy. Downstream scheme has; total storage volume: 16×10^6 m^3 , catchment area: 1,273 km^2, concrete gravity dam of 33 m high and 133,200 m^3 in volume. The powerhouse is a dam-waterway type which generates maximum output of 67 MW. Total maximum output of this combined plan is 305 MW. The construction period is estimated to be four years and eleven months (59 months).

15.1.2 Basis in Formulating Construction Plan and Schedule

(1) Mobilization

In the estimate of construction period, it is deemed that seven (7) months of time is required in mobilization. The construction is, therefore, expected to start in the eighth month.

(2) Transportation

Laos is an inland-country that has no marine ports. Transportation of construction equipment and materials will be done by river. Pakse, which is a center of southern Laos, is considered to be the transportation base. Pakse faces Me Kong River and there is ferry boat service to bridge the land transportation from Thailand.

National roads that connect Pakse and Sites are assumed to have width of 6 to 10 meters and well-maintained pavement. Further assumption is made that at every river-crossing point there is a steel bridge with its bearing weight of 20 tones, and most of such bridges are passable even in rainy season. Some parts of the roads may require alignment modification and reinforcement of wooden bridges for the purpose of transporting heavy construction and generation equipment. However such modifications and reinforcement are supposed not to effect the construction plans and schedules.

Pavement and improvement works for National Road Route 16 between Se Kong and Attapu have been under execution by ADB fund. Therefore, it is supposed that these works will be completed before the commencement of the relevant Projects in this Study.

In order to pass heavy equipment and materials across rivers where only ferry service is available, special cargo boat, i.e., barge, will be required.

As for the local roads, the present condition is not sufficient for the project use. All the reach of local roads relevant to the construction must be improved and some parts may have to be newly constructed. Such works are on the basis of the standard for the passage of 30-tonne trailer.

Existing road network is described in detail in Chapter 8, sub-section 8.5.2. and in **Table 8.5-2**.

(3) Construction Road

The roads that connect project sites and National Roads is to be regarded as Construction Roads, and to be newly constructed or improved. Some local roads may be included in construction roads. **Table 15.1-1** shows the reaches of construction and improvement necessary for each project. Construction and improvement of these construction roads is taken into account in the estimate of construction period.

(4) Power for Construction

Electricity required in construction is supplied by diesel power plants via sub-stations that are provided in the project site. There are no adequate power stations in the vicinity of project sites.

(5) Concrete Facilities

Necessary batching plants and crushing plants are considered that meet the use in construction of each scheme. This should be investigated in detail, later at the Feasibility Study.

Cement will be imported. Aggregate and sand will be exploited at the quarry and produced at the crushing plants.

Facilities relevant to concrete production are; crushing plant, batching plant, concrete pump and steel form, etc.

Concrete volumes estimated to be used in the projects are tabulated below.

Project	Concrete Volume [m^3]
Se Kong No.4	600,000
Xe Kaman No.1	1,800,000
Xe Namnoy Midstream	350,000
Xe Namnoy Downstream	270,000

(6) Telecommunication System

Telecommunication base should be established in Pakse or Attapu. Radio communication system will be used between the project site and the base. Other communication will be on the basis of public communication systems.

(7) Other Facilities

Other facilities for construction use such as air supply, water supply, drainage system, ventilation system, temporary houses and others will be studied in detail at the time of further study such as feasibility study.

(8) Working Days

The number of monthly working days for open works is assumed to be 20 days in consideration of holidays and bad weather. For underground works monthly working days is assumed to be 25 days.

Table 15.1-1 Summary Table of Construction Road

Project Name	Construction [km]	Improvement [km]	Total [km]
Se Kong No.4			
Se Kong to the site	14.0	14.0	28.0
Xe Kaman No.1			
Attapu to the dam site	22.0	23.0	45.0
Xe Namnoy Midstream			
(a) Route232 to Ban Latsasin	0.0	16.0	16.0
(b) Ban Latsasin to Surge Tank	8.0	18.0	26.0
(c) Route 16 to Powerhouse	18.0	0.0	18.0
(d) Route 232 to Xe Pian	3.0	0.0	3.0
Total	29.0	34.0	63.0
Xe Namnoy Downstream	included in Xe Namnoy Midstream		
(a) Route 16 to Downstream P/S	(10.0)	(0.0)	(10.0)
(b) P/S to dam	(6.0)	(0.0)	(6.0)
Total	(16.0)	(0.0)	(16.0)

15.2 Se Kong No.4 Project

15.2.1 Construction Plan

(1) Preparatory Works

Construction road of 28 km long between Se Kong town and the project site will be secured by improvement of existing road for 14 km long and newly constructed road of 14 km. These road works are estimated to take twelve (12) months after the mobilization of construction equipment and materials.

General site installation works and construction of haulage roads to main work sites will be completed within the aforementioned twelve months.

(2) River Diversion

a) Diversion Tunnel

Diversion tunnel consists of two lines of underground waterways that have circular cross-section with diameter of 12.5 m each and their lengths are 850 m and 745 m, respectively. Excavation of these tunnels will be done in parallel, started from both ends of each tunnel. Excavation method will be the upper-half and NATM method. The excavation work will take 6.5 months.

One unit of steel slide form will be employed for lining work of each tunnel. Concreting will be done by full-round placing system. The necessary time for the lining work is estimated to be nine and a half (9.5) months.

Prior to the diversion tunnel excavation, open excavation for diversion work should be completed which is estimated to take three (3) months. This work will be immediately followed by concrete works which will be done in parallel with and completed with tunneling works.

b) Temporary Cofferdam

After the river diversion, excavation for cofferdam abutment of 85,000 m^3 in volume will be carried out. Necessary time for the work is estimated to be two (2) months. Embankment of secondary cofferdam of 513,000 m^3 will take six (6) months. Con-

struction of concrete wall at the downstream of the main dam will take ten (10) months for placing concrete of 23,000 m^3.

(3) **Dam Works**

a) **Excavation for Dam Body**

Total excavation volume will be 2,648,000 m^3: 1,588,800 m^3 for common, 1,059,200 m^3 for rock. The excavation will be done in two steps: pre-diversion and post-diversion. In pre-diversion step, common excavation of 794,400 m^3 and rock excavation of 529,600 m^3, 1,324,000 m^3 in total, will take nine (9) months. In post-diversion step, the work consists of excavation of 1,324,000 m^3 in volume and foundation treatment and is estimated to take ten (10) months.

b) **Toe slab and Facing slab works**

b-1) Excavation for the toe slab is carried out together with dam foundation excavation, from top of the both abutment towards the bottom. The work is estimated sixteen (16) months.

Toe slab concrete is immediately placed following dam foundation treatment. The slab concrete at river bed portion is structured three (3) months ahead the commencement of the embankment work.

The slab concrete at both abutments is placed in advance of dam body embankment progress.

b-2) Facing slab concrete work employed steel sliding form, fifteen (15) m width span, is executed following completion of the dam embankment.

Two steel sliding forms, of 15 meters in span each, are necessary in this work because the dam crest length is very long (910 m).
The necessary time is estimated to be ten (10) months.

b-3) Starter slab between toe slab and facing slab is planned to be placed after the dam body embankment has reached to designed elevation.

The necessary time is considered to be well within the period of the embankment work on the construction schedule.

c) **Body embankment**

Dam body embankment work is estimated to take 2 years and 5 months to complete on the basis of average progress rate of 500,000 m^3 per month.

d) **Upstream backfill**

This backfill having healant function for crack in facing slab, is necessary.
This work is commenced before completion of the facing works because the working area has enough spaces to fill and completed two (2) months after curing period of the slab concrete.

The total volume of backfill is 2,265,000 m^3.

e) **Downstream backfill**

In parallel with the progress of the sub-structural concrete for powerhouse, the backfill is carried out up to the elevation of 154.5 m.

f) **Grouting for dam foundation**

The grouting is executed from the toe slab surface, by means of fabricating scaffold on the slab. This work continues through the construction period of the toe slab, dam embankment and facing slab work, and for two months thereafter.

(4) **Spillway Works**

The works are executed independently from the dam-related works because of side spillway type.

A total excavation volume of 5,310,000 m^3, common excavation of 3,186,000 m^3 and rock excavation of 2,214,000 m^3, takes two (2) years and seven (7) months.

Structural concrete of 208,000m^3 is considered to take two (2) years and four (4) months to be completed.

The necessary time for grouting work is estimated to add two (2) months to the above period for concreting .

The necessary time for installation of spillway gates is estimated to add seven (7) months to the above period for concreting.

The construction period of this work is that commencement is in the thirtieth (30th) month, same as the dam excavation works, and completion is the ninety-third (93rd) month.

(5) **Power Intakes, Headrace Tunnel and Penstock Works**

a) **Power Intake Works**

Open excavation of the intake and downstream portal of the headrace tunnel is carried out prior to tunnel driving which is to be commenced just after completion of excavation of diversion tunnel.

The intake excavation of 104,000 m^3 is estimated to take four (4) months and the downstream portal is estimated to take seven (7) months.

b) **Headrace tunnel works**

There are two lines of tunnel consisting of headrace tunnel portion and underground penstock tunnel portion. The headrace tunnel has an inner diameter of 6.2 m, and the underground penstock has an inner diameter of 5.4 m. Length of the tunnels are 385 m and 435 m respectively and these tunnels are driven with full face NATM method. The necessary time is estimated four (4) months.

Lining concrete is placed in both tunnels with only one unit of steel slide form by means of full round placing system. The necessary time is estimated twelve (12) months.

c) **Penstock works**

Open excavation of the open penstock is commenced after excavation of downstream portal has completed.

Excavation of 120,000 m^3, sum of common and rock, is considered to take eight (8) months.

Total concrete volume for the penstock route is 22,000 m^3. In this concrete work, for invert concrete and base of anchor blocks for penstock pipes, it is estimated to take nine (9) months.
After installation of penstock pipe, secondary concrete of the pedestal and backfill concrete in tunnel portion are carried out. Those are estimated to take nine (9) months.

(6) **Powerhouse and Tailrace Work**

a) **Powerhouse**

Powerhouse excavation of 46,000 m^3 and tailrace of 43,000 m^3 are started following river bed excavation of dam. They are estimated to take three (3) months and two (2) months respectively.
Powerhouse building work will be divided into two portions: one is a substructure of the powerhouse which is below EL.154.5 m and the other is a superstructure as a powerhouse building (above EL.154.5 m).
Construction takes eleven (11) months for substructure and nine (9) months for superstructure. The substructure and superstructure are constructed leaving the space required to install the relevant electric/mechanical equipment.

In composing construction schedule, second stage concrete around electric/mechanical equipment is regarded as being included in installation works and not indicated on the schedule table.

b) **Tailrace work**

Tailrace structures are assumed to have box culvert shape and estimated to take eleven (11) months in placing concrete of 16,000 m^3 in volume.
The works are done in parallel with sub-structures concrete of powerhouse.

Backfill is carried out following the progress of the tailrace concreting work and completed at the evaluation of 154.5 m.

The activity is finished at the same time of completion of powerhouse sub-structure.

(7) Switchyard Works

This work is executed following the powerhouse works and takes three (3) months.

(8) Impounding

For the purpose of ensuring storage in reservoir for running test of the generating equipment, it is considered that commencement of impounding is necessary to be eight (8) months prior to the test.
The facing slab concrete work may be influenced by the impounding.

It is considered that the periods of impounding and construction of facing slab are overlapped for three (3) months on the construction schedule, however, it is assumed that the rise of water level by impounding does not affect the facing slab works in this stage.

Further examination on this matter is required when feasibility study will be executed in the future.

(9) Hydraulic Metal Works

Period of designing, manufacturing, transportation, fabrication in site, etc. are not taken into account in the construction schedule table.

Periods of installation on site are only described as following;

Diversion gate and Intake gate	Beginning of 35th month ~ End of 40th month
Penstock pipe	Beginning of 47th months ~ End of 58th months
Tailrace Gate	Beginning of 63rd months ~ End of 67th months
Spillway Gate	Beginning of 88th months ~ End of 95th months

(10) Electrical and Mechanical Equipment

Prior to the major electro-mechanical works, the draft tube liner is installed firstly following the excavation of powerhouse foundation. The major works for the electro-

mechanical equipment are started after facilitation of civil structures by blocks of each unit. In the erection works of electro-mechanical equipment, a over head crane, casings, turbine runners and generators are installed in order.

Required period of the installation works of electro-mechanical equipment is estimated to be 24 month including secondary concrete work upto the commencement of first generating unit.

(11) Transmission Line Works

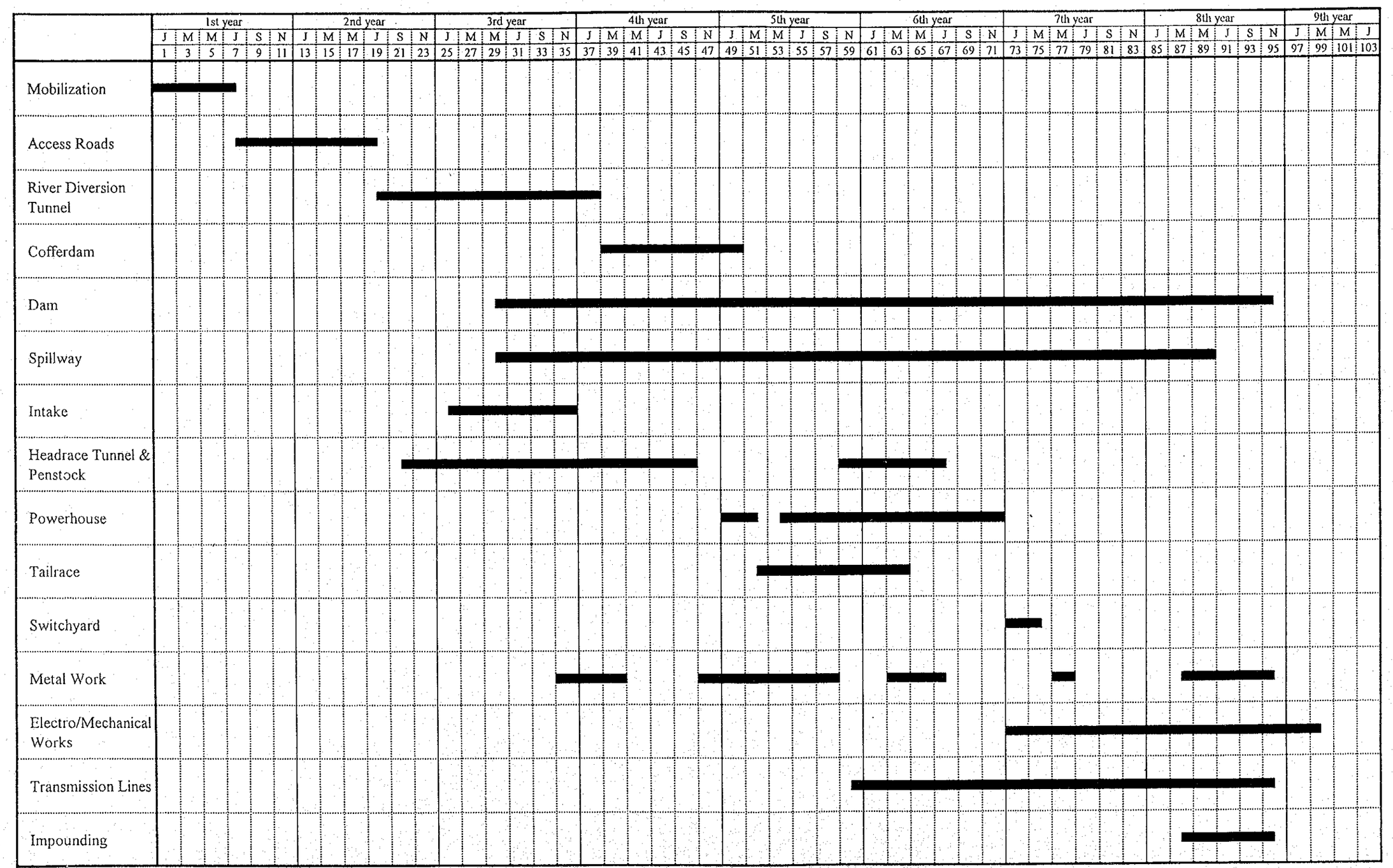
The following schedule is estimated in the transmission line works;

Manufacturing	2 years
Check survey	1 year
Construction of foundation of tower	1.5 years
Tower erection	1 year
Stringing work	1 year
Final inspection	4 months

15.2.2 Construction Schedule

According to construction plan mentioned in clause 15.2.1, the construction schedule was examined. The result is shown in **Fig. 15.2-1**.

Fig. 15.2-1 Construction Schedule of Se Kong No.4 Project



15.3 Xe Kaman No.1 Project

15.3.1 Construction Plan

(1) Preparatory Works

The special cargo boat, i.e., barge will be required instead of existing ferry boat to cross the Se Kong River at Attapu for the transportation of heavy equipment such as construction equipment and turbine/generator etc.. The construction road of 45 km in length between Attapu and the project site is necessary. The existing road of 23 km is required to be improved and the new road of 22 km is necessary to be constructed (Refer to **Table 15.1-1**). The road works are estimated to take twelve (12) months. General site installation works and construction of haulage roads to main work sites will be completed within the aforementioned twelve (12) months.

(2) River Diversion

a) Diversion Tunnel

Excavation for the portal is estimated two (2) months. Concrete work for the portal will be carried out in parallel with the tunnel work. The concreting work is estimated to take nine and half (9.5) months. A tunnel with diameter of 13.5 m and length of 435 m is planned for the diversion work. The tunnel will be excavated by two tunnel driving machines from the both portals in the manner of the top heading method and NATM method. The work takes four and half (4.5) months. One unit of steel slide form will be employed for lining work and concrete in full round will be placed. The work takes five (5) months.

b) Temporary Cofferdam

After river diversion, excavation for cofferdam abutment of 40,000 m^3 in volume will be carried out. It takes one (1) month. Embankment of 416,000 m^3 in volume takes four and half (4.5) months.

(3) Dam Works

a) Excavation for Dam Body

The total volume will be 311,000 m^3 : 186,000 m^3 for common, 124,400 m^3 for rock. The excavation will be done in two steps: pre-diversion and post-diversion. In pre-diversion step, common excavation of 112,000 m^3 (60%) and rock excavation of 50,000 m^3 (40%), 162,000 m^3 in total, will take three and half (3.5) months. In post-diversion step, the work consists of excavation of 149,000 m^3 in volume and foundation treatment, and is estimated to take four and half (4.5) months.

b) Dam Concrete Works

The work consists of dam and spillway concrete work of 1,618,000 m^3 and 52,000 m^3 in volume, respectively. The concrete of 1,528,000 m^3 of the main dam will be placed as a Roller Compacted Concrete : R.C.C. and the concrete of 90,000 m^3 will be placed as a outer segment of the dam body.

Dam concrete work is estimated to take one (1) year and nine (9) months on the condition that average concreting volume per month is 80,000 m^3. In other words, the dam will be constructed by 0.3 m in height per day.
In the construction schedule, it is estimated that concrete work of spillway is to be completed in seven (7) months after completion of dam concrete work.

c) Grouting for Dam Foundation

Consolidation grouting of 7,000 m and curtain grouting of 13,000 m in length will be carried out from the inspection gallery. The grouting work will be finished in two (2) months after completion of dam and spillway concrete works.

(4) Spillway Stilling Basin Works

Excavation of 243,000 m^3 in volume for a stilling basin is carried out in parallel with the dam excavation work. Supposing that excavation of half of said volume and the rest are executed before and after diversion, necessary period for the works take two and half (2.5) and four and half (4.5) months, respectively. Concrete work of 32,100 m^3 in volume takes five (5) months. Therefore, the work will start with excavation in the twenty-ninth (29th) month and complete with concrete work in the fortieth (40th) month. The backfill will be

carried out up to the elevation of 150 m during concrete work. It takes two (2) months including asphalt surface pavement.

(5) Power Intake, Headrace Tunnel and Penstock Works

a) Power intake works

Open excavation of the intake and downstream portal is carried out prior to tunnel driving. The intake excavation of 80,000 m^3 and the portal are estimated to take three (3) months. Two pits for the intake gate shaft will be driven downward and muck will be lifted by a crane. The excavation work takes one and half (1.5) month.The concrete of 4,000 m^3 for the intake structure is placed after lining concrete work of the headrace tunnel. The concrete work is estimated to take four (4) months. The concrete work for the gate shafts will be executed after completion of the lining. Necessary period is estimated one (1) month per one gate shaft.

b) Headrace tunnel and Penstock tunnel Works

There are two lines of headrace and penstock tunnel of which the length are 367 and 365 m in total of each line, respectively and the diameter are 4.8 m of the headrace tunnel and 4.2 m of the penstock tunnel, respectively. Suppose that one tunnel is excavated by one tunnel driving machine in the manner of full face cutting and NATM. The excavation work is estimated to take three and half (3.5) months. Lining concrete is placed in both tunnels with only one unit of steel slide form. The necessary time is estimated seven (7) months.

c) Penstock Open Portion

Open excavation will be commenced after completion of portal excavation for tunnel works. Total volume of the excavation is 210,000 m^3. The work is estimated to take seven (7) months. Total concrete volume for the penstock route is 18,100 m^3. In this concrete work, for invert concrete and base of anchor blocks for penstock pipes, it is estimated to take eight (8) months. After installation of penstock pipe, secondary concrete of the pedestal and backfill concrete in tunnel portion are carried out. Those are estimated to take seven (7) months.

(6) Powerhouse and Tailrace Work

a) Powerhouse

Powerhouse excavation of 26,500 m^3 and tailrace excavation of 35,000 m^3 are started following open excavation of the penstock route. The necessary period for the both excavation works is estimated five (5) months. Powerhouse building work will be divided into two portions: one is a substructure of the powerhouse which is below EL.135.5 m and the other is a superstructure as a powerhouse building (above EL.135.5 m). Construction takes eight (8) months for substructure and five (5) months for superstructure.

The superstructure and substructure are constructed leaving the space required to install electric/mechanical equipment.

In composing construction schedule, second stage concrete around electric/mechanical equipment is regarded as being included in installation works and not indicated on the schedule table.

b) Tailrace work

Prior to the tailrace work, temporary coffering, such as cofferdam will be necessary. Coffering work will take one (1) month. Tailrace excavation of 14,000 m^3 is carried out in parallel with the powerhouse excavation and estimated to take one (1) month.

Concrete work will be carried out from firstly the tailrace bay, secondly powerhouse substructure, thirdly tailrace, and finally retaining walls. Concrete work for the tailrace bay and tailrace takes eight (8) months which is the same period as that of concrete work for the powerhouse substructure. The concrete work of 15,200 m^3 for the retaining walls is estimated five (5) months. Backfill will be carried out step by step during concrete work for the retaining walls and finished one (1) month after completion of the concrete work for the walls.

(7) Switchyard Work

This work is executed following the powerhouse works and takes three (3) months.

(8) Impounding

For the purpose of ensuring storage in reservoir for running test of the generating equipment, it is considered that commencement of impounding is necessary to be thirty (30) months prior to the test. Accordingly, concrete work for the dam and spillway will be influenced by the long term impounding. It is assumed, however, that the rise of water level by impounding does not affect the concrete work in this report.
Further study on this point is required when feasibility study will be executed in the future.

(9) Hydraulic Equipment Works

Period of designing, manufacturing, transportation, fabrication in situ, and so on are not taken into account in the construction schedule table.
Period of installation on site are only described as following.

Closing gate at diversion tunnel	: Beginning of 29th month - Middle of 30th month
Intake gate	: Beginning of 39th month - End of 42nd month
Penstock pipe	: Beginning of 44th month - End of 56th month
Draft gate	: Beginning of 55th month - End of 57th month
Spillway gate	: Beginning of 55th month - End of 65th month

(10) Electrical/Mechanical Works

Prior to the major electro-mechanical works, the draft chube liner is installed firstly following the excavation of powerhouse foundation. The major works for the electro-mechanical equipment are started after facilitation of civil structures by blocks of each unit. In the erection works of electro-mechanical equipment, a over head crane, casings, turbine runners and generators are installed in order.

Required period of the installation works of electro-mechanical equipment is estimated to be 24 month including secondary concrete work upto the commencement of first generating unit.

(11) Transmission Line Works

The following schedule is estimated;

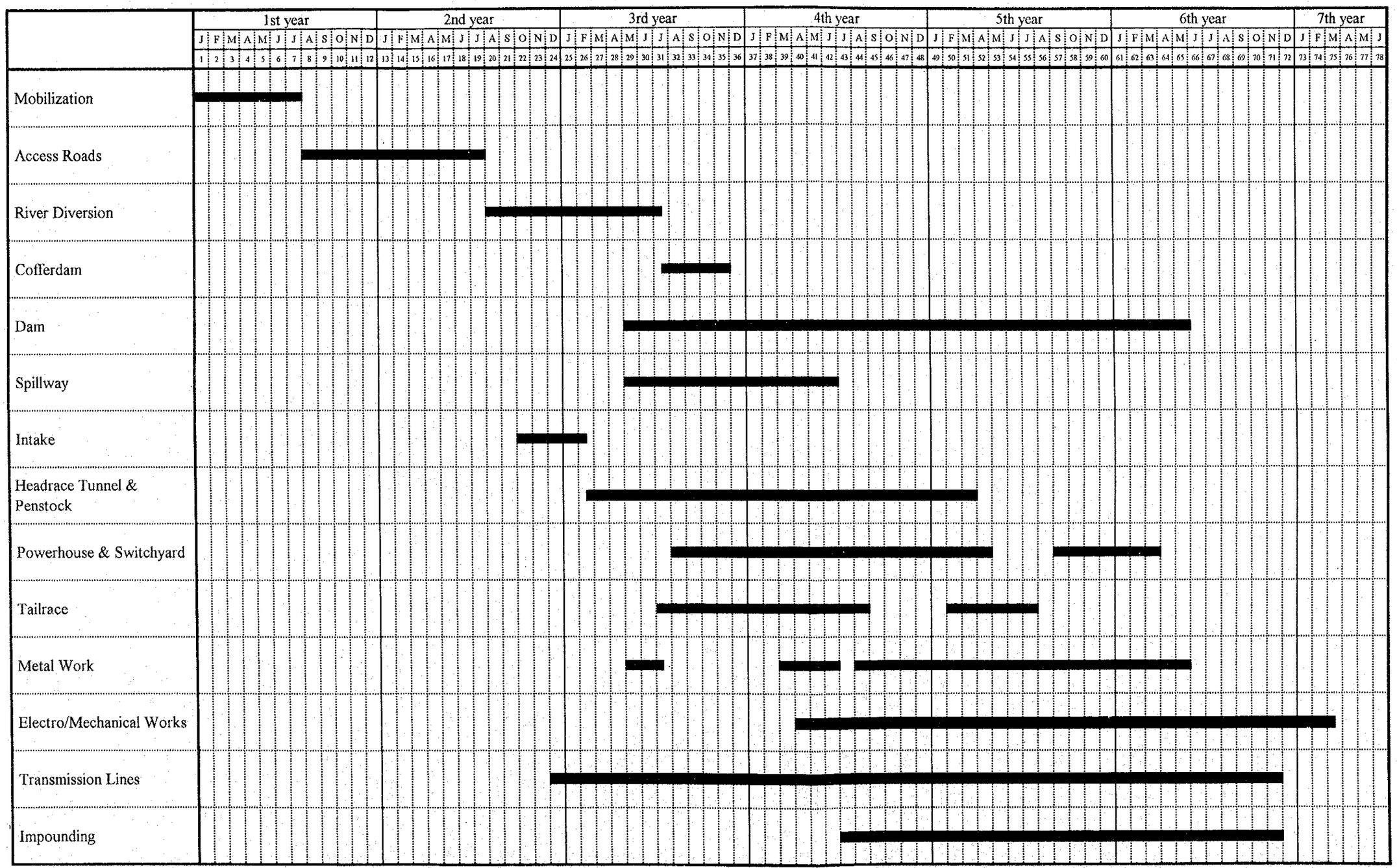
Manufacturing	2 years
Check survey	1 year
Construction of foundation	2 years

Tower erection	1.5 years
Stringing	1.5 years
Final inspection	4 months

15.3.2 Construction Schedule

According to construction plan mentioned in clause 15.3.1 above, the construction schedule was examined and result is shown in **Fig. 15.3-1**.

Fig. 15.3-1 Construction Schedule of Xe Kaman No.1 Project



15.4 Xe Namnoy Project

15.4.1 Xe Namnoy Midstream Project

(1) Cnstruction Plan

a) Gneral

In this project, the construction area is to be divided into two portions, that are Xe Namnoy Midstream Scheme and Xe Pian River Diversion Scheme.

In the Xe Namnoy Midstream Scheme, works for the headrace tunnel is to be a critical path. It is scheduled to execute the tunnel driving at total four faces at the same time for total 9,030 m length of the tunnel, but for this construction it is required to prepare an access road and adits, which are rather long. Therefore, for such preparatory works it takes a longer period prior to the commencement of the main works.
Total construction period for this scheme is estimated fifty nine (59) months from the commencement of the works to a commercial operation.

In the Xe Pian Diversion Scheme, firstly a diversion channel is constructed and after completion of the channel, a flow of the H. Lieng river is temporarily diverted to the Xe Pian River even though the flow gradient will be adverse. The purpose is to make the construction works easy without a drainage work during the construction at the site of the H. Lieng. After completion of the works in the H. Lieng river site, an intake weir of the Xe Pian will be commenced. Total construction period is estimated thirty-three (33) months from commencement of access road construction to completion of whole works in this area.

b) Preparatory Works

Prior to commencement of main works, a construction work of 26 km of new road and improvement works for 34 km of the existing roads is needed. (Refer to **Fig. 15.2-1**) The construction period for the work is totally estimated as fifteen (15) months. During this period, each temporary facility will be mobilized and installed at the site.

c) **Xe Namnoy Midstream Project**

In this area, the improvement of the National road No.232 and the local road between B. Latsasing and the dam site are required for the execution of the main construction works. Therefore, after commencement of the work, seven (7) months for mobilization of construction equipment and material, and six (6) months for road construction are required and in the fourteenth (14th) month the main works in this section will be commenced.

i) **River Diversion**

i-1) **Diversion Tunnel**

For the excavation work of portal of the tunnel, consisting of 57,400 m^3 of common and rock excavation, a construction period is estimated two and half (2.5) months.

For the tunnel excavation of 340 m length and 9.6 m of internal diameter, excavation of the tunnel will be done from both portals in parallel by the method of upper-half section and NATM method. The excavation work will take three (3) months.

For concrete lining, a steel slide form will be employed and a full section at one time will be lined. A total construction period for concrete lining is estimated four and half (4.5) months.

Outside concrete of 23,000 m^3 will be placed after completion of tunnel excavation and is continued one month after completion of the tunnel concrete lining.

i-2) **Temporary Cofferdam**

After the river diversion, excavation for cofferdam foundation of 23,000 m^3 in volume will be carried out. Necessary period for the excavation is estimated to be one and half (1.5) months. For the embankment of 111,000 m^3, a construction period is estimated to be two and half (2.5) months.

ii) Dam Works

ii-1) Excavation of Dam Body

Total excavation volume is 781,000 m^3, consisting of 468,600 m^3 of common excavation and 312,400 m^3 of rock excavation. The excavation will be done in two steps: pre-river diversion and post-river diversion. In pre-river diversion , common excavation of 187,000 m^3 (40%) and rock excavation of 125,000 m^3 (40%) will be completed in total four (4) months. After river diversion, excavation of 468,500 m^3 in total including foundation treatment will be done in seven (7) months.

ii-2) Rockfill Dam Embankment

It is estimated that embankment of rockfill, 1,253,000 m^3 in total volume, will be completed in nine (9) months.

ii-3) Grouting Work at Dam Foundation

Grouting work will be carried out in a gallery at the bottom of dam body. The quantity of grouting are estimated 2,500 m of consolidation grout and 20,000 m of consolidation grout. The grouting work will be carried out together with other works in parallel and therefore, in a construction schedule after completion of embankment of dam body, three (3) months is estimated.

iii) Spillway Works

As a spillway is designed in a location separately from the dam structure in this project, the construction work of the spillway is possible to carry out without any disturbance from the main dam construction.

An excavation work of 888,000 m^3 in total, consisting of 532,800 m^3 of common excavation and 355,200 m^3 of rock excavation will be carried out in one (1) year and two (2) months.

For concrete placement of 152,000 m^3 of the spillway structure, a steel slide form will be applied and the work will be complete in one (1) year and eight (8) months. Grouting work is considered to be included in the schedule above.

iv) **Power Intake Works**

For the excavation work of total 33,000 m^3 in volume, consisting of 19,800 m^3 of common excavation and 13,200 m^3 of rock excavation, it is estimated that a construction period required for the work including construction of access road t the site is three (3) months.

Excavation of the vertical shaft(H=30 m) for gate structure will be carried out in two steps by a method of pilot excavation using a climber and by enlargement method. Total period is estimated to be one (1) month.

Concrete placement for open portion of 2,700 m^3 in volume will be carried out after completion of the shaft excavation and a work period is to be three (3) months. Concreting methods are by a steel slide form for the pier portion and by a steel form for the inlet portion.

Concrete placement for the vertical shaft will be done after completion of concrete lining for the headrace tunnel and it is estimated to be two (2) months.

v) **Headrace Tunnel Works**

For the construction work of the headrace tunnel which has 4.5 m of internal diameter and 9,030 m length, three (3) construction adits will (No.1, No. and No.3, named tentatively) be prepared and the whole tunnel will be divided into four (4) sections(Section I, II, III and IV).

For the tunnel excavation, four (4) units of jumbo will be used for a full section excavation by NATM method.

For concrete lining, it is proposed to use four (4) units of a steel slide form with 18 m length.

Required duration for construction of access road to each construction adit is estimated thirteen (13) months for No.1 adit, sixteen (16) months for No.2 adit and twenty-two (22) months for adit No.3, respectively, after starting of the project. Construction periods for each construction adit is estimated two (2) months for adit No.1, six (6) months for adit No.2, and eight (8) months for adit No.3, respectively.

In relation to the main headrace tunnel, in Sections I and II, the excavation will be finished at thirty-eighth (38th) month and concrete lining will be completed at forty-eighth (48th) month. In Sections III and IV, the tunnel excavation will be finished at forty-fifth (45th) month and concrete lining will be completed at fifty-fifth (55th) month from the commencement. As concrete

lining works and grouting works will be carried out with some overlapping in schedule, additional one and half (1.5) months after completion of concrete lining will be estimated in the construction schedule.
Total construction period for the main works of the headrace tunnel is forty four (44) months starting the excavation of construction adit and finishing the grouting work in the headrace tunnel.

vi) Surge Tank Works

At the time of completion of the tunnel excavation in Section IV of the headrace tunnel, successively the excavation of the surge tank, which has an internal diameter 16 m and 109 m height, will be commenced.

The shaft excavation will be done in two steps; one is pilot tunnel excavation using a climber and the other is enlargement excavation using a jumbo. Total construction period for excavation is estimated to be seven (7) months.
Concrete lining for the shaft will be carried out using a steel slide form and a crane. Required time is estimated to be four (4) months.

A construction period for open excavation is considered to be included in the schedule above.

vii) Penstock Works

After completion of the main access roads, soon for preparatory works of the construction of a horizontal tunnel at the intermediate elevation and open excavation , construction of access roads for installation of penstock pipe and open excavation work will be started. Required time for the work is estimated to be three (3) months.

vii-1) Tunnel Portion

Excavation of the horizontal tunnel portion which has a dimension of internal diameter, 4.0 m, and 600 m length, will be done with a full section by NATM method.
Required time for the excavation is estimated to be seven (7) months.
Excavation of the inclined tunnel portion which has a diameter 4.0 m, and 280 m length, will be executed in two steps; one is a pilot tunnel excavation using

a climber and the other is an enlargement by leg drills. Required time for the excavation is estimated to be seven (7) months.

In relation to concrete works, after excavation, concrete will be placed in the invert section of the horizontal tunnel at first. It is estimated to be taken one month. Next after installation of the steel pipes, filling concrete will be placed and the required time for the work is estimated to be seven (7) months. Grouting work will be done after concrete placement, but both works are possible to be carried out with some overlapping in terms of time. Therefore, after filling concrete placement, additional two (2) months are considered to be required.

vii-2) Open Portion

Regarding the excavation for the open portion, which gas a work volume of total 177,000 m^3, consisting of 106,000 m^3 for common excavation and 70,800 m^3 for rock excavation, required time for the execution is estimated to be sixteen (16) months in total. In parallel to the excavation, shotcrete protection to the surface of slope will be placed. In relation to the open excavation, as the difference of elevation is more 285 m, some number of transportation roads will be constructed each 50 m difference of elevation for excavation purpose.

As the concrete works in the open portion, there are anchor blocks and saddles. The placement of such concrete will be carried out in two steps; one is for foundation for steel pipes and the other is for covering of steel pipes at each location of support. Required time for the work is estimated to be three (3) months for foundation and three (3) months for covering, and six (6) months in total.

viii) Installation of Penstock Pipe

Installation of the penstock pipe is considered to carry out separately in the tunnel portion, L1=880 m, and in the open portion, L=720 m, and total 1,520 m. For this work, it is estimated that required time are ten (10) months for tunnel portion and seven (7) months for open portion, but in a construction schedule, it is considered that there are some overlapping in time between

both portions. As a result, thirteen (13) months in total is estimated to be required for the work.

ix) Powerhouse Works

In this area, it is required to construct a new road of 15 km from the National road No.16 to the powerhouse site. Including time for mobilization, required time is estimated to be nineteen (19) months. Therefore, after twenty (20) months from the commencement of the works, the construction of the powerhouse will be started.

Regarding to the excavation work, of which volume is 158,000 m^3 in total; consisting of 94,800 m^3 for common excavation and 63,200 m^3 for rock excavation, it is estimated that total seven (7) months is required.

For the concrete works consisting of foundation concrete and building concrete, required time is estimated to be nine (9) months.

As the backfilling will be done in a line of progress of concrete works, in a construction schedule, additional one (1) month is estimated.

x) Tailrace Works

Prior to the excavation. a temporary cofferdam will be constructed around the tailrace structure. For the work it is estimated to be one (1) month required for the execution.

The main works consists of construction of tailrace structure and retaining wall. Excavation for tailrace and concrete work will be carried out together with the works for the powerhouse in parallel. Therefore, in the construction schedule, the construction period of seven (7) months including the temporary cofferdam construction is estimated.

For the retaining wall construction which will be carried out after completion of the powerhouse building, it is estimated to be five (5) months.

xi) Hydraulic Equipment Works

In relation to a construction schedule, periods of designing, manufacturing, transportation, fabrication at site and others are not shown in the construction schedule. Only the construction period for the installation Works is to be

drawn in a time schedule. Period for installation of each equipment are as follows;

Closing gate at diversion tunnel	:	Beginning of 22nd month ~ End of 24th month
Intake gate	:	Beginning of 25th month ~ End of 28th month
Penstock Pipe	:	Beginning of 38th month ~ End of 50th month
Tailrace gate	:	Beginning of 29th month ~ End of 31st month
Spillway gate	:	Beginning of 45th month ~ End of 52nd month

xii) Electrical and Mechanical Works at Powerhouse

Prior to the major electro-mechanical works, the draft tube liner is installed firstly following the excavation of powerhouse foundation. The major works for the electro-mechanical equipment are started after facilitation of civil structures by blocks of each unit. In the erection works of electro-mechanical equipment, a over head crane, casings, turbine runners and generators are installed in order.

Required period of the installation works of electro-mechanical equipment is estimated to be 24 month including secondary concrete work upto the commencement of first generating unit.

xiii) Transmission Line Works

A construction schedule of transmission Line is summarize as follows;

Manufacturing	1 year
Check survey	6 months
Construction of foundation of tower	1 year
Tower erection	7 months
Stringing	6 months
Final inspection	2 months

d) **Xe Pian River Diversion**

i) **Diversion Channel**

An excavation for the diversion channel consists of 79,200 m^3 of common excavation and 52,800 m^3 of rock excavation, i.e. total of 132,000 m^3 will be carried out for five (5) months. Consequently, 3,300 m^3 of concrete will be placed within four (4) months.
It is possible to execute excavation work and concreting work in parallel and therefore, in a construction schedule, two (2) months will be considered in addition to the above construction period. Also backfilling is carried out at any time following the progress of the concrete placement. In such condition, one month is allocated for the backfilling after concreting work in the schedule.

As mentioned in the section (1) above, it is considered to divert temporarily the flow of the H. Lieng river to the Xe Pian river. For this work, a cofferdam will be constructed just downstream of outlet of the diversion channel at the H. Lieng river as a temporary work. However, in relation to this plan, it will be required to examine a structure and type of cofferdam, structure of the channel, necessity of water supply to the inhabitant in the area concerned and a review of probable flood in a further study stage.

ii) **Riverbed Excavation of H. Lieng River**

It is estimated that a construction period is five (5) months for excavation of total 18,600 m^3 consisting of 3,700 m^3 of soil/earth and 14,900 m^3 of rock. A starting time for excavation is considered to be after the excavation work of the open channel between the Xe Pian river and the H. Lieng river is progressed in some extent, and it is twenty-eighth (28th) month.

iii) **H. Lieng Intake Weir**

At the time of construction of the weir, a flow of the H. Lieng river would be diverted to the Xe Pian river. Therefore, it is considered that only sump pits will be prepared for water treatment. For the weir, the quantity of excavation is total 24,900 m^3 consisting of 14,900 m^3 for common excavation and 10,000 m^3 for rock excavation. For these excavation, total construction period

is estimated one and half (1.5) months. For 19,800 m^3 of concrete placement of the intake weir, total construction period is estimated five (5) months. For the construction work in this section, construction method and temporary facilities required will be studied in detail in the further study.

iv) H. Lieng water Channel

iv-1) Open Channel

For the open channel of 4,100 m length, the excavation volume is a total 410,000 m^3 consisting of 234,000 m^3 for common excavation and 176,000 m^3 for rock excavation. For this work, a construction period is estimated totally sixteen (16) months. Also for the concrete of 26,400 m^3, a construction period is considered to be required thirteen (13) months, but as a construction schedule, excavation work and concreting work are possible to carry out in parallel. Therefore, only two months is added after end of the excavation works.

In the construction work in this section, the length of the structure is long and the quantity of the works are also much and therefore, this work is on a critical path among the works in the H. Lieng area.

iv-2) Tunnel Works

In the tunnel section, which has 900 m length and 14.2 m^2 of internal sectional area, the tunnel is driven from the both portal, downstream side and upstream side, in parallel. It is estimated one month for preparation of portal, five (5) months for tunnel excavation, six (6) months for concrete lining and two (2) months for grouting and a total period is fourteen (14) months.

v) Xe Pian Intake Weir

For construction, the flow of H. Lieng river which was once diverted to the Xe Pian river using the diversion channel, is re-diverted to the original flow and a flow of the Xe Pian river is flowed to the H. Lieng river, using the diversion channel. After this, the construction of the intake weir at the Xe Pian river is commenced. For the preparatory work, one (1) month is estimated.

For the excavation works of total 7,200 m^3, consisting of 3,600 m^3 of common excavation and 3,600 m^3 of rock excavation, total one and half (1.5) months of construction period is estimated.

For concrete placement work of total 11,000 m^3, a construction period is estimated two and half (2.5) months. In this section, a construction method should be examined in detail in a further study stage.

(2) Construction Schedule

Following the construction plan mentioned in the Section 15.4.1.(1), the construction schedule was examined and the result is shown in **Fig. 15.4-1**.

15.4.2 Xe Namnoy Midstream and Xe Namnoy Downstream

Xe Namnoy Midstream and Downstream Project means a total development of Xe Namnoy Downstream Project and Xe Namnoy Midstream scheme mentioned in the previous section.

Regarding to the Xe Namnoy Midstream scheme is mentioned in the section 15.4.1. Therefore, in this section, a construction plan on the Dam-waterway type power station consisting of a concrete gravity type dam of 133,200 m^3 in volume and 33 m height.

(1) Construction Plan

a) Preparatory Works

To approach the project site from the Route 16, construction of a new road of 16 km is necessary. (Refer to **Table 15.1-1**) Required time for this work is estimated to be ten (10) months. During this period, mobilization of each construction equipment and material and construction of the major access road will be completed.

b) River Diversion

i) Diversion Tunnel

For the open excavation at portal of 47,000 m^3 in total, required time is estimated to be three (3) months. Concrete work for open area will be carried

out together with the tunnel works in parallel and it is estimated to be thirteen (13) months.

For the tunnel excavation of 570 m length and 11.0 m of internal diameter, excavation of the tunnel will be done with two units of jumbo from both portals in parallel by the method of upper-half section and NATM method. The excavation work will take five (5) months.
For concrete lining, a steel slide form will be employed and a full section at one time will be lined. A total construction period for concrete lining is estimated eight (8) months.

ii) **Cofferdam**

After the river diversion, excavation for cofferdam foundation of 19,100 m^3 in volume will be carried out soon. Necessary period for the excavation is estimated to be one and half (1.5) months. Successively the embankment of 75,500 m^3 in volume will be carried out. A construction period is estimated to be one and half (1.5) months.

c) **Dam Works**

i) **Dam Body Excavation**

Total excavation volume is 107,000 m^3, consisting of 64,200 m^3 of common excavation and 42,800 m^3 of rock excavation. The excavation will be commenced together with the cofferdam excavation at the same time. Required time for excavation including the river foundation treatment is estimated to be seven (7) months.

ii) **Dam Concrete**

Concrete placement of the dam body, consisting of 133,200 m^3 in volume, will be carried out using a crane and relevant equipment. It is estimated that a construction period takes nine (9) months.

Concerning the concrete facilities, a detailed examination in the next study stage will be carried out.

iii) **Grouting Works at Dam Site**

Prior to the concrete placement of the dam body, total 6,500 m of grouting works, consisting of 5,500 m of curtain grout and 1,000 m of consolidation grout, will be carried out along the riverbed portion in two and half (2.5) months and before finishing of dam concrete placement, the grouting work will be completed.

d) **Spillway Works**

As a spillway type is a overflow type from the top of the dam structure, pier portion and inlet portion are considered to be included in the dam concrete. Therefore, in this section, for construction planning, only a portion of stilling basin is considered.
As this portion is close by the dam structure, the excavation work will be carried out together with dam excavation at the same time. The excavation volume is 70,500 m^3 in total and it is estimated that the required time for the work is five and half (5.5) months.
For concrete placement of total 32,000 m^3, a required time is estimated to be five and half (5.5) months.

In relation to the backfilling, it is considered that such work will be carried out in accordance with the progress of concrete works and therefore, there are some overlapping time. Then it is estimated to be two (2) months after completion of the concrete work.

e) **Intake Works**

After the river diversion, the works related to the intake structure will be carried out. Required time for open excavation of 8,000 m^3 in total is estimated to be one (1) month. Required time for structural concrete of 1,900 m^3 is estimated to be two and half (2.5) months. Required time for excavation of the vertical shaft for gate structure is estimated to be one month. Required time for concrete for gate shaft is estimated to be one (1) month.

In total, a construction period for intake structure is five and half (5.5) months.

f) **Headrace Tunnel Works**

For the construction work of the headrace tunnel which has 5.8 m of internal diameter and 3,670 m length, three (3) construction audits (No.1, No.2 and No.3, named tentatively) will be prepared and the whole tunnel will be divided into four (4) sections (Section I, II, III and IV).

For the tunnel excavation, three (3) units of jumbo will be used for a full section excavation by NATM method.

For concrete lining, it is proposed to use two (2) units of a steel slide form with 12 m length.

Required duration for construction of access road to each construction adit is estimated seventeen and half (17.5) months for No.1 adit, twenty (20) months for No.2 adit and twenty and half (20.5) months for adit No.3, respectively, after starting of the project. Construction periods for each construction adit is estimated three (3) months for adit No.1, three (3) months for adit No.2, and four (4) months for adit No.3, respectively.

In relation to the main headrace tunnel, the excavation will be finished at thirty-fourth (34th) month. The concrete lining will be completed with a construction period of thirteen (13) months.

Regarding to the grouting works, in the construction schedule, it is estimated to be completed two (2) months after completion of concrete lining..

g) **Surge Tank Works**

After completion of the tunnel excavation for the headrace tunnel, horizontal tunnel under the surge tank, and upper horizontal penstock tunnel, the excavation of vertical shaft of the surge tank (Inner diameter D=16.0 m, height H=45.0 m) will be carried out in two steps; the first is a pilot excavation using a climber and the second is excavation for enlargement using a jumbo equipment by NATM method. Construction period is estimated to be three (3) months.

Concrete for the vertical shaft will be placed after completion of concreting for the tunnel portion and it is estimated to be three (3) months as a required time.

Prior to the shaft excavation, in order to carry out the open excavation of 4,500 m^3 at the top of surge tank, it is required to construct a connection road. For these

works, 2 months for road construction and one month for open excavation is estimated in the construction schedule.

h) Penstock Works

The penstock structure in this project is a tunnel in all length with inner diameter D=5.6 m~5.4 m, and total length of 470 m, consisting of horizontal portion L1=380 m, and inclined shaft portion L2=90 m. For the construction of the penstock, a construction adit is required for at the horizontal section at the downstream, and the required time for construction is estimated to be seven (7) months.
Excavation of the horizontal tunnel will be carried out with a full section by NATM tire method. required time for construction is estimated to be four (4) months.

Excavation of the inclined tunnel portion, 90 m length, will be executed in two steps; one is a pilot tunnel excavation using a climber and the other is an enlargement by jumbo. Required time for the excavation is estimated to be three (3) months.
Required time for installation of penstock pipe is estimated to be nine (9) months and after completion of the filling concrete it is estimated one month for grouting work.

i) Powerhouse Works

To approach the powerhouse site from the Route 16, construction of a new road of 10 km is necessary. Required time for this work is estimated to be fifteen (15) months including mobilization. Therefore, after commencement of the project, the construction work at the powerhouse site will be commenced from the sixteenth (16th) month.
Required time for the excavation of 51,200 m^3 in total is estimated to be seven (7) months. Required time for foundation concrete and building concrete is estimated to be nine (9) months.

j) Tailrace Works

Prior to the excavation, a temporary cofferdam will be constructed around the tailrace structure. For the work it is estimated to be one month required for the execution.
The main works consists of construction of tailrace structure and retaining wall. Excavation for tailrace and concrete work will be carried out together with the

works for the powerhouse in parallel. Therefore, in the construction schedule, the construction period of eleven (11) months including the temporary cofferdam construction is estimated.

For the retaining wall construction which will be carried out after completion of the powerhouse building, it is estimated to be five (5) months.

k) Hydraulic Equipment Works

In relation to a construction schedule, periods of designing, manufacturing, transportation, fabrication at site and others are not shown in the construction schedule. Only the construction period for the installation Works is to be drawn in a time schedule. Period for installation of each equipment are as follows;

Closing gate at diversion tunnel	: Beginning of 32nd month~ Mid of 33rd month
Intake gate	: Beginning of 45th month ~ End of 47th month
Penstock Pipe	: Beginning of 36th month ~ End of 44th month
Tailrace gate	: Beginning of 25th month ~ End of 27th month
Spillway gate	: Beginning of 48th month ~ End of 53rd month

l) Electrical and Mechanical Equipment Works

Prior to the major electro-mechanical works, the draft tube liner is installed firstly following the excavation of powerhouse foundation. The major works for the electro-mechanical equipment are started after facilitation of civil structures by blocks of each unit. In the erection works of electro-mechanical equipment, a over head crane, casings, turbine runners and generators are installed in order.

Required period of the installation works of electro-mechanical equipment is estimated to be 24 month including secondary concrete work upto the commencement of first generating unit.

m) Transmission Line Works

A construction schedule of transmission line works is summarized as follows;

Manufacturing	1 year
Check survey	6 months
Construction of foundation	1 year
Tower erection	7 months

Stringing	6 months
Final inspection	2 months

(2) Construction Schedule

Following the construction plan mentioned in the Section 15.4.,2.(1), the construction schedule was examined and the result is shown in **Fig. 15.4-2**.

Fig. 15.4-1 Construction Schedule of Xe Namnoy Midstream Project

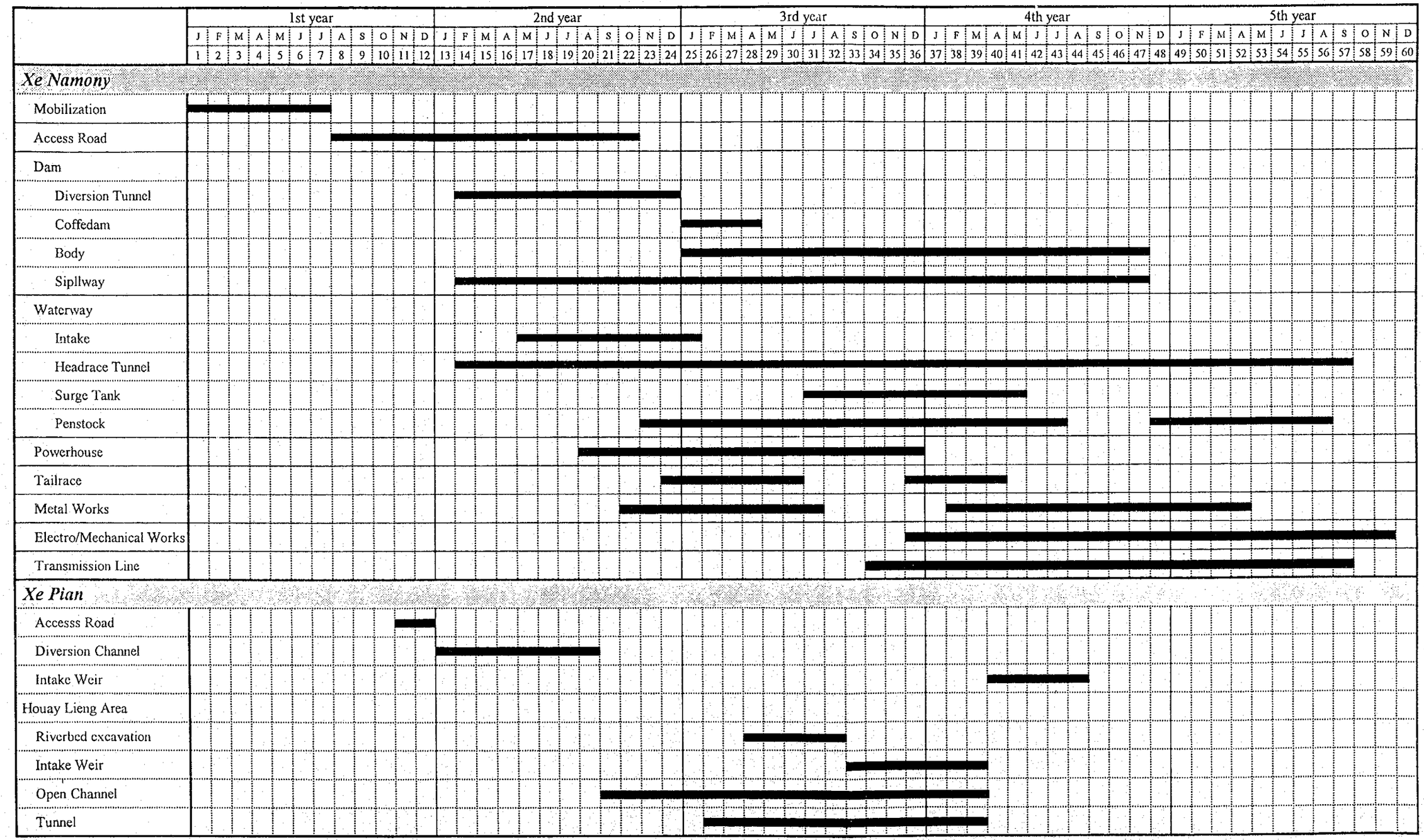
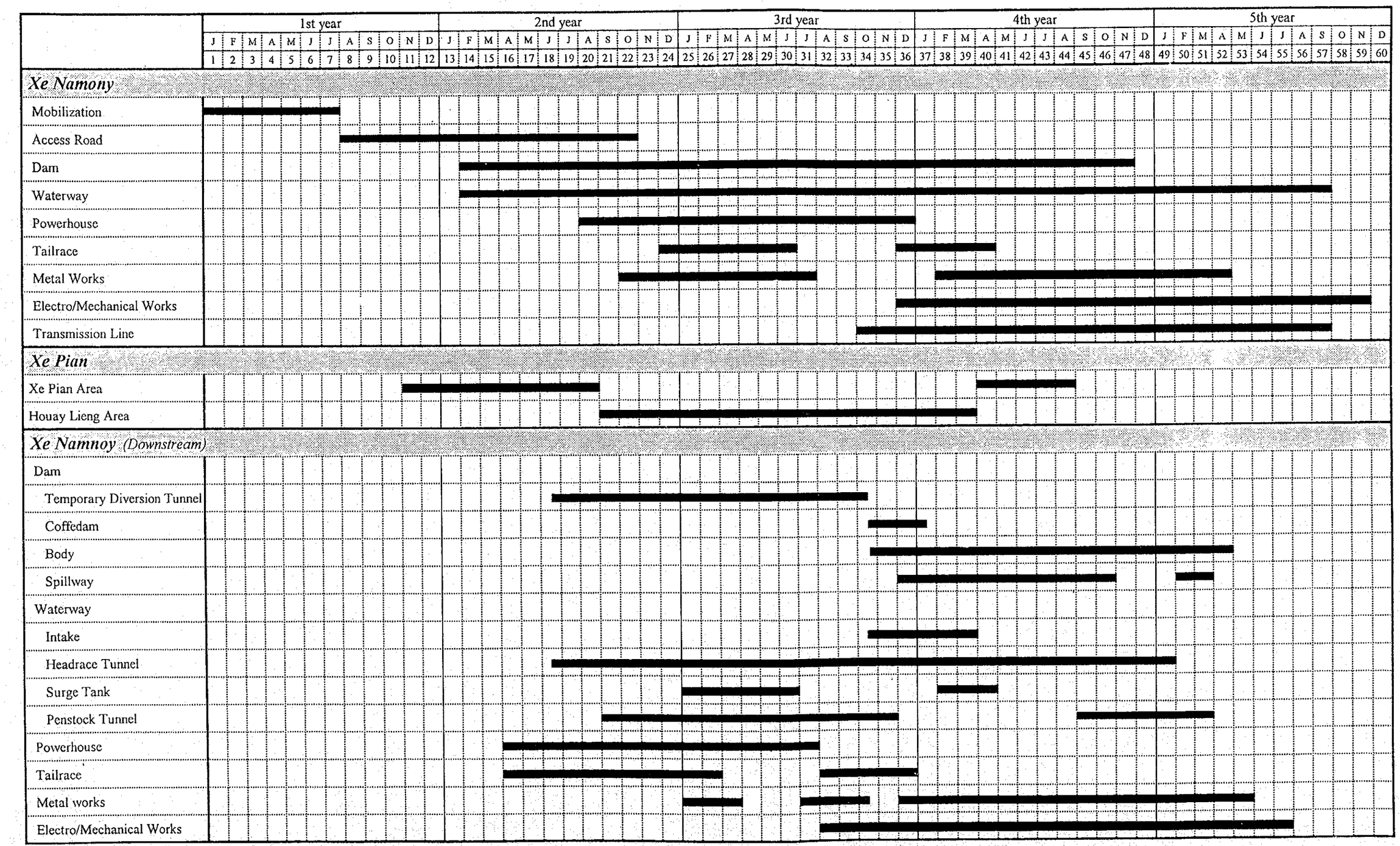


Fig. 15.4-2 Construction Schedule of Xe Namnoy Midstream and Downstream Project



16. Cost Estimates

16. Cost Estimates

		Page
16.1	Outline	16- 1
16.1.1	Basic Consideration	16- 1
16.1.2	Construction Cost	16- 2
16.1.3	Unit Price	16- 3
16.2	Se Kong No. 4 Project	16- 6
16.2.1	Unit Price	16- 6
16.2.2	Bills of Quantities	16- 6
16.2.3	Construction Cost	16- 6
16.3	Xe Kaman No. 1 Project	16- 9
16.3.1	Unit Price	16- 9
16.3.2	Bills of Quantities	16- 9
16.3.3	Construction Cost	16- 9
16.4	Xe Namnoy Project	16-11
16.4.1	Xe Namnoy Midstream Project	16-11
16.4.2	Xe Namnoy Midstream and Downstream Projects	16-13

List of Tables

Tables	Description
Table 16.1-1	List of Unit Rate
Table 16.2-1	Summary of Construction Cost for Se Kong No. 4 Project
Table 16.3-1	Summary of Construction Cost for Xe Kaman No. 1 Project
Table 16.4-1	Summary of Construction Cost for Xe Namnoy Midstream Project
Table 16.4-2	Summary of Construction Cost for Xe Namnoy Midstream Project and Downstream Project

16. Cost Estimates

16.1 Outline

16.1.1 Basic Consideration

The study is at the stage of pre-feasibility and the design itself is also a preliminary design stage. Under this condition, the bills of quantities for only the main structures are calculated. Therefore, in such condition, it is not required to evaluate each unit rate exactly by summing up from each cost component.

Under the above understanding, in this study, the cost estimates for the projects were proceeded referring to the unit rates which were decided by the cost data from the actual record of the existing projects and the projects under planning or under construction. In addition to these data, a natural condition and the site conditions which has been investigated during the site reconnaissance in this study, and the project scale were also taken into consideration.

In relation to reference data on construction costs, material costs and labor costs which will be useful for calculation for the project cost in this study as a big scale hydroelectric power development in Southern Area in Lao PDR where the projects in this study are located, the data of the Xe Set Hydroelectric Power Project in Saravane Province completed in 1987 was obtained. However, the project scale is small and therefore, it is not used directly for our purpose.

The study team collected F/S and Pre-F/S reports related to the projects in Lao PDR during the site investigation in 1993 and 1994 and the data in these reports are referred to the cost estimate. Also, the similar data in the neighbor countries, especially in Thailand were referred to.

The cost estimation for the project is in a basis in 1994 and a cost escalation in future is not considered in this calculation.

Also, the cost estimates was done in US $ as the study is in a preliminary design stage as mentioned above.

16.1.2 Construction Cost

The construction cost consists of the following items;

1) Civil Works
   a) Direct costs
   b) Costs for temporary facilities
   c) Indirect costs
2) Hydraulic Equipment
3) Electrical and Mechanical Equipment
4) Transmission Line Facilities
5) Preparatory Works
6) Compensation Costs
7) Engineering Fee for Construction Supervision
8) Owner's Administration Costs
9) Physical Contingency

In this Pre-feasibility Study stage, it is not possible to predict unforeseen costs during the construction stage. Therefore, the following physical contingencies will be evaluated in the construction cost.

a)	For civil works	: 15 % of the construction cost of civil works
b)	For hydraulic equipment	: 5 % of the construction cost of hydraulic equipment
c)	For electrical and mechanical equipment	: 5 % of the construction cost of electrical and mechanical equipment
d)	For transmission line facilities	: 5 % of the construction cost of transmission line facilities
e)	For engineering fee	: 5 % of the total construction cost
f)	For owner's administration cost	: 2.5 % of the total construction cost
g)	For preparatory works	: 10 % of the cost for preparatory works
h)	For compensation	: 10 % of the cost for compensation

10) Interest during Construction (IDC)

The cost of interest during the construction period is not considered in the cost estimates.

16.1.3 Unit Price

(1) Civil Works

As a basis of calculation, only the major items of civil works are considered and calculated the quantities, because a design itself is at the preliminary stage. For the remaining subsidiary work items , from the past experience and actual data, the costs were evaluated with a percentage for the cost of the major work items selected in the cost calculation, in which the major work items are excavation, concrete, reinforcing bar, grouting, etc.

For a cost of general site installation for the construction is also estimated with percentage of the total costs for main work items.
The unit rates for the main work items are shown in **Table 16.1-1**. In this table, the indirect costs for construction such as site expense, and overheads are included in the unit price. Also in the unit prices of tunnel excavation and vertical and inclined shaft excavation, a cost for temporary supports during execution are included.

(2) Hydraulic Equipment

In respect to unit prices for the hydraulic equipment, it is considered with an assumption that materials, manufacturing and fabrication will be done in the abroad and only erection will be carried out at the site and also experience and actual records in the similar hydroelectric projects in abroad are referred to the examination. Unit prices which are applied in the project are shown in **Table 16.1-1**.

(3) Electrical and Mechanical Equipment

Relating to costs of the electrical and mechanical equipment, it is considered with an assumption that a contract with erection and adjustment under an international tendering will be applied, and also it is calculated from the actual records of the construction costs in Asia.

(4) Transmission Line Facilities

On the unit prices for the transmission line works, it is assumed that materials of steel tower, insulator, and electric wires will be purchased in the abroad and that the foundation work of tower, fabrication work and stringing work will be carried out at the site. Under the assumption above, the prices were decided also referring the actual cost data from the projects in the abroad. Also the topographic conditions at site, and tools, vehicles, and spare parts required for maintenance work are considered in the unit prices.

Table 16.1-1 List of Unit Rate

Description	Unit	Unit Rate (US$)
Open Excavation		
Common	m3	3
Rock	m3	7
Underground Excavation		
Tunnel	m3	70
Vertical Shaft	m3	80
Inclined	m3	100
Embankment and Backfill		
Rockfill	m3	8
Dam Fill	m3	10
Backfill	m3	5
Concrete		
Structural Conc.	m3	130
Mass Conc.	m3	100
Lining Conc.	m3	140
Shaft Conc.	m3	150
Filling Conc.	m3	110
Rolled Compacted Conc.	m3	70
Surface Conc. for Rockfill Dam	m3	220
Reinforcement Bar	ton	900
Grouting		
Consolidation	m	65
Curtain	m	95
Hydraulic Equipment		
Penstock Steel Pipe	ton	3,500
Gate and Screen	ton	4,000

16.2 Se Kong No. 4 Project

16.2.1 Unit Price

Unit prices applied for the Se Kong No. 4 Project are the same as shown in **Table 16.1-1**.

16.2.2 Bills of Quantities

Bills of quantities for the Se Kong No. 4 Project are calculated only for main work items for the major structures based on the conditions stated in the Chapter 14 "Preliminary Design" and Chapter 15 "Construction Plan and schedule". The results are shown in the **Appendix-4**.

16.2.3 Construction Cost

Construction cost for the Se Kong No.4 Project are evaluated applying the unit prices and quantities stated in the Sections 16.2.1 and 16.2.2 above. However, as per request by MIH, the construction cost are examined for three cases as described bellows;

1) Base case: In the project cost, only the cost for a transmission line (230 kv) from the power station to the substation, which will be constructed at Ban Houaykong in another project, is included.

2) Case 1: In addition to the Base case stated above 1), the construction costs of Ban Houaykong substation and 500 kv transmission line from the Ban Houaykong substation to the Thailand border are included in the project cost. These costs are allocated to the three projects selected in the Study, the Se Kong No.4 Project, the Xe Kaman No.1 Project and the Xe Namnoy Project, respectively in proportion to each installed capacity of the power station.

3) Case 2: The transmission line from the power station to the Thailand border will be constructed independently for each project, and the cost will be included in the project cost.

The results are as follows:

Unit: 1,000 US$

	Base Case	Case 1	Case 2
Foreign Portion	542,216	586,174	583,283
Local Portion	101,393	107,378	106,986
Total	643,609	693,552	690,269

The details are shown in Table 16.2-1.

On a distribution of the construction cost between the foreign currency portion and the local currency portion, the following figures are used in accordance with synthetic judgment from a country conditions of Lao PDR, and money procurement, condition for material purchase and others around and between the relevant countries.

Item	Foreign Currency	Local Currency
Civil Works	85%	15%
Hydraulic Equipment Electrical and Mechanical Equipment Transmission Line Works Engineering Fee Physical Contingency	90%	10%
Preparatory Works Compensation Owner's Administration	0%	100%

Table 16.2-1 Summary of Construction Cost for Se Kong No.4 Project

Unit : 1,000 US$

WORK ITEM	FOREIGN CURRENCY PORTION	LOCAL CURRENCY PORTION	TOTAL
Preliminary Works	0	2,000	2,000
Civil Works			
General Site Installation	29,615	5,226	34,841
River Diversion Works	45,121	7,962	53,083
Dam	174,465	30,788	205,253
Spillway	56,873	10,036	66,909
Intake	1,688	298	1,986
Headrace/Penstock	5,396	952	6,348
Powerhouse/Switchyard	8,837	1,560	10,397
Tailrace	2,516	444	2,960
Road Works	1,254	221	1,475
Sub Total	325,765	57,487	383,252
Hydraulic Equipment	33,145	3,683	36,828
Electrical/Mechanical Works /1	85,500	9,500	95,000
Transmission Line /2	11,340	1,260	12,600
Commpensation Cost	0	4,500	4,500
Total Direct Cost	455,750	78,430	534,180
Engineering Fee	24,038	2,671	26,709
Administration Cost	0	13,355	13,355
Physical Contingency	62,428	6,937	69,365
Total Project Cost /3	542,216	101,393	643,609

Foot Note : /1 In case of independent transmission line(Case 2), one additional bank at switchyard is required and the cost is to be 95.8 million US$.

/2 In Case 1, for Ban Houaykong substation and T/L(500kv) to Thailand border, the additional cost is to be 42.4 million US$ as an allocation of the total cost for the said facilities and therefore, the total cost is to be 55 million US$. In Case 2 (Independent T/L from power station to Thailand border),the total cost of T/L will be 53 million US$.

/3 The total construction costs are as follows ;
For Case 1 : 693,552 thousand US$
For Case 2 : 690,269 thousand US$

16.3 Xe Kaman No.1 Project

16.3.1 Unit Price

Unit prices applied for the Xe Kaman No.1 Project are the same as shown in **Table 16.1-1**.

16.3.2 Bills of Quantities

Bills of quantities for the Xe Kaman No.1 Project are evaluated only for main work items of the major structures based on the conditions stated in the Chapter 14 "Preliminary Design" and Chapter 15 "Construction Plan and schedule". The results are shown in the **Appendix-4**.

16.3.3 Construction Cost

Construction cost for the Xe Kaman No.1 Project are evaluated applying the unit prices and the quantities stated in the Sections 16.3.1 and 16.3.2 above, respectively. For the Xe Kaman No.1 Project, the construction costs are also examined in three cases as stated in the section 16.2.3, and the results are summarized as follows;

Unit: 1,000 US$

	Base Case	Case 1	Case 2
Foreign Portion	342,443	367,861	375,934
Local Portion	61,607	65,069	66,168
Total	404,050	432,930	442,102

The details are shown in **Table 16.3-1**.

On a distribution of the construction cost between the foreign currency portion and the local currency portion, the same method stated in the Section 16.2.3 above is applied..

Table - 16.3-1 Summary of Construction Cost for Xe Kaman No.1 Project

Unit : 1,000 US$

WORK ITEM	FOREIGN CURRENCY PORTION	LOCAL CURRENCY PORTION	TOTAL
Preliminary Works	0	2,000	2,000
Civil Works			
General Site Installation	17,008	3,002	20,010
River Diversion Works	15,490	2,733	18,223
Dam	130,617	23,049	153,666
Spillway	5,757	1,016	6,773
Intake	1,136	201	1,337
Headrace/Penstock	5,463	964	6,427
Powerhouse/Switchyard	5,016	885	5,901
Tailrace	2,292	404	2,696
Road Works	4,318	762	5,080
Sub Total	187,097	33,016	220,113
Hydraulic Equipment	21,150	2,350	23,500
Electrical/Mechanical Works /1	66,150	7,350	73,500
Transmission Line /2	15,480	1,720	17,200
Commpensation Cost	0	900	900
Total Direct Cost	289,877	47,336	337,213
Engineering Fee	15,175	1,686	16,861
Administration Cost	0	8,430	8,430
Physical Contingency	37,391	4,155	41,546
Total Project Cost /3	342,443	61,607	404,050

Foot Note : /1 In case of independent transmission line(Case 2), one additional bank at switchyard is required and the cost is to be 74.3 million US$.

/2 In Case 1, for Ban Houaykong substation and T/L(500kv) to Thailand border, the additional cost is to be 28.4 million US$ as an allocation of the total cost for the said facilities and therefore, the total cost is to be 50 million US$. In Case 2 (Independent T/L from power station to Thailand border),the total cost of T/L will be 53 million US$.

/3 The total construction costs are as follows ;
For Case 1 : 432,930 thousand US$
For Case 2 : 442,102 thousand US$

16.4 Xe Namnoy Project

16.4.1 Xe Namnoy Midstream Project

(1) Unit Prices

Unit prices applied for the Xe Namnoy Midstream Project are the same as shown in **Table 16.1-1**.

(2) Bills of Quantities

Bills of quantities for the Xe Namnoy Midstream Project are evaluated only for main work items of the major structures based on the conditions stated in the Chapter 14 "Preliminary Design" and Chapter 15 "Construction Plan and schedule". The results are shown in the **Appendix-4**.

(3) Construction Cost

Construction cost for the Xe Namnoy Midstream Project are evaluated applying the unit prices and quantities stated in the Sections 16.4.1(1) and 16.4.1(2) above, respectively. As stated in the section 16.2.3, for the Xe Namnoy Midstream Project, the construction costs are also examined in three cases, and the results are summarized as follows;

Unit: 1,000 US$

	Base Case	Case 1	Case 2
Foreign Portion	237,578	267,880	262,996
Local Portion	44,229	48,355	47,690
Total	281,807	316,235	310,686

The details are shown in **Table 16.4-1**.

On a distribution of the construction cost between the foreign currency portion and the local currency portion, the same method stated in the Section 16.2.3 above is applied..

Table 16.4-1 Summary of Construction Cost for Xe Namnoy Midstreram Project
(With Xe Pian River Diversion Channel)

Unit : 1,000 US$

WORK ITEM	FOREIGN CURRENCY PORTION	LOCAL CURRENCY PORTION	TOTAL
1. Xe Namnoy Midstream			
Preliminary Works	0	2,000	2,000
Civil Works			
General Site Installation	10,055	1,775	11,830
River Diversion Works	9,060	1,599	10,659
Dam	18,549	3,273	21,822
Spillway	28,864	5,094	33,958
Intake	711	126	837
Headrace Tunnel	26,882	4,744	31,626
Surgetank	3,887	686	4,573
Penstock	3,417	603	4,020
Powerhouse/Switchyard	4,082	720	4,802
Tailrace	1,546	273	1,819
Road Works	3,553	627	4,180
Sub Total	110,606	19,520	130,126
Hydraulic Equipment	30,452	3,384	33,836
Electrical/Mechanical Works /1	40,140	4,460	44,600
Transmission Line /2	1,170	130	1,300
Commpensation Cost	0	1,500	1,500
Total Direct Cost	182,368	30,994	213,362
Engineering Fee	9,601	1,067	10,668
Administration Cost	0	5,334	5,334
Physical Contingency	22,910	2,546	25,456
Project Cost (Sub Total 1)	214,879	39,941	254,820
2. Xe Pian River Diversion Channel			
Preliminary Works	0	0	0
General Site Installation	1,692	299	1,991
Xe Pian Main Intake Weir	1,470	259	1,729
Xe Pian River Diversion	1,079	191	1,270
Riverbed Improvement	66	12	78
H. Lieng Intake Weir	2,683	473	3,156
H. Lieng River Diversion Channel	5,808	1,025	6,833
Tunnel Section	2,928	517	3,445
Road Works	1,313	232	1,545
Miscellaneous Works	1,572	278	1,850
Sub Total	18,611	3,286	21,897
Total Direct Cost	18,611	3,286	21,897
Engineering Fee	985	110	1,095
Administration Cost	0	547	547
Physical Contingency	3,103	345	3,448
Project Cost (Sub Total 2)	22,699	4,288	26,987
Total Project Cost /3	237,578	44,229	281,807

Foot Note : /1 In case of independent transmission line(Case 2), one additional bank at switchyard is required and the cost is to be 45.4 million US$.

/2 In Case 1, for Ban Houaykong substation and T/L(500kv) to Thailand border, the additional cost is to be 29.2 million US$ as an allocation of the total cost for the said facilities and therefore, the total cost is to be 30.5 million US$. In Case 2 (Independent T/L from power station to Thailand border),the total cost of T/L will be 26 million US$.

/3 The total construction costs are as follows ;
For Case 1 : 316,235 thousand US$
For Case 2 : 310,686 thousand US$

16.4.2 Xe Namnoy Midstream and Downstream Projects

(1) Unit Prices

In this section, the case is that the construction of the both projects, Xe Namnoy Midstream and Xe Namnoy Downstream will be realized at the same time as one package. In this case, also Unit prices applied for the Project are the same as shown in **Table 16.1-1**.

(2) Bills of Quantities

Bills of quantities for the Xe Namnoy Midstream is provided in the Section 16.4.1.2) above. Bills of quantities for the Xe Namnoy Downstream Project are also evaluated only for main work items of the major structures based on the conditions stated in the Chapter 14 "Preliminary Design" and Chapter 15 "Construction Plan and schedule". The results are shown in the **Appendix-4**.

(3) Construction Cost

Construction cost for the Project are evaluated applying the unit prices and quantities stated in the Sections 16.4.2(1) and 16.4.2(2) above, respectively.

Although the examination of the construction cost in three cases are requested as stated in the section 16.2.3, in case of the Xe Namnoy Downstream Project, the project will be performed together with the Xe Namnoy Midstream project or after completion of the Xe Namnoy Midstream Project and the power generated in the Xe Namnoy Downstream power station will be linked to the transmission line to the Xe Namnoy Midstream Power station. Therefore, the construction cost of the Xe Namnoy Downstream Project is not affected to the condition of the transmission line and is same in three cases. As a result, the construction costs for the Xe Namnoy Midstream and Down stream Project are summarized as follows;

Unit: 1,000 US$

	Base Case	Case 1	Case 2
Foreign Portion	367,092	397,394	392,510
Local Portion	66,132	70,258	69,593
Total	433,224	467,652	462,103

The details are shown in **Table 16.4-2**.

On a distribution of the construction cost between the foreign currency portion and the local currency portion, the same method stated in the Section 16.2.3 above is applied..

Table 16.4-2(1/2) Summary of Construction Cost for Xe Namnoy Midstreram Project and Downstream Project
(With Xe Pian River Diversion Channel)

Unit : 1,000 US$

WORK ITEM		FOREIGN CURRENCY PORTION	LOCAL CURRENCY PORTION	TOTAL
1. Xe Namnoy Midstream				
Preliminary Works		0	2,000	2,000
Civil Works				
General Site Installation		10,055	1,775	11,830
River Diversion Works		9,060	1,599	10,659
Dam		18,549	3,273	21,822
Spillway		28,864	5,094	33,958
Intake		711	126	837
Headrace Tunnel		26,882	4,744	31,626
Surgetank		3,887	686	4,573
Penstock		3,417	603	4,020
Powerhouse/Switchyard		4,082	720	4,802
Tailrace		1,546	273	1,819
Road Works		3,553	627	4,180
Sub Total		110,606	19,520	130,126
Hydraulic Equipment		30,452	3,384	33,836
Electrical/Mechanical Works	/1	40,140	4,460	44,600
Transmission Line	/2	1,170	130	1,300
Commpensation Cost		0	1,500	1,500
Total Direct Cost		182,368	30,994	213,362
Engineering Fee		9,601	1,067	10,668
Administration Cost		0	5,334	5,334
Physical Contingency		22,910	2,546	25,456
Project Cost (Sub Total 1)		214,879	39,941	254,820
2. Xe Pian River Diversion Channel				
Preliminary Works		0	0	0
General Site Installation		1,692	299	1,991
Xe Pian Main Intake Weir		1,470	259	1,729
Xe Pian River Diversion		1,079	191	1,270
Riverbed Improvement		66	12	78
H. Lieng Intake Weir		2,683	473	3,156
H. Lieng River Diversion Channel		5,808	1,025	6,833
Tunnel Section		2,928	517	3,445
Road Works		1,313	232	1,545
Miscellaneous Works		1,572	278	1,850
Sub Total		18,611	3,286	21,897
Total Direct Cost		18,611	3,286	21,897
Engineering Fee		985	110	1,095
Administration Cost		0	547	547
Physical Contingency		3,103	345	3,448
Project Cost (Sub Total 2)		22,699	4,288	26,987

Table 16.4-2(2/2) Summary of Construction Cost for Xe Namnoy Midstreram Project and Downstream Project
(With Xe Pian River Diversion Channel)

Unit : 1,000 US$

WORK ITEM	FOREIGN CURRENCY PORTION	LOCAL CURRENCY PORTION	TOTAL
3. Xe Namnoy Downstream			
Preliminary Works	0	0	0
Civil Works			
General Site Installation	6,038	1,066	7,104
River Diversion Works	12,421	2,192	14,613
Dam	16,096	2,841	18,937
Spillway	5,652	997	6,649
Intake	386	68	454
Headrace Tunnel	17,263	3,046	20,309
Surgetank	1,555	275	1,830
Penstock	2,425	428	2,853
Powerhouse/Switchyard	3,588	633	4,221
Tailrace	1,000	177	1,177
Road Works	0	0	0
Sub Total	66,424	11,723	78,147
Hydraulic Equipment	12,019	1,335	13,354
Electrical/Mechanical Works	30,600	3,400	34,000
Transmission Line	1,170	130	1,300
Commpensation Cost	0	0	0
Total Direct Cost	110,213	16,588	126,801
Engineering Fee	5,706	634	6,340
Administration Cost	0	3,170	3,170
Physical Contingency	13,595	1,511	15,106
Project Cost (Sub Total 3)	129,514	21,903	151,417
Total Project Cost /3	367,092	66,132	433,224

Foot Note : /1 In case of independent transmission line(Case 2), one additional bank at switchyard is required and the cost is to be 45.4 million US$.

/2 In Case 1, for Ban Houaykong substation and T/L(500kv) to Thailand border, the additional cost is to be 29.2 million US$ as an allocation of the total cost for the said facilities and therefore, the total cost is to be 30.5 million US$. In Case 2 (Independent T/L from power station to Thailand border),the total cost of T/L will be 26 million US$.

/3 The total construction costs are as follows ;
For Case 1 : 467,652 thousand US$
For Case 2 : 462,103 thousand US$