CHAPTER 12 CONSTRUCTION PLAN AND COST FOR CONSTRUCTION

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CHAPTER 12 CONSTRUCTION PLAN AND COST FOR CONSTRUCTION

12.1 General

12.1.1 Access to the Site

(1) Airway

Tribhuvan Airport located in Kathmandu, the capital city, is the only international airport in Nepal. Airports for domestic flights are in principal cities, and Pokhara airport is the nearest to the site. It takes 1.5 hours by vehicle from Damauli, located near the site, to Pokhara.

(2) Roads

The Upper Seti Hydroelectric Project site is located on the Seti river in the Tanahu District in the Midwest Region of the country and 140 km from Katmandu. It takes around 4 hours by vehicle from Kathmandu via the Prithivi Highway.

For access from Pokhara to the site, they turn right at the entrance of the existing road located about 600m from the bridge crossing the Madi river near Damauli on the national highway from Pokarah to Kathmandu. The existing road branching from the national highway is around 3 km long and almost unpaved, but accessible by vehicle. The dam site is located 2 km from the end of the existing road.

Electromechanical equipment, construction machines and construction materials imported from foreign countries to Nepal are transported through roads in India after they are unloaded at Kolkata.

It is considered that the transportation route for the construction works of the Project will be the same one used for Marsyangdi hydroelectric project, such as India - Birganj – Hetauda – Narayangad - Mugling – this project site. The weight limit of that route was 24.8 tons according to a site survey for that project.

12.1.2 Temporary Power Supply during Construction

33 kV Damauli Substation owned by NEA is located near the site. It is considered that a 33 kV distribution line with 3 km in length from the substation to a temporary transformer to be installed at Jhaputar (near the conjunction of the Seti and Madi Rivers) will be constructed as a part of the preparatory works. The contractors will receive power for construction works at the temporary transformer.

12.1.3 Concrete Aggregates

As outcrops are found at the project site, it is estimated that volume of the soil and sand excavation is not so much, and rock excavation will be main in excavation works. Hence, excavated rocks at diversion tunnel, dam, waterway, and powerhouse will be reserved, and processed into aggregates in crushing plant. Fine aggregates are also planned to be supplied at the plant. As fine aggregates are collected at a few km upstream of the confluence with Seti and Madi Rivers, they can be procured from here, if the volume of fine aggregates is insufficient.

The volume of rock excavation and concrete for each main structures of this project is shown in **Table 12.1.3-1**.

Table 12.1.3-1 Excavation and Concrete volume for Main Structures

(Unit: m^3)

Structure	Rock excavation	Concrete
Diversion Tunnel	80,400	22,900
Coffer Dam	1,200	5,400
Dam	1,260,000	890,000
Intake	68,400	6,600
Headrace Tunnel	65,600	15,800
Surge Tank	16,200	3,700
Penstock	8,300	3,500
Powerhouse	72,400	20,400
Tailrace Tunnel	34,500	9,500
Tailrace Surge Tank	24,900	5,100
Tailrace	9,200	2,900
Service Tunnels	70,700	4,400
Cable Shaft	10,500	3,000
Switchyard	37,600	800
Total	1,759,900	994,000

Required aggregates volume is estimated by next equation.

$V = 994,000 \times 2.046 / 2.6 \times 1.125 = 880,000\ m^3$

Here;

Aggregates mass per 1 m^3 Concrete = 2.046 t/m^3
Aggregates specific gravity = 2.6
Loss at aggregates production 12.5%

Assumed that 70 % of the excavated rock volume can be appropriated, considering the situation of the excavation work, whereby excavated rocks are thrown away from a high elevation part to the riverbed, the potential volume of excavated rock usable for aggregates is estimated by the following equation:

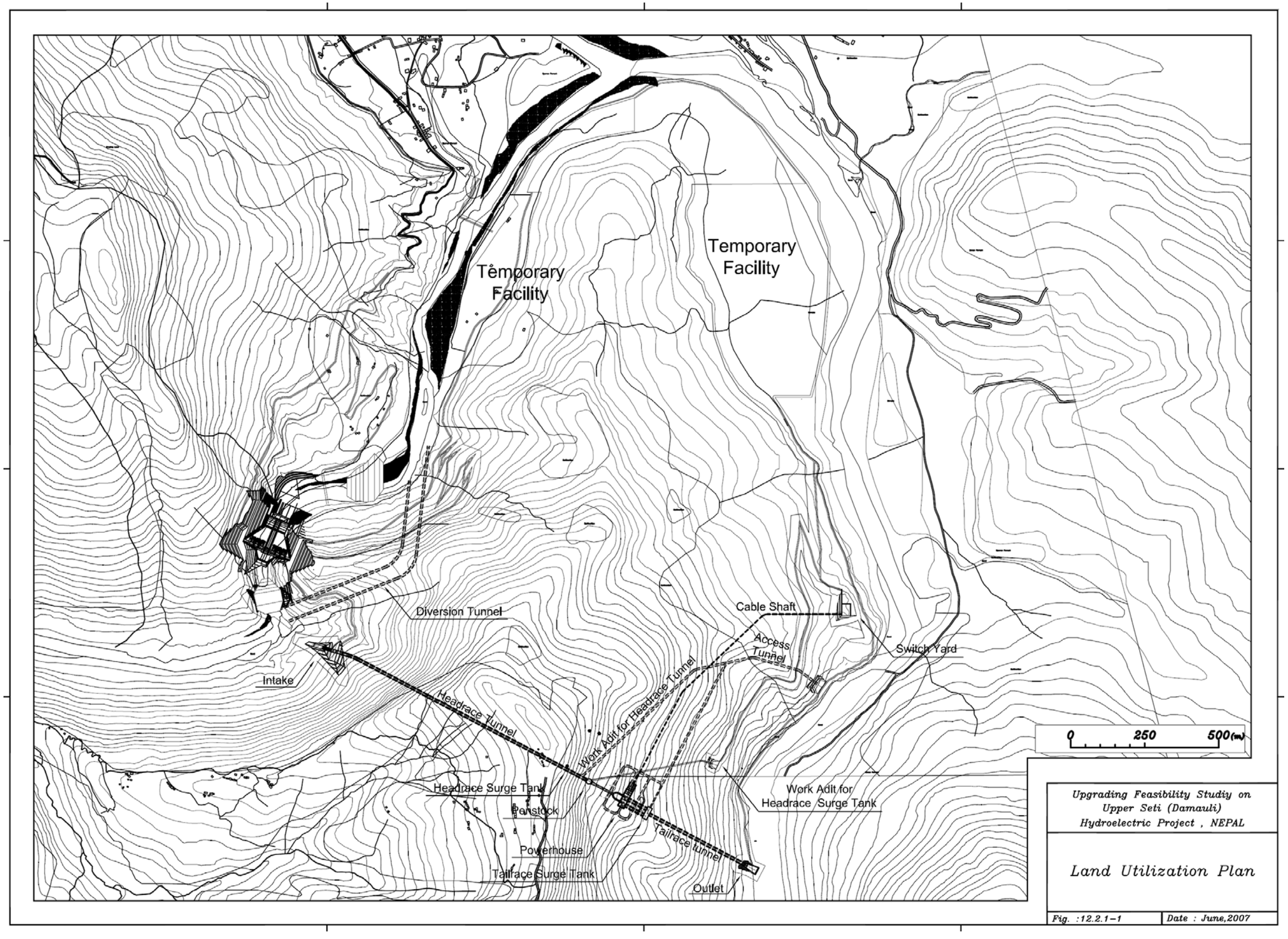
$1,260,000 \times 0.7 = 882,000\ m^3$

Therefore, excavated rocks in dam excavation works will have sufficient volume for concrete aggregates. If the volume is short for required volume for aggregates, excavated rocks in the waterway or powerhouse excavation works can be properly supplied.

12.2 Implementation Plan and Schedule

12.2.1 Basic Conditions

Main structures constructed in the project are concrete gravity dam whose height is 140m, 1 line of headrace tunnel whose inner diameter is 7.8 m, penstock, tailrace tunnel, underground type powerhouse, and etc. Total excavation volume is about 1,760,000 m^3, and concrete volume for dam is about 890,000 m^3, and that for other structures are 104,000 m^3. Land utilization plan for construction is shown in **Fig. 12.2.1-1**.


Temporary Facility
Temporary Facility
Diversion Tunnel
Cable Shaft
Access Tunnel
Switch Yard
Intake
Headrace Tunnel
Work Adit for Headrace Tunnel
Headrace Surge Tank
Penstock
Powerhouse
Tailrace Surge Tank
Tailrace tunnel
Outlet
Work Adit for Headrace Surge Tank
0 250 500(m)
Upgrading Feasibility Studiy on Upper Seti (Damauli) Hydroelectric Project , NEPAL
Land Utilization Plan
Fig. :12.2.1-1
Date : June,2007

Implementation plan and factors which can influence schedule are as follows;

(1) Number of Working Days

Working days for dam construction is defined as the days which following days off are eliminated from calendar days.

- In Nepal, every Saturday is weekly one holiday. Every Saturday and other official holidays are defined as days off, considering actual situation.
- Half the number of days whose precipitation is more than 20 mm is defined as days off.
- One regular maintenance day is considered every month.

To estimate the number of working day, climate data of the meteorological stations near dam site are checked, and days off are examined based on temperature and precipitation data.

- Temperature : 0815 Kharinitar Meteorological Station data between 1995 and 2004
- Precipitation : 0817 Damauli Meteorological Station data between 1995 and 2004

Finally, it is confirmed that main work items such as dam excavation works, grouting tunnel excavation works, and drilling and grout works which are open and tunnel can be conducted through a year, and that the number of monthly working days are estimated, considering the above numbers of days off, as shown in **Table 12.2.1-1**.

Table 12.2.1-1 Number of Monthly Working Days

month / Work issue	1	2	3	4	5	6	7	8	9	10	11	12	Sum	Ave
Dam Excavation Tunnel Excavation	22	22	25	22	21	22	20	20	21	25	23	21	264	22
Concrete Works	22	22	25	22	21	23	21	21	21	25	23	21	267	22
Drilling for Grout														
Open	23	23	26	23	22	23	21	21	22	26	24	22	276	23
Galley and Tunnel	23	23	26	24	24	26	25	24	23	26	24	22	290	24

Any work in tunnels and underground can also carried out through a year

The number of monthly working days is defined as monthly average days, considering flexibility against schedule changes.

(2) Construction Materials

As there are cement factories in Nepal, cement can be procured inside Nepal. But it should be procures not only in Nepal but also from other countries, because this project needs so much volume of cement in short term. Construction materials such as reinforcing bars, steel products and etc. should be procured from foreign countries.

(3) Concrete Production Plant

As shown in **Fig. 12.2.1-2,** concrete production plant is set at #1 service facility land located

at right abutment downstream of the dam.

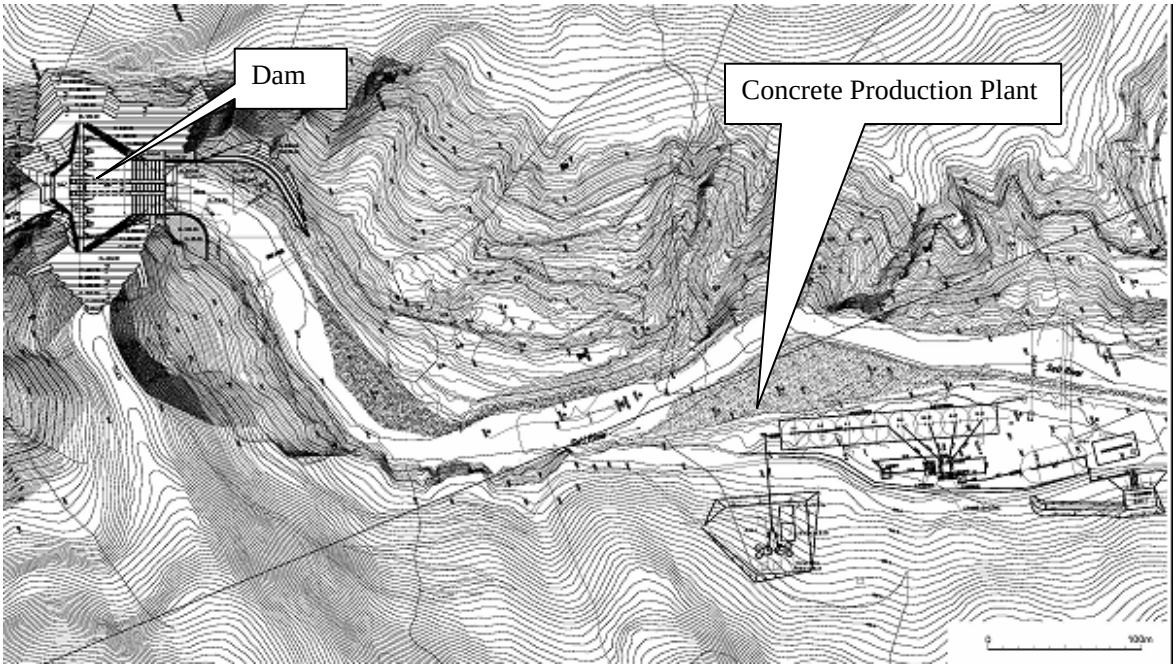


Fig. 12.2.1-2 Location of the Concrete Production Plant

The capacity of the concrete production plant is decided based on the past records of concrete gravity type dam construction works, and construction schedule. By carrying excavated rocks at the dam site and waterways stocked at the #1 service facility area properly, concrete aggregates are also produced by the crashing plant installed there. Cement silos, batching plant, cooling plant and other facilities for concrete production are also installed there.

General Plan of the Concrete Production Plant is as shown in **Fig. 12.2.1-3,** and the plant is composed of facilities, as shown in **Table 12.2.1-2**.

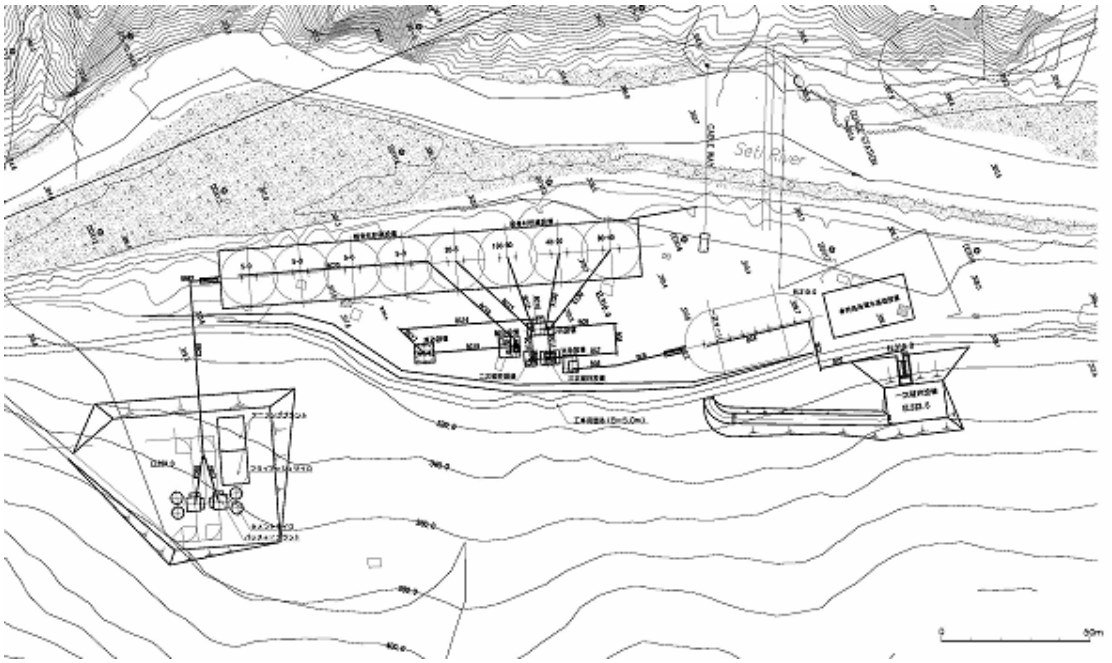


Fig. 12.2.1-3 General Plan of the Concrete Production Plant

Table 12.2.1-2 Specification of the Concrete Production Plant

Work	Machine	Specification	Number
Aggregates Production	Shaking Feeder	1,800 mm × 4,800 mm, 600 t/h DHS-6, 30 kW, 12.1t	1
	Jaw Crasher	1,220 mm × 1,520 mm, 410 t/h ASJ-60-48D, 150 kW, 78.0 t	1
	Cone crasher	300 mm × 1,520 mm, 193 t/h 1,260 Course Type, 110 kW, 38 t	1
	Cone Crasher	90 mm × 1,300 mm, 87 t/h 3 1/2 51 Fine Type, 260 kW, 50 t	2
	Rod Mill	2,700 mm × 4,500 mm, 87 t/h KRM-915 CD, 480 kW, 75.0 t	1
	Belt Conveyer	B=0.9 m × L=320 m, B=0.8 m × L=230 m B=0.6 m × L=210 m, B=0.5 m × L=410 m B=1.5 m × L=482 m, B=0.9 m × L=320 m	1
Cement Stock	Cement Silo	500 t class, Steel, 38 t	2
	Fry-ash Silo	200 t class, Steel, 10.0 t	2
Mixing	Batcher Plant	2.25 m^3 × 2 × 2 set =295 m^3/h, 314.0 t	2
Cooling	Water mixing cooler	100 JRT	2
	Wind Cooler	120 JRT	2
	Freezing Machine	250 JRT 300 JRT for pipe cooling	1 1

12.2.2 Implementation Plan and Schedule

The expected project implementation schedule which is prepared under discussions with NEA is shown in **Table 12.2.2-1**.

Based on the above described basic conditions and work quantities, construction plan and schedule is prepared. The construction period is estimated as 6 years. The critical path of this project is Dam construction works. The construction schedule for the Project is as shown in **Fig. 12.2.2-2**.

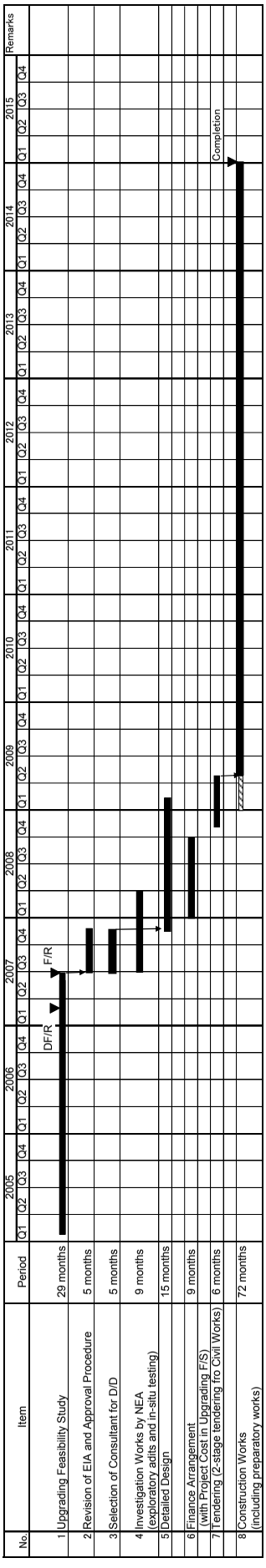


Fig. 12.2.2-1 Expected Schedule for Upper Seti Storage Hydroelectric Project

Description	Quantity	Unit
1 Preparatory Works		
1.1 Access Road		
(1) Improvement of Existing Road		
(2) Access to Dam Site (2 km)		
(3) Bridge No. 2		
1.2 Temporary Power Supply		
1.3 Camp and Office for NEA &Engineer		
2 Civil Works		
2.0 Temporary Works		
Access to Work Fronts		
2.1 Diversion Tunnel		
(1) Tunnel Excavation	88,800	m^3
(2) Cocrete Lining	44,180	m^3
(3) Grounting Work	1	LS
(4) Upstream Coffer Dam	1	LS
(5) Downstream Coffer Dam	1	LS
(6) Plug Concrete	1	LS
2.2 Dam & Spillway		
(1) Excavation	1,200,000	m^3
(2) Grout Tunnel	680	m
(3) Curtain Grout	30,200	m
(4) Consolidation Grout	2,700	m
(5) Dam & Spillway Concrete	863,000	m^3
(6) Sand-drain Valve Installation	198	t
(7) Maintenance Flow Outlet Valve	23	t
(8) Spillway Gate Installation	444	t
2.3 Intake		
(1) Open Excavation	97,670	
(2) Tunnel Excavation	5,730	
(3) Shaft Excavation	3,970	
(4) Tunnel Lining	2,370	
(5) Shaft Lining	1,100	
(6) Concrete	2,400	
(7) Gate & Screen Installation	219	
2.4 Headrace Tunnel		
(1) Work Adit	640	m
(2) Tunnel Excavation	970	m
(3) Tunnel Lining	15800	m^3
(4) Grouting	LS	
2.5 Penstock		
(1) Tunnel Excavation (Branch)	80	m
(2) Tunnel Excavation (Horizontal)	25	m
(3) Shaft Excavation	90	m
(4) Steel Liner (with Backfill Concrete)	195	m
2.6 Headrace Surge Tank		
(1) Work Adit	440	m
(2) Shaft Excavation	16200	m^3
(3) Concrete Lining	3700	m^3
2.7 Powerhouse		
(1) Excavation	72400	m^3
(2) Concrete	20400	m^3
(3) Archtectual Work	LS	
2.8 Tailrace Surge Tank		
(1) Excavation	24900	m^3
(2) Concrete	5100	m^3
2.9 Tailrace Tunnel (including Draft Tunnel)		
(1) Tunnel Excavation (Tailrace Tunnel)	365	m
(2) Tunnel Excavation (Draft Tunnel)	138	m
(3) Tunnel Lining	11000	m^3
(4) Grouting	LS	
2.10 Tailrace Outlet		
(1) Coffering	LS	
(2) Open Excavation	15100	m^3
(3) Concrete	2900	m^3
2.11 Access Tunnel and Access Adit		
(1) Main Access Tunnel		
Portal Excavation	15700	m^3
Tunnel Excavation	940	m
Invert Concrete & Lining	5300	m^3
(2) Powerhouse Top Access Adit	220	m
(3) Penstock Installation Adit	151	m
(4) Powerhouse Bottom Access Adit	128	m
(5) Tailrace S/T Access Adit	89	m
2.12 Switch Yard		
(1) Excavation	74200	m^3
(2) Concrete	800	m^3
(3) Control Building	LS	
2.14 Cable Tunnel		
(1) Tunnel Excavation	860	m
(2) Inclined shaft Excavation	155	m
(3) Concrete	3600	m^3
3 Hydromechanical Equipment		
3.1 Dam & Spillway		
(1) Sand-drain Valve Installation	198	t
(2) Maintenance Flow Outlet Valve	23	t
(3) Spillway Gate Installation	444	t
3.2 Intake		
Gate & Screen Installation	219	
3.3 Penstock		
Steel Liner (with Backfill Concrete)	195	m
3.4 Tailrace Outlet		
Gate & Screen Installation	LS	
4 Elecromechanical Equipment		
4.1 Overhed Traveling Crane	LS	
4.2 #1 Unit		
(1) Draft cube	LS	
(2) Spiral casing	LS	
(3) Runner	LS	
(4) Stator	LS	
(5) Rotor	LS	
4.3 #2 Unit	LS	
4.4 Power Plant Equipment	LS	
4.5 Main Transformer	LS	
4.6 Switchyard	LS	
4.7 River Maintenance Generation Facility	LS	
5 Tansmission line	LS	

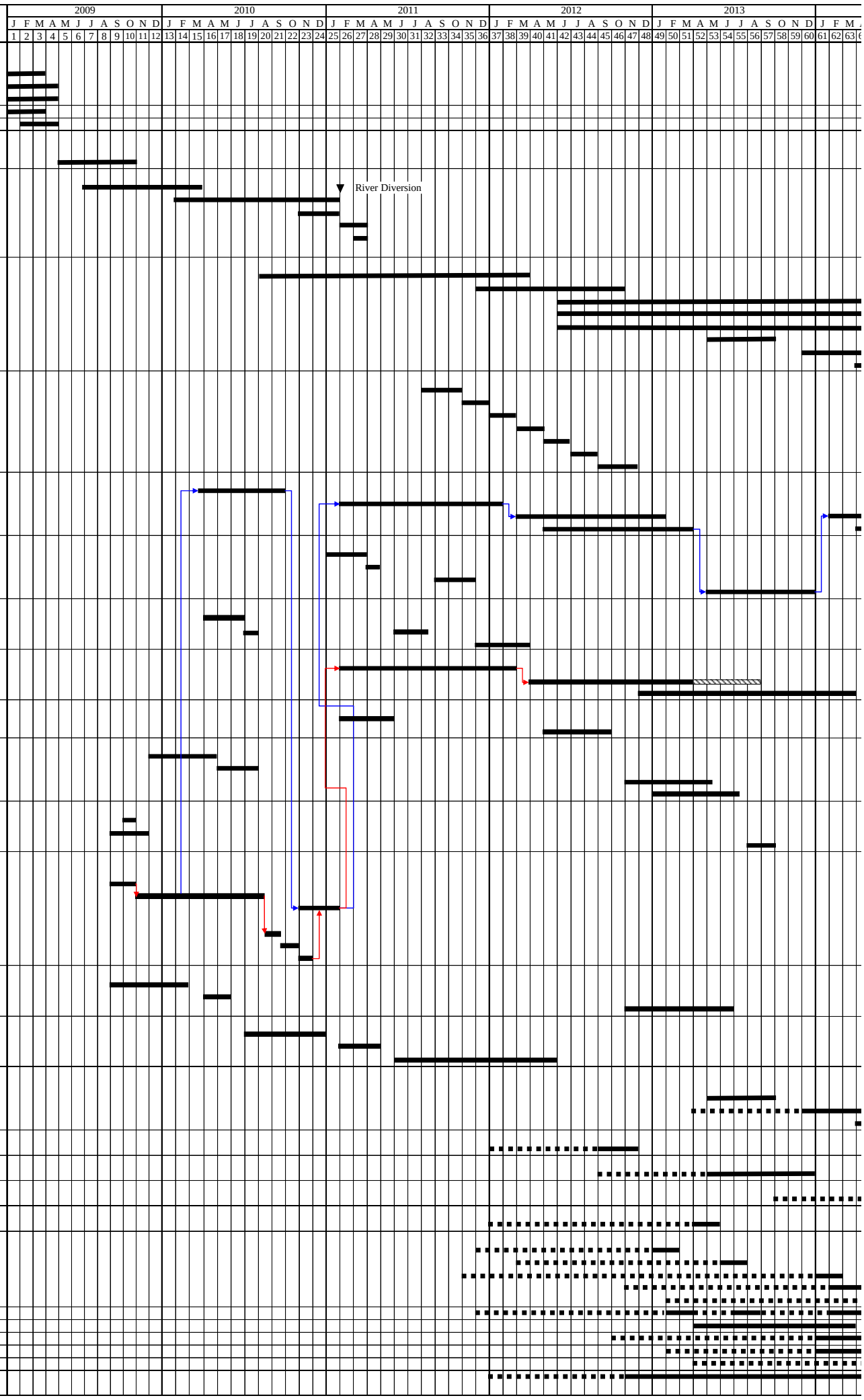


Fig. 12.2.2-2 Construction Schedule

Structures implemented in this project are as follows;

Diversion Tunnel	Inner diameter 6.6 m (Horse Shoe type), 2 lines (700 m, 900 m)
Dam	Concrete gravity type Height: 140 m, Crest length: 170 m, Dam volume: 890,000 m^3
Intake	Inclined surface intake type, Shaft type gate 1 unit
Headrace Tunnel	Concrete Lining type, Inner diameter: 7.8 m, Length: 927 m
Surge Tank	Underground Orifice type, Inner diameter: 17 m, Height:53 m
Penstock	Tunnel type, Inner diameter: 7.8~3.1 m, Length: 195 m
Powerhouse	Underground type, Width 22 m × Height 42 m × Length 90 m
P/H Access Tunnel	Upper semicircle and Bottom rectangle(Diameter 7m) × 940 m
Cable Shaft	Circle (Diameter 3 m) × 1015 m
Tailrace Surge tank	Underground type, Height 8.5 m × Width 6.5 m × Length 30 m
Tailrace Tunnel	Concrete lining type, Inner diameter: 8.2 m, Length:365 m
Outlet	Width 25 m × Height 20 m
Switchyard	Open type

(1) Preparatory Work

The existing road improvement (2 km), access road to dam abutment (2 km), and service facility bridge crossing the Seti river, power supply facility for construction work, camp for NEA and engineers are included in Preparatory Work. These works should be completed under another contract before starting main civil works.

(2) Dam

1) Care of River

Care of river work is started after access road to outlets of the diversion tunnels is completed. As their length is comparatively long, 2 tunnels are excavated at the same time. As there is no access road to the upstream area of the dam axis, tunnels are excavated from downstream side.

Excavation method is full section blasting with bench cut support. Construction machines used for this work are listed in **Table 12.2.2-1**. Excavated rocks is stocked temporarily at tunnel entrance, and then carried to the #1 or #2 service facility area to be processed into aggregates.

Table 12.2.2-1 Excavating Machines for Diversion Tunnel Work

Process	Machine	Num.
Drilling	3 Boom wheel Jumbo	2
Picking	Giant breaker	2
Loading	Wheel loader (with side dump of mounting 2.3 m^3)	2
Shotcrete	Wet type wheel shotcreting machine	1

Steel support (@1.2 m), shotcrete, and rock bolts are applied to tunnel support in accordance with geological conditions. After excavation work is finished, invert concrete is placed at first, and then lining concrete is poured by using a sliding-tunnel lining form. These concrete will be supplied with the plant installed at the #1 service facility area.

After the # 2 diversion tunnel works is completed, as heavy machines can be carried to the upstream area of the dam through the #2 diversion tunnel, Intake and dam excavation works can be started. A part of excavated rocks will be used to construct the primary coffer dam to let river flows into #1 diversion tunnel in dry season. After the upstream coffer dam site area is made dry, coffer dam construction work will be started. The coffer dam is assumed to be concrete gravity type. At the same time, excavated rocks should be carried to the upstream side of the outlet of the #1 diversion tunnel for construction of the downstream coffer dam.

2) Dam excavation

Dam excavation work can be started after access roads to dam abutments are completed. During diversion tunnel excavation works, excavation works at the site whose elevation level is higher than EL. 420 m will be executed. As surface deposit is assumed to be little, according to the geological investigation results, excavation works should be done by short bench cut method from top of the slopes. Before river diversion, excavated rocks can not be thrown into river directly. Therefore, rock fence should be installed at EL.420m to gather excavated rocks, and then they will be carried to the aggregates stock yard at the #2 service facility area which is located 2 km downstream of the dam axis. After that, considering progress of the care-of-river works, excavation works for the area whose elevation level is lower than EL. 420m properly, considering safety at construction site.

After the care-of-river work is completed, excavation works by bench cut method should be started at both abutments, and excavated rocks are dropped to the riverbed. Excavation works should be sometimes stopped to have excavated rocks thrown into riverbed carried to the service facility area properly. After abutment excavation works are completed, riverbed is excavated down into dam foundation elevation EL. 280 m.

Machines used for the dam excavation works are listed in **Table 12.2.2-2**.

Table 12.2.2-2 Machines for Dam Excavation

Process	Machine	Specification	Num.
Drilling	Crawler drill with oil pressure 150kg class	8.4 t Bit diameter 65 mm	6
	Leg-hammer	40 kg class	18
Bulling	Bulldozer with lipper 32t class	31.7 t	6
Loading	Backhoe mounting volume 1.6m^3	33.8 t	7
Carrying	10t Dump track	9.7 t	10

Contact surface with rock and concrete should be arranged by pick-hammer.

13, 12, and 15 parties are planned to be engaged in drilling work at the left abutment, at the right abutment, and at the riverbed area. In this case, monthly planned excavation volume and required construction period will be as shown in **Table 12.2.2-3**.

Table 12.2.2-3 Monthly Planned Excavation Volume and Required Construction Period

Item	Site			Total
	Left abutment	Right abutment	Riverbed	
Monthly planned excavation volume	57,159	30,912	35,241	―
Required months	11.3	11.3	5.8	18

3) Foundation treatment

During dam excavation works, when excavation surface reaches the elevation for grouting tunnel entrance at EL.420 m, EL.345 m, and EL.283 m, grouting tunnel excavation works will be started. After tunnel excavation works is finished, drilling work is executed in grouting tunnel with planned pattern, and then grout material is injected.

Machines for grouting tunnel excavation and grout injection work are listed in **Table 12.2.2-4** and **5**.

Table 12.2.2-4 Machines for Grouting Tunnel Excavation

Process	Machine	Num.
Drilling	Wheel type 2 boom jumbo	2
Picking	Giant breaker Oil pressure type 600～800 kg class	2
Loading	Wheel loader with side dump type mounting 2.3 m^3	2
Shotcreting	Wet type wheel shotcreting machine	2

Table 12.2.2-5 Machines for Grouting Work

Process	Machine	Num.
Drilling	Rotary drilling machine	6
	Percussion drilling machine Crawler type 150 kg class ϕ 65	1
Injection	Grout mixer (Vertical type, 2 tanks)	4
	Grout Pump	4
	Injection pressure control device	4

4) Dam concreting

Dam concrete volume is about 890,000 m^3. The dam site is located in the narrow gorge. **Table 12.2.2-6** shows the concrete gravity dams with small ratios of the dam height (H) to the crest length (L) among those constructed or under construction with the layer method (RCC method).

Table 12.2.2-6 Examples of Small Ratio of Height to Length of RCC Gravity Dams

No.	Country	Name	Height (H) (m)	Length (L) (m)	L/H	Remarks
1	Alegeria	Koudiat Acerdoune	116	335	2.89	
2	Chile	Ralco	155	360	2.32	
3	China	Jiangya	131	327	2.50	
4	China	Mianhuantan	111	310	2.79	
5	Colombia	Miel I	188	345	1.84	
6	Japan	Chiya	98	259	2.64	
7	Japan	Kazunogawa	105	264	2.51	
8	Japan	Kubusugawa	95	253	2.66	
9	Japan	Sakaigawa	115	298	2.59	
10	Japan	Tomisato	111	250	2.25	
11	Mexico	Trigomil	100	250	2.50	
		Upper Seti (conventional)	140	170	1.21	for comparison

Source: Yaerbook 2005, Water Power & Dam Construction
Note: Study Team picked up smaller ratio of L/H of RCC gravity dams in the world listed. in the source.

Because there is no dam with small L/H such as that of the Upper Seti dam site, it is judged that the layer method should be difficult to be adopted, and that a conventional concreting method should be available.

Concrete should be carried by 4.5 m^3 agitator truck from the batching plant installed at the #1service facility area, where is located about 1km downstream of the dam axis, to dam site. Concrete will be loaded to forward type transfer cars, which carries concrete to bucket stand cars, unloaded into a bucket. The bucket carries the concrete to the work front for concreting by tower crane for concrete placement. Installation locations of the tower crane and operation zone are shown in **Fig. 12.2.2-3**. Normally both-side running type cable crane which can cover all the concreting area is often expected to be used for such work, but it is not adopted, because of the topographical conditions. Steep ridges at both abutments are not suitable for cable crane installation.

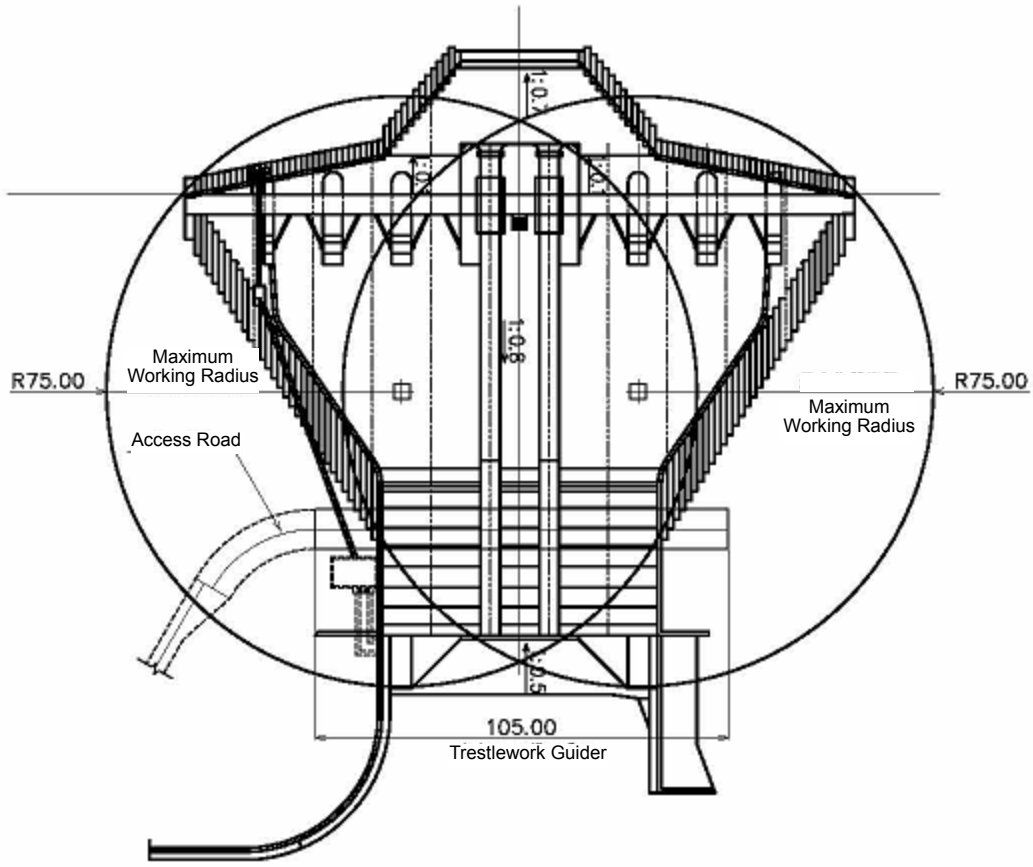


Fig. 12.2.2-3 Tower Crane Location and Workable Zone

About 1,000,000 m^3 in volume of concrete is requested to be poured for this project. Assumed that dam concreting period should be 24 months, machines listed in **Table 12.2.2-7** are required.

Table 12.2.2-7 Machines for Concreting Work

Machine	Specification	Num.	Remarks
Agitator Track	4.5 m^3	10	Plant to Dam
Transfer Car	4.5 m^3 （Dump Forward type）	2	For dumping to bucket
Steel Stage	（for 2 set of rails） W: 8.0 m × L: 90 m	1	Set at EL.330m
Bucket stand Car	4.5 m^3	2	
Tower Crane	with oil pressure fixed type (Pear height is 75 m.) Hanging Load × Movable radius 13.5 t × 75 m	2	

Construction joints of the dam concrete are considered as follows;

a) Longitudinal Joints

Intervals of longitudinal joints should be 15m for standard part, and 12 m near the left and right abutments. Therefore, 10 longitudinal joints are set in the dam as shown in **Fig. 12.2.2-4**.

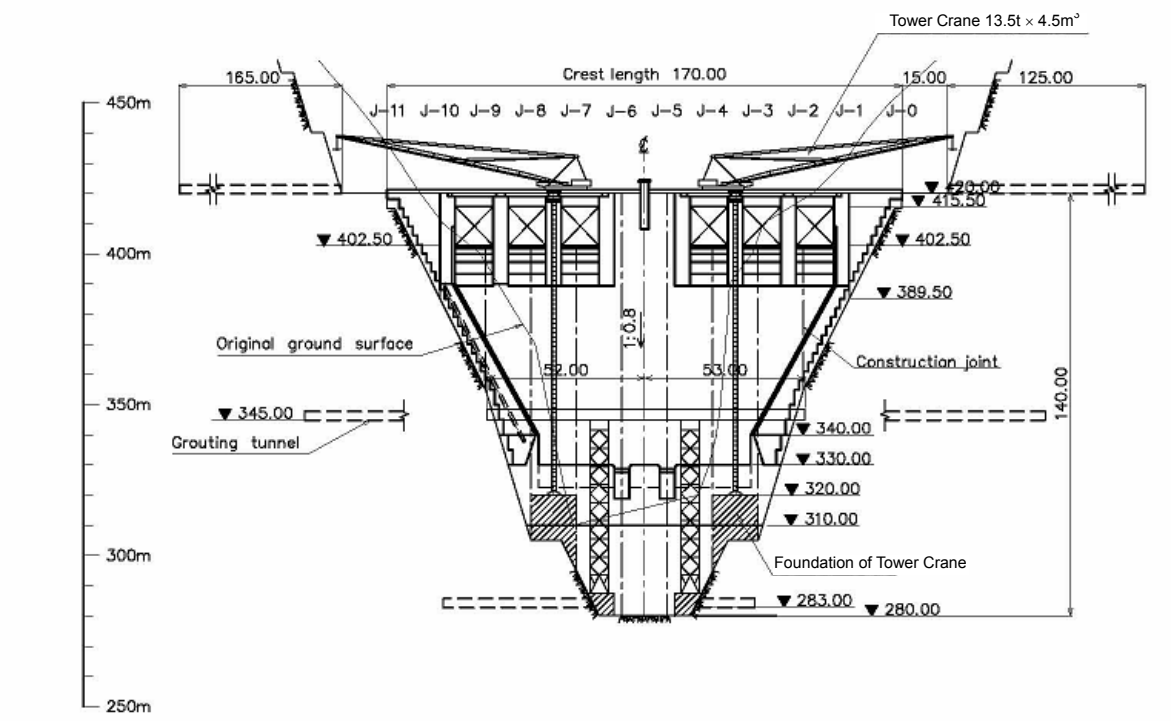


Fig. 12.2.2-4 Longitudinal Joints of Dam Concrete

b) Transverse Joints of Dam Concrete

Based on the past records, any transverse joint should not be set within 50 m height from dam crest elevation. Therefore, transverse joints are set between dam foundation and EL. 370 m as shown in **Fig. 12.2.2-5**.

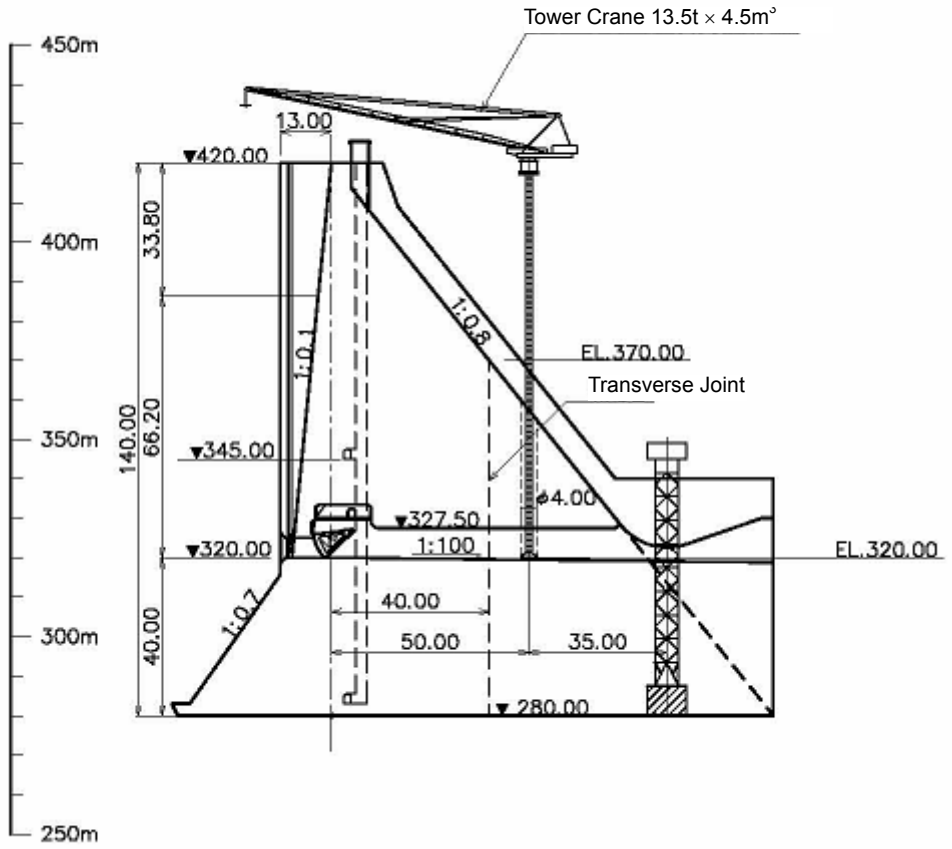


Fig. 12.2.2-5 Transverse Joints in Upstream-Downstream sections

c) Concreting lift height

Concreting lift height is basically 1.5 m. However, half of standard concreting lift height is applied to 4 lifts from dam foundation which is between EL.280 m and 283 m, and lifts which should be left for a long time. It is also applied to the lift whose volume exceeds probable daily maximum concreting volume (concreting volume per hour multiplied 11 hours).

d) Concreting intervals

Considering concrete curing and time for from removal, concreting intervals are 3 days for half lift height (0.75 m), and 5 days for full lift height (1.5 m). The height difference of the lift between neighboring longitudinal section block should be kept within 12m, which means 8 lifts with full lift height.

After concreting, the concrete will be compacted by 4-ton class backhoe type vibrators. The zone near form is compacted by handy vibrator. Concrete surface treatment is executed by men using super high pressure jet (200 kg/cm^2), and concrete cooling is made by cool water supplied by cooling plant installed at dam site through steel pipe. The cool water should be of circulation type.

5) Sediment flushing gate

2 sediment flushing gates are installed at EL.320 m, when concreting lift reaches EL.320 m. Downstream side radial gate should be also installed in accordance with concreting lift progress. After gate installation is completed, it should be set open to use sediment flushing gate for outlet in the case that the a flood happens in rainy seasons when it overflow upstream coffer dam.. In accordance with dam upstream surface lift progress, slide gate at upstream side will be also installed in order.

6) Spillway gate and Stop log gate

When concreting lift reach EL. 402 m, metal parts of the gates will be installed in accordance with lift progress. After concreting work is finished, gates will be installed by truck crane on the spillway bridges.

(3) Intake

After dam right abutment access road is completed, intake access road will be constructed continuously. Then open excavation work is started at part higher than EL. 420 m. Excavation method is the same as that for dam excavation, and excavated rocks are carried to aggregates stock yard at the #2 service facility area. After the diversion tunnel works is completed, access road will be prepared from the #2 diversion tunnel inlet to Intake, and then open excavation work for the areas below EL. 420 m will be executed.

After open excavation is finished, excavation work of the tunnel whose length is 65 m from entrance will be started. After that, gate shaft excavation work will be started. Pilot shaft will be excavated by raise borer at first, and then the shaft will be cut down with 1 or 2 m intervals by bench method or breaker picking. Excavated rocks will be dropped down through pilot shaft. The shaft should be supported by ring type steel support, shotcrete, or rock bolts in accordance with geological conditions of the surrounding wall. The shaft should be concrete lined by slide form and etc.

After shaft excavation is finished, concrete lining and consolidation grouting work will be conducted. Then the intake structure will be concreted. Gate and screen installation work will be executed properly in accordance with concrete progress.

（4） Headrace Tunnel

The headrace tunnel is a circular type tunnel of about 927 m in length and 7.8 m in finished diameter. One work adit of about 640 m long is necessary, which is branched from the station point of about 330 m along the access tunnel. The inner diameter of the work adit is set at 7.0m, considering the transportation of the penstock steel liner.

The tunnel will be driven by the full face tunneling method, using a 3-boom wheel jumbo, 2.3 m^3 side dump type muck loader and 20 ton dump truck. The tunnel supporting work will be done with shotcrete, rock bolt, and steel supports. The monthly progress of the tunnel excavation is expected to be about 105 m/month for the work adit and 83.1 m for the headrace tunnel.

The lining concrete will be placed with a 10.5 m long circular traveling steel form. The monthly progress of lining concrete is expected to be about 85 m/month, by using one set of the form.

The tunnel excavation work will commence after the completion of the invert lining of the access tunnel for the powerhouse, and about one year of construction period is required. The lining concrete work will start at the upstream side after the completion of the tunnel excavation. Lining concrete in the downstream section from the work adit can be placed after the completion of the penstock tunnel, since the penstock pipe needs to be hauled through the work adit for headrace tunnel to the upper bend of the penstock tunnel.

(5) Headrace Surge Tank

The cavern excavation work of the surge tank will be carried out in 2 steps: arch excavation and body excavation with pre-splitting blasting method. The arch excavation will be carried out with a center drift heading and side enlargement method, approaching from the 440 m long of work adit tunnel whose portal is located at EL.420 m. The pilot hole will be driven with a raise climber upward from the headrace tunnel. The drilling work will be made by 2 sets of stopper drill, and 2 m long guide-rail will be extended after every 2 rounds of blasting work. The average progress rate for the pilot hole excavation is expected to be about 70 m/month. After the pilot hole excavation, enlargement excavation will be carried out downward from the arch of the cavern by the drill and blasting method. The excavated rock material will be dropped to the headrace tunnel through the pilot hole and then hauled to the outside by dump truck through the work adit tunnel for the headrace tunnel. The monthly progress of the enlargement excavation is expected to be about 25 m/month, and 2 months of the construction period is needed for the cavern excavation work. Concrete lining work for the surge tank will be commenced after the completion of the penstock shaft excavation, and 4 months of construction period is required for it.

(6) Penstock Tunnel

The penstock tunnel is a steel lined tunnel connecting to the powerhouse cavern. The tunnel consists of the following three parts:

Vertical shaft	90 m long, 5.9 m diameter
Lower horizontal tunnel	25 m, 5.9 m diameter
Lower branch tunnel	40x2 m, 4.0 m diameter

The lower horizontal tunnel and lower branched tunnel will be driven by the same method as that for the headrace tunnel. Therefore, the monthly progress of the tunnel excavation is expected to be about 105 m/month.

The shaft will be excavated by the pilot hole and downward enlargement method. The pilot hole will be driven with a raise climber upward from the lower horizontal tunnel. The drilling work will be made by 2 sets of stopper drill and 2 m long guide-rail will be extended

after every 2 rounds of blasting work. The average progress rate for the pilot hole excavation is expected to be about 70 m/month. After the pilot hole excavation, enlargement excavation will be carried out downward from the upper horizontal tunnel by the drill and blasting method. The excavated rock material will be dropped to the lower horizontal tunnel through the pilot hole and then hauled to the outside by dump truck through the access tunnel. The monthly progress of the enlargement excavation is expected to be about 60 m/month.

The concrete placement around the steel penstock pipe will be carried out in parallel with the installation work of the pipes, using a concrete bucket controlled by a winch. The concrete pouring will be made after jointing 3 pieces of 6 m long unit pipe.

The shaft excavation will commence after completion of the lower horizontal tunnel excavation. The construction period for installation of penstock pipe and backfill concrete work is estimated at about 8 months.

(7) Access Tunnel and Work Adit Tunnel

The access tunnel is a road tunnel connecting to the erection bay of the underground powerhouse, about 940 m in total length and 7.0 m in diameter. Four work adit tunnels will be provided in order to connect the access tunnel with the powerhouse arch, powerhouse bottom, lower penstock horizontal tunnel and tailrace surge tank respectively.

The access and work adit tunnels will be driven by the same method as that for the headrace tunnel. The invert concrete in the access tunnel will be placed after the tunnel excavation. During this period, the excavation work for each work adit tunnel will need to be suspended.

The access tunnel excavation will commence after both mobilization and construction of a temporary access road to the access tunnel. The average progress rate of the tunnel excavation is estimated at 105 m/month. The required construction period for both the access tunnel and powerhouse top adit is about 10.5 months.

(8) Powerhouse

The powerhouse is of a bullet type having a dimension of 22 m wide, 42 m high and 90 m long. The cavern excavation work will be carried out in two steps: arch excavation and body excavation with pre-splitting blasting method.

The arch excavation will be carried out with a center drift heading and side enlargement method, approaching from the upper work tunnel branching off from the access tunnel and employing the same equipment fleet as that for the headrace tunnel. The setting of PS anchor and glory holes will be made in parallel with the excavation work.

After the arch excavation, the powerhouse ground will be lowered to its bottom level by the bench cut method. The pre-splitting blasting method will be applied to the wall to minimize damage to the surrounding rock and to get a smooth wall surface. The muck will be loaded by 2.3 m^3 wheel loader into 20 ton dump truck, and hauled to the outside through each work adit tunnel and access tunnel. The seepage water during construction will be gathered into

the ditch and drained to outside using a submersible pump. The construction period for body excavation is estimated at about 12 month.

The concrete work will be carried out, floor by floor, from the powerhouse bottom. The mixed concrete will be delivered to the cavern by 4.5 m^3 agitator truck and placed by 100 m^3/h concrete pump car. The required construction period for the concrete work is estimated at about 17 months.

After the civil work, architectural and utility work including the electrical work will be carried out. These works will be completed within about 16 months.

(9) Cable Tunnel

The cable tunnel is composed of 155 m long of inclined shaft and 680 m of horizontal tunnel. Tunnel section is horseshoe shape with vertical leg and inner diameter is 3m. Inclined shaft is excavated by using the pilot hole, which is constructed by same method of the penstock shaft from the access tunnel for the powerhouse. While, the horizontal tunnel is excavated by full face tunneling method from the switchyard. The required period for the excavation is estimated at 9 months

After completion of the excavation work, lining concrete will be placed by 6 m long of steel form. The construction period of the concrete lining work is estimated at 12 months for the inclined shaft and horizontal tunnel.

(10) Tailrace Surge Tank and Draft Gate Chamber

The tailrace surge tank is a cavern of 15 m wide, 32.5 m high and 40 m long, located about 70 m downstream of the powerhouse cavern. The tailrace surge tank is connected with the powerhouse by 2 lines of draft tunnels.

The arch excavation will be carried out by applying the same method as that for the powerhouse, approaching from the work adit tunnel branch off from the access tunnel. The excavated rock material will be dropped to the tailrace tunnel through the pilot hole and then hauled to the tailrace outlet by dump truck through the tailrace tunnel.

In the upstream of the tailrace surge tank, a draft gate chamber is provided. It will be excavated by the full face tunneling method approaching from the access tunnel.

The concrete will be hauled by 4.5 m^3 agitator truck to the site through the access road and placed by a 100 m^3/h concrete pump car. The construction period for the tailrace surge tank is estimated at about 4 months for the excavation work and 5 months for the concrete work respectively.

(11) Tailrace Tunnel and Draft Tunnel

The tailrace consists of 2 x 65 m long of draft tunnels and a 365m long tailrace tunnel. The tailrace tunnel is pressure tunnel with 8.2 m of the inner diameter.

The tailrace tunnel is driven by the same method as that for the headrace tunnel. The

progress rate of the excavation for the tailrace tunnel and the draft tunnel is estimated at 80 m/month. After completion of the excavation work, lining concrete will be placed by the same procedure as that for the headrace tunnel. The monthly progress of lining concrete worls is expected to be about 85 m/month. The construction period is estimated at 8 months for the excavation and 6.5 months for the concreting work.

The common open excavation will be carried out by using a 21 ton bulldozer with ripper, 1.4 m^3 wheel loader, 0.6 m^3 backhoe, and 10 ton dump truck. The open rock excavation will be carried out by the low bench cut method with a bench height of less than 3 m. The open concrete work will be carried out using a 25 ton truck crane with bucket capacity of 1.0 m^3, 100 m^3/h concrete pump car, and 4.5 m^3 agitator car.

(12) Hydraulic Turbine, Generator, etc

It will be started to install Draft Tube of No. 1 Unit from forty sixth (49) month, and Hydraulic Turbine, Generator, etc using Overhead Traveling Crane from fifty four (54) month. The commissioning operation of No. 1 Unit will be after completion of the Dry and Wet tests on seventy first (71) month. The commissioning of No. 2 Unit will be one (1) month later than No. 1 unit (13) 220 kV Transmission Line

It will be started to construct 220 kV transmission line, Doubble Circuit (D/C), approximate 39 km from third (3) years. It will complete the latter half of fifth (5) years.

(13) 220 kV Transmission Line

It will be started to construct 220 kV transmission line, Dabble Circuit (D/C), approximate 39 km from third (3) years. It will complete the latter half of fifth (5) years.

12.3 Construction Cost

Construction cost has been calculated by applying the following basic criteria and reflecting meteorology and geology at the site, general area conditions and the construction work scale.

12.3.1 Basic Criteria for Cost Estimate

The construction cost for the Project has been estimated for calculation of financial amount and for economic and financial evaluation of the project.

(1) Unit prices of materials, labor and equipment, which constitute the unit costs of the work items are based on the price level at the end of December, 2006.
Exchange rates for the estimation are as follows;
US$ 1 = NRs. 70.71 = JPY 120.11 at the end of December 2006

(2) Administration and engineering fee is estimates as 7% of the total cost of preparatory works, civil works, hydromechanical equipment, electromechanical equipment, and transmission line.

(3) Contingency is estimated as 10% of both foreign and local currencies of preparatory works

and civil works, and 5% of those of hydromechanical equipment, electromechanical equipment, and transmission line.

(4) All costs are expressed in US$ and are assorted into the Local Currency and a Foreign Currency.

(5) Unit prices and construction costs include taxes and duties to be paid outside Nepal, but for imported materials or equipment, local taxes and customs duties in Nepal are not included..

(6) Price escalation is not included in the project cost.

(7) Interest during the construction period is not included in the project cost.

12.3.2 Constitution of Project Cost

The project cost consists of the following cost items.

(1)	Preparatory Construction Cost:	Existing road improvement works, access roads, temporary yards, power supply facilities for construction power, office and camp facilities for NEA and Engineer.
(2)	Civil Works Construction Cost:	
	Care of River	Diversion tunnel, upstream and downstream coffer dams
	Dam	Main dam body, foundation treatment, spillway main body, stilling basin wall
	Waterway	Intake, headrace tunnel, headrace surge tank, penstock, tailrace surge tank, tailrace tunnel, outlet
	Powerhouse	Powerhouse foundation, machine room, main transformer room etc., building and control room, switchyard foundation
(3)	Hydromechanical Equipment:	Gates, Penstock, Screen, sediment flushing facilities
(4)	Hydroelectric Equipment:	Turbine, generator, related auxiliary equipment, main transformer
(5)	Transmission Line:	220 kV double circuit transmission line 38 km long
(6)	Environmental cost:	Cost for compensation, mitigation, monitoring, etc.
(7)	Physical Contingency:	10% for preparatory works and civil works, 5% for hydromechanical equipment, electromechanical equipment and transmission line
(8)	Administrative and Engineering Costs:	Administrative/management and engineering costs on detailed design and construction supervision (7% of direct cost)

The direct construction cost comprises the total of Items (1) through (5) above. The project cost comprises the total for direct construction cost and indirect cost consisting of Items (6) and (9) above.

12.3.3 Construction Cost of Civil Works

Production rates for unit price estimation used for similar projects or normal public works in Japan, or unit costs estimated in similar projects in Nepal and neighboring countries are basically referred to cost estimation of civil works.

Labor costs are calculated based on those announced in Nepal. **Table 12.3.3-1** shows labor costs used for cost estimation in the Study.

Table 12.3.3-1 Labor Cost in Nepal (Tanabu District)

Code	Particular	Unit	FC (US$)	LC (US$)	**LC Per day (Nrs)**	Remark
L1010	Foreman, foreign	m.d.	200.00			
L0010	Foreman A (Skilled)	m.d.		8.952	**633.00**	Tanahu
L0011	Foreman B (Semi-skilled)	m.d.		7.114	**503.00**	Tanahu
L0020	Operator A (Skilled)	m.d.		8.952	**633.00**	Tanahu
L0021	Operator B (Semi-skilled)	m.d.		7.114	**503.00**	Tanahu
L0030	Assistant operator	m.d.		4.893	**346.00**	Tanahu
L0040	Driver A (Heavey Truck)	m.d.		7.114	**503.00**	Tanahu
L0041	Driver B (Light Viecle)	m.d.		4.893	**346.00**	Tanahu
L0050	Mechanic A (Skilled)	m.d.		8.952	**633.00**	Tanahu
L0051	Mechanic B (Semi-skilled)	m.d.		7.114	**503.00**	Tanahu
L0060	Electrician A (Skilled)	m.d.		7.114	**503.00**	Tanahu
L0061	Electrician B (Semi-skilled)	m.d.		4.893	**346.00**	Tanahu
L0070	Welder A	m.d.		7.114	**503.00**	Tanahu
L0090	Carpenter A (Skilled)	m.d.		8.952	**633.00**	Tanahu
L0091	Carpenter B (Semi-skilled)	m.d.		7.114	**503.00**	Tanahu
L0100	Form worker	m.d.		4.893	**346.00**	Tanahu
L0120	Boring worker	m.d.		4.893	**346.00**	Tanahu
L0121	Grout worker	m.d.		4.893	**346.00**	Tanahu
L0130	Concrete worker	m.d.		4.893	**346.00**	Tanahu
L0140	Driller A	m.d.		7.114	**503.00**	Tanahu
L0150	Tunnel worker A	m.d.		7.114	**503.00**	Tanahu
L0151	Tunnel worker B	m.d.		4.893	**346.00**	Tanahu
L0200	Blasting worker	m.d.		7.114	**503.00**	Tanahu
L0210	Steel worker	m.d.		7.114	**503.00**	Tanahu
L0220	Rebar worker	m.d.		7.114	**503.00**	Tanahu
L0230	Grout worker A (Skilled)	m.d.		7.114	**503.00**	Tanahu
L0231	Grout worker B (Semi-skilled)	m.d.		4.893	**346.00**	Tanahu
L0290	Skilled labor	m.d.		4.893	**346.00**	Tanahu
L0300	Common labor	m.d.		3.536	**250.00**	Tanahu

Data and information on material prices are collected during Study Team's site works in Nepal and used for cost estimation in the Study. Some material prices are listed in **Table 12.3.3-2**

Table 12.3.3-2 District Construction Material Rate in Tanahu District

S.No	Description	Unit	Rate (NRPs)	Rates (US$)	Remarks
2	Cement (50 Kg)				
	Hetauda	bag	340.00	4.81	
	Udayapur	bag	340.00	4.81	
	Indian, 43 Grade	bag	350.00	4.95	
	Indian, 53 Grade	bag	355.00	5.02	
	White cement (50 Kg)	bag	910.00	12.87	
12	Wood				
	Sa lwood	Cu. Ft	1,136.00	16.07	
	Sissau wood	Cu. Ft	600.00	8.49	
	Fi rewood	100 kg	300.00	4.24	
15	steel Reinforcement Bar				
	dia 6-8mm	kg	43.00	0.61	
	dia 10-22mm	kg	42.00	0.59	
	dia 25- 32mm	kg	43.00	0.61	
	dia4.75- 7mm	kg	45.00	0.64	
16	Gl sheet				
	26 gauge, heavy	Bundle	5,000.00	70.71	
	26 gauge, medium	Bundle	4,550.00	64.35	
	26 gauge, commercial	Bundle	3,900.00	55.15	
	28 gauge, commercial	Bundle	3,600.00	50.91	
17	Steel pipe (φ150mm)	m	2,350.00	33.23	
18	Dynamite 25/32 mm	kg		4.16	
	Special Dynamite	kg		20.80	
	ANFO	kg		2.75	

Note:
1 Value added tax is not included in the above specified items.
2 The rates specified above are for the headquarter ofTanahun district, damauli and adjacent at
For other places, transportation cost is to be added.
3 Rates for the items other than specified items will be as per the rate of any HMG/N authorised
4 For the excavation of road by using dozzar, the rate will be as per Heavy Equipment Division o

12.3.4 Project Construction Cost

Construction cost (direct cost) estimated with conditions described in **12.3.1** and **12.3.2** above consists of costs for preparatory works, civil works, hydro mechanical works, electromechanical works and transmission line.

Project construction cost comprises the above construction cost, administration and engineering spending, environmental cost, and physical contingency.

Project construction cost by each main item with foreign and local currencies is shown in **Table 12.3.4-1**.

Table 12.3.4-1 Project Construction Cost

No.	Item	Unit	Quantity	Unit Price(US$)			Amount (US$)		
				Total	Foreign	Local	Total	Foreign	Local
1	**Preparatory Works**								
1.1	Access Road	LS	1				640,000	0	640,000
1.2	Temporary Power Supply	LS	1				400,000		400,000
1.3	Camp and Office for NEA & Engineer	LS	1				1,200,000	0	1,200,000
	Total						**2,240,000**	**0**	**2,240,000**
2	**Civil Works**								
2.1	Diversion Tunnel & Care of River								
	Tunnel Excavation	m3	80,400	42.6	31.7	10.9	3,425,040	2,548,680	876,360
	Tunnel Supporting Work								
	Shotcrete 5cm	m^2	30,700	14.0	8.0	6.0	429,800	245,600	184,200
	Shotcrete 10cm	m^2	9,000	27.4	17.0	10.4	246,600	153,000	93,600
	Rock Bolt	m	14,100	22.3	8.3	14.0	314,430	117,030	197,400
	Steel Support	ton	50	1323.6	24.1	1299.5	66,180	1,205	64,975
	Concrete Lining	m3	22,900	82.8	56.9	25.9	1,896,120	1,303,010	593,110
	Reinforce Bar	t	950	888.6	25.6	863.0	844,170	24,320	819,850
	Formwork	m^2	1,910	12.5	0.1	12.4	23,875	191	23,684
	Others	LS	0				2,898,486	1,757,214	1,141,272
	Care of River	LS	1				4,464,000	2,678,000	1,786,000
	Sub-total						**14,608,701**	**8,828,250**	**5,780,451**
2.2	Dam & Spillway								
	Open Excavation (Rock)	m3	1,260,000	7.4	6.1	1.3	9,324,000	7,686,000	1,638,000
	Downstream Channel	m3	63,900	7.4	6.1	1.3	472,860	389,790	83,070
	Dam Cocrete	m3	888,900	112.2	66.7	45.5	99,734,580	59,289,630	40,444,950
	Reinforce Bar	ton	2,900	888.6	25.6	863.0	2,576,940	74,240	2,502,700
	Grouting Tunnel	m	680	4954.0	3566.9	1387.1	3,368,720	2,425,492	943,228
	Curtain Grout	m	45,200	111.0	106.8	4.2	5,017,200	4,827,360	189,840
	Consolidation Grout	m	4,000	108.6	105.3	3.3	434,400	421,200	13,200
	Protection Concrete	m3	19,800	74.0	48.1	25.9	1,465,200	952,380	512,820
	Form	m2	10,900	11.4	7.2	4.2	124,260	78,480	45,780
	Others		0				3,675,545	2,284,337	1,391,208
	Sub-total						**126,193,705**	**78,428,909**	**47,764,796**
2.3	Intake								
	Open Excavation (Common)	m3	29,300	2.9	1.7	1.2	84,970	49,810	35,160
	Open Excavation (Rock)	m3	68,370	7.5	4.8	2.7	512,775	328,176	184,599
	Tunnel Excavation	m3	5,730	42.6	31.7	10.9	244,098	181,641	62,457
	Tunnel Supporting Work								
	Shotcrete 10cm	m2	1,770	27.2	16.9	10.3	48,144	29,913	18,231
	Rock Bolt	m	3,680	22.3	8.3	14.0	82,064	30,544	51,520
	Steel Support	ton	35	1323.6	24.1	1299.5	46,326	844	45,483
	Shaft Excavation	m3	3,970	29.7	21.7	8.0	117,909	86,149	31,760
	Shaft Supporting Work								
	Shotcrete 5cm	m2	1,020	14.0	8.0	6.0	14,280	8,160	6,120
	Shotcrete 10cm	m2	690	27.2	16.9	10.3	18,768	11,661	7,107
	Rock Bolt	m	640	22.3	8.3	14.0	14,272	5,312	8,960
	Steel Support	ton	12	1323.6	24.1	1299.5	15,883	289	15,594
	Shotcrete for Slope Protection	m2	5,500	27.2	16.9	10.3	149,600	92,950	56,650
	Structure Concrete	m3	3,080	74.1	47.9	26.2	228,228	147,532	80,696
	Shaft Lining Concrete	m3	1,100	82.8	56.9	25.9	91,080	62,590	28,490
	Tunnel Lining Concrete	m3	2,370	82.8	56.9	25.9	196,236	134,853	61,383
	Wall Concrete	m3	2,400	74.0	48.1	25.9	177,600	115,440	62,160
	Reinforce Bar	t	650	888.6	25.6	863.0	577,590	16,640	560,950
	Tunnel Formwork	m^2	2,690	18.2	12.5	5.7	48,958	33,625	15,333
	Shaft Formwork	m^2	2,630	11.5	7.3	4.2	30,245	19,199	11,046
	Structure Formwork	m2	2,230	11.5	7.3	4.2	25,645	16,279	9,366
	Others	LS	1				413,516	192,002	221,514
	Sub-total						**3,138,187**	**1,563,609**	**1,574,578**

No.	Item	Unit	Quantity	Unit Price(US$)			Amount (US$)		
				Total	Foreign	Local	Total	Foreign	Local
2.4	Headrace Tunnel								
	Excavation, tunnel	m^3	65,600	42.6	31.7	10.9	2,794,560	2,079,520	715,040
	Tunnel supporting work								
	Shotcrete 5cm	m^2	13,900	14.0	8.0	6.0	194,600	111,200	83,400
	Shotcrete 10cm	m^2	7,700	27.4	17.0	10.4	210,980	130,900	80,080
	Rock Bolt	m	23,400	23.7	9.4	14.3	554,580	219,960	334,620
	Steel Support	ton	9	1341.3	23.8	1317.5	12,072	214	11,858
	Concrete, lining	m^3	15,800	82.8	56.9	25.9	1,308,240	899,020	409,220
	Re-bar	ton	480	888.6	25.6	863.0	426,528	12,288	414,240
	Formwork	m^2	8,700	12.5	0.1	12.4	108,750	870	107,880
	Work adit	m	640	4413.1	3046.7	1366.4	2,824,384	1,949,888	874,496
	Others	7%					590,429	378,270	212,158
	Sub-total						**9,025,122**	**5,782,130**	**3,242,992**
2.5	Headrace Surge Tank								
	Excavation, shaft	m^3	16,200	29.7	21.7	8.0	481,140	351,540	129,600
	Tunnel supporting work								
	Shotcrete 10cm	m^2	3,400	27.4	17.0	10.4	93,160	57,800	35,360
	Rock Bolt, 25mm dia., 5m length	m	4,020	20.5	8.7	11.8	82,410	34,974	47,436
	Concrete, Structure	m^3	3,700	74.1	47.9	26.2	274,170	177,230	96,940
	Re-bar	ton	185	888.6	25.6	863.0	164,391	4,736	159,655
	Formwork	m^2	3,100	11.5	7.3	4.2	35,650	22,630	13,020
	Work Adit	m	425	2506.8	1600.6	906.2	1,065,390	680,255	385,135
	Others	7%					153,742	93,042	60,700
	Sub-total						**2,350,053**	**1,422,207**	**927,846**
2.6	Penstock								
	Excavation, tunnel	m^3	3,500	46.6	34.8	11.8	163,100	121,800	41,300
	Excavation, inclined shaft	m^3	4,800	118.3	93.7	24.6	567,840	449,760	118,080
	Tunnel supporting work								
	Shotcrete 10cm	m^2	3,800	27.4	17.0	10.4	104,120	64,600	39,520
	Rockbolt	m	3,200	23.7	9.4	14.3	75,840	30,080	45,760
	Concrete, backfill	m^3	3,500	74.1	47.9	26.2	259,350	167,650	91,700
	Others	7%					81,918	58,372	23,545
	Sub-total						**1,252,168**	**892,262**	**359,905**
2.7	Powerhouse								
	Excavation, Cavern	m^3	72,400	32.6	23.6	9.0	2,360,240	1,708,640	651,600
	Cavern supporting work								
	Shotcrete 32cm	m^2	3,300	111.3	84.6	26.7	367,290	279,180	88,110
	Shotcrete 24cm	m^2	3,400	78.2	59.5	18.7	265,880	202,300	63,580
	Shotcrete 16cm	m^2	2,900	55.6	42.3	13.3	161,240	122,670	38,570
	PS Anchor, 100t, 20m	m	35,800	146.5	139.1	7.4	5,244,700	4,979,780	264,920
	PS Anchor, 60t, 15m	m	1,800	93.4	88.1	5.3	168,120	158,580	9,540
	PS Anchor, 60t, 10m	m	1,400	97.9	92.4	5.5	137,060	129,360	7,700
	Rockbolt, 25mm dia., 5m length	m	10,500	20.5	8.7	11.8	215,250	91,350	123,900
	Concrete, structure	m^3	20,400	74.1	47.9	26.2	1,511,640	977,160	534,480
	Re-bar	ton	1,370	888.6	25.6	863.0	1,217,382	35,072	1,182,310
	Formwork	m^2	18,000	11.5	7.3	4.2	207,000	131,400	75,600
	Building and utility works	LS					2,756,474	2,049,602	706,872
	Others	7%					1,022,859	760,556.6	262,302.7
	Sub-total						**15,635,135**	**11,625,651**	**4,009,485**
2.8	Access Tunnel								
	Excavation, common	m^3	9,900	2.9	1.7	1.2	28,710	16,830	11,880
	Excavation, Rock	m^3	5,800	7.5	4.8	2.7	43,500	27,840	15,660
	Excavation, Tunnel	m^3	74,800	50.3	37.6	12.7	3,762,440	2,812,480	949,960
	Slope protection work								
	Shorcrete 10cm	m^2	900	27.4	17.0	10.4	24,660	15,300	9,360
	Concrete, wall	m^3	700	74.1	47.9	26.2	51,870	33,530	18,340
	Re-bar	ton	35	888.6	25.6	863.0	31,101	896	30,205
	Formwork	m^2	900	11.5	7.3	4.2	10,350	6,570	3,780
	Tunnel supporting work								
	Shotcrete, 10cm	m^2	28,700	27.4	17.0	10.4	786,380	487,900	298,480
	Rockbolt, 25mm dia., 3m length	m	35,300	23.7	9.4	14.3	836,610	331,820	504,790
	Steel Support	ton	20	1341.6	24.1	1317.5	26,832	482	26,350
	Concrete, lining	m^3	5,300	82.8	56.9	25.9	438,840	301,570	137,270
	Re-bar	ton	160	888.6	25.6	863.0	142,176	4,096	138,080
	Formwork	m^2	1,050	11.5	7.3	4.2	12,075	7,665	4,410
	Others	7%					433,688	283,289	150,400
	Sub-total						**6,629,232**	**4,330,268**	**2,298,965**

No.	Item	Unit	Quantity	Unit Price(US$)			Amount (US$)		
				Total	Foreign	Local	Total	Foreign	Local
2.9	Cable Shaft								
	Excavation, Tunnel	m^3	10,900	69.6	17.1	52.5	758,640	186,390	572,250
	Excavation, inclined shaft	m^3	1,900	156.5	138.9	17.6	297,350	263,910	33,440
	Tunnel supporting work								
	Shorcrete 10cm	m^2	10,300	14.1	8.0	6.1	145,230	82,400	62,830
	Rockbolt, 25mm dia., 2m length	m	8,500	23.7	9.4	14.3	201,450	79,900	121,550
	Steel Support	ton	10	1323.6	24.1	1299.5	13,236	241	12,995
	Concrete lining	m^3	3,600	82.8	56.9	25.9	298,080	204,840	93,240
	Re-bar	ton	100	888.6	25.6	863.0	88,860	2,560	86,300
	Formwork	m^2	8,500	11.5	7.3	4.2	97,750	62,050	35,700
	Others	7%					133,042	61,760	71,281
	Sub-total						**2,033,638**	**944,051**	**1,089,586**
2.10	Switchyard								
	Excavation, common	m^3	36,600	2.9	1.7	1.2	106,140	62,220	43,920
	Excavation, rock	m^3	37,600	7.5	4.8	2.7	282,000	180,480	101,520
	Slope protection work								
	Shorcrete 10cm	m^2	1,400	27.4	17.0	10.4	38,360	23,800	14,560
	Concrete, wall	m^3	800	74.1	47.9	26.2	59,280	38,320	20,960
	Re-bar	ton	40	888.6	25.6	863.0	35,544	1,024	34,520
	Formwork	m^2	1,100	11.5	7.3	4.2	12,650	8,030	4,620
	Others	7%					37,378	21,971	15,407
	Sub-total						**571,352**	**335,845**	**235,507**
2.11	Tailrace Surge Chamber								
	Excavation, shaft	m^3	24,900	29.7	21.7	8.0	739,530	540,330	199,200
	Tunnel supporting work								
	Shotcrete 10cm	m^2	4,100	27.4	17.0	10.4	112,340	69,700	42,640
	Rock Bolt, 25mm dia., 5m length	m	4,900	20.5	8.7	11.8	100,450	42,630	57,820
	PS Anchor, 60t, 10m	m	9,900	97.9	92.4	5.5	969,210	914,760	54,450
	Concrete, Structure	m^3	5,100	82.8	56.9	25.9	422,280	290,190	132,090
	Re-bar	ton	260	888.6	25.6	863.0	231,036	6,656	224,380
	Formwork	m^2	4,500	11.5	7.3	4.2	51,750	32,850	18,900
	Work Adit	m	180	2134.9	1424.9	710.0	384,282	256,482	127,800
	Others	7%					210,761	150,752	60,010
	Sub-total						**3,221,639**	**2,304,350**	**917,290**
2.12	Tailrace Tunnel								
	Excavation, tunnel	m^3	40,000	42.5	31.7	10.8	1,700,000	1,268,000	432,000
	Tunnel supporting work								
	Shotcrete 5cm	m^2	1,700	14.1	8.0	6.1	23,970	13,600	10,370
	Shotcrete 10cm	m^2	10,500	27.4	17.0	10.4	287,700	178,500	109,200
	Rock Bolt	m	16,200	22.3	8.3	14.0	361,260	134,460	226,800
	Steel Support	ton	20	1341.6	24.1	1317.5	26,832	482	26,350
	Concrete, lining	m^3	11,000	82.8	56.9	25.9	910,800	625,900	284,900
	Re-bar	ton	400	888.6	25.6	863.0	355,440	10,240	345,200
	Formwork	m^2	12,500	11.5	7.3	4.2	143,750	91,250	52,500
	Others	7%					266,683	162,570	104,112
	Sub-total						**4,076,435**	**2,485,002**	**1,591,432**
2.13	Outlet								
	Excavation, common	m^3	5,900	2.9	1.7	1.2	17,110	10,030	7,080
	Excavation, rock	m^3	9,200	7.5	4.8	2.7	69,000	44,160	24,840
	Concrete, Structure	m^3	2,900	74.1	47.9	26.2	214,890	138,910	75,980
	Re-bar	ton	210	888.6	25.6	863.0	186,606	5,376	181,230
	Formwork	m^2	2,100	11.5	7.3	4.2	24,150	15,330	8,820
	Others	15%					76,763	32,071	44,693
	Sub-total						**588,519**	**245,877**	**342,643**
2.14	Miscellaneous Works		1%				**1,893,239**	**1,191,884**	**701,355**
2.15	Slope Protection at Reservoir Critical Area						**2,100,000**	**0**	**2,100,000**
	Total						**193,317,125**	**120,380,296**	**72,936,829**

No.	Item	Unit	Quantity	Unit Price(US$)			Amount (US$)		
				Total	Foreign	Local	Total	Foreign	Local
3	**Hydromechanical Equipment**								
3.1	Spillway Gate	t	444	6150	5500	650	2,730,600	2,442,000	288,600
3.2	Sediment Flushing Facilities								
	High-pressure Slide Gate	t	200	6700	6000	700	1,340,000	1,200,000	140,000
	High-pressure Radial Gate	t	241	6700	6000	700	1,614,700	1,446,000	168,700
	Flushing Tube	t	396	5500	4500	1000	2,178,000	1,782,000	396,000
3.3	Intake Gate	t	141	6260	5600	660	882,660	789,600	93,060
3.4	Intake Screen	t	78	5500	4500	1000	429,000	351,000	78,000
3.5	Maintenance Flow Outlet Valve	t	23	8050	7200	850	185,150	165,600	19,550
3.6	Steel Penstock	t	930	5500	4500	1000	5,115,000	4,185,000	930,000
3.7	Draft Gate	t	224	8050	7200	850	1,803,200	1,612,800	190,400
3.8	Tailrace Gate	t	56	6350	5700	650	352,425	316,350	36,075
	Total						**16,630,735**	**14,290,350**	**2,340,385**
4	**Elecromechanical Equipment**								
4.1	Overhed Traveling Crane	LS	1				1,520,000	1,450,000	70,000
4.2	Turbine & Generator	LS	1				36,210,000	34,490,000	1,720,000
4.3	Main Transformer (incl. Switchyard)	LS	1				6,450,000	6,140,000	310,000
4.4	River Maintenance Generation Facility	LS	1				3,000,000	2,700,000	300,000
	Total						**47,180,000**	**44,780,000**	**2,400,000**
5	**Tansmission line**	LS	1				**9,000,000**	**7,650,000**	**1,350,000**
	Construction Cost								
	Total of Direct Cost (1 to 5)						**268,367,860**	**187,100,646**	**81,267,214**
6	**Environmental Cost**								
6.1	Cost for Physical Environment	LS	1				2,386,000	0	2,386,000
6.2	Cost for Biological Environment	LS	1				7,430,000	900,000	6,530,000
6.3	Cost for Resettlement Plan	LS	1				15,943,000	0	15,943,000
6.4	Social Action Program	LS	1				3,339,000	0	3,339,000
	Total						**29,098,000**	**900,000**	**28,198,000**
7	**Adiministration and Engineering Fee**						**18,785,750**	**13,097,045**	**5,688,705**
8	**Contingency**						**24,651,149**	**15,419,047**	**9,232,102**
	Total of Indirect Cost (6 to 8)						**72,534,899**	**29,416,092**	**43,118,807**
9	**Project Construction Cost (1 to 9)**						**340,902,759**	**216,516,738**	**124,386,022**

12.3.5 Disbursement Schedule

The annual required funding (disbursement schedule) is indicated in **Table 12.3.5-1**.

Table 12.3.5-1 Disbursement Schedule of Project Construction Cost

No.	Item	1st Year	2nd Year	3rd Year	4th Year	5th Year	6th Year	Total
1	Preparatory Works	2,240	0	0	0	0	0	2,240
	Foreign	0	0	0	0	0	0	0
	Local	2,240	0	0	0	0	0	2,240
2	Civil Works	12,167	28,488	24,770	65,045	60,667	2,180	193,317
	Foreign	7,540	19,483	16,287	39,351	37,025	694	120,380
	Local	4,627	9,005	8,483	25,694	23,642	1,486	72,937
3	Hydromechanical Equipment	0	0	3,160	3,326	6,676	3,469	16,631
	Foreign	0	0	2,715	2,858	5,716	3,001	14,290
	Local	0	0	445	468	960	468	2,341
4	Elecromechanical Equipment	0	0	8,836	9,436	24,190	4,718	47,180
	Foreign	0	0	8,416	8,956	22,930	4,478	44,780
	Local	0	0	420	480	1,260	240	2,400
5	Tansmission line	0	0	1,800	1,800	4,500	900	9,000
	Foreign	0	0	1,530	1,530	3,825	765	7,650
	Local	0	0	270	270	675	135	1,350
6	Environmental Cost	25,425	0	0	0	1,298	2,375	29,098
	Foreign	0	0	0	0	0	900	900
	Local	25,425	0	0	0	1,298	1,475	28,198
7	Adiministration and Engineering Fee	1,009	1,994	2,699	5,573	6,723	789	18,787
	Foreign	528	1,364	2,026	3,689	4,865	626	13,098
	Local	481	630	673	1,884	1,858	163	5,689
8	Contingency	2,712	2,849	3,167	7,232	7,900	790	24,650
	Foreign	754	1,948	2,262	4,602	5,326	527	18,800
	Local	1,958	901	905	2,630	2,574	263	10,947
9	Total	43,553	33,331	44,432	92,412	111,954	15,221	340,903
	Foreign	8,822	22,795	33,236	60,986	79,687	10,991	216,517
	Local	34,731	10,536	11,196	31,426	32,267	4,230	124,386

An advance payment will be made to contractors according to the type of works. The retention money will be released to the contractors after the acceptance inspections during the final year of works. The above conditions are incorporated in the disbursement schedule.

CHAPTER 13 ECONOMIC AND FINANCIAL EVALUATION

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CHAPTER 13 ECONOMIC AND FINANCIAL EVALUATION

13.1 Economic Evaluation

13.1.1 Methodology

(1) Methodology

Economic evaluation aims at measuring the "economic" impact brought about to a country by implementing a project from a viewpoint of national economy. Here, a comparison of costs and benefits expressed in terms of economic prices will be made by applying the Discount Cash Flow Method, which is widely adopted for such purposes.

The basic approach for this method is as follows. First, the cash outflow (costs) and inflow (benefits) are developed on an annual basis over the project life. Secondly the amount generated during different years will be discounted to the start year of the project and expressed it as an accumulated present value at the same standard year. Then a comparison will be made between the costs and benefits. Evaluation indices to be obtained will be the Net Present Value, the Benefit/Cost Ratio, and the Economic Internal Rate of Return (EIRR). The EIRR is a discount rate at which the present values of the two cash flows become equal. This rate shows the return to be expected from the project. EIRR is expressed in the following equation:

$$\sum_{t=0}^{n} C_t / (1+r)^t - \sum_{t=0}^{n} B_t / (1+r)^t = 0$$

where,

Ct	= Cost
Bt	= Benefit
t	= year
n	= project life (year)
r	= discount rate (= EIRR)

(2) Basic Conditions

According to the discussions with NEA, as well as in line with the existing reports for other projects in Nepal, the following basic conditions were adopted.

- Opportunity cost of capital:
  Opportunity cost of capital refers to an interest rate at which the appropriateness of investment can be justified. A rate of 10% was used in view of the rates used for other projects in Nepal.

- Discount rate:

  A discount rate of 10% will be used. This rate of 10% is also used by the World Bank. 8 % and 12 % were also used for sensitivity analysis.

- Conversion factor:

  Standard conversion factor of 0.9, adopted by the World Bank, was used. This is a coefficient to calculate the economic price from the construction costs estimated at the market price, and applied to the domestic currency portion.

- Service life:

  Service life of each facility, according to the experience of the Consultant, was determined as follows:

  - 50 years for civil works
  - 30 years for hydro-mechanical and electro-mechanical equipment
  - 30 years for transmission lines

- Project life (Calculation period)

  Calculation period for evaluation is 56 years: 50 years of service life of civil facilities and 6 years of construction works. It is assumed that the power plant will become commercially operational in late December.

- Evaluation Point

  Evaluation was made at the entrance of the Substation to which the transmission line from Upper Seti Project is connected. It is also assumed that the alternative thermal power plant would be constructed at an adjacent place for connection with a grid.

- Cost Estimate

  Estimation of cost was based on the price level of December 2006.

- Escalation

  No escalation was considered, therefore, a constant price will be used.

- Tax

  Taxes including VAT and customs are excluded from the calculation, being a transfer item.

13.1.2 Economic Costs of the Project

The economic costs of the Project were calculated from the market price as presented in the **Chapter 12**. Construction cost and Operation and Maintenance cost were included in the cost stream. The method of economic pricing is as follows:

Foreign currency portion

- Exclusion of transfer items such as taxes (import tax, value added tax) and subsidies

Local currency portion

- Exclusion of transfer items such as taxes and subsidies
- Conversion of market prices to economic price (applying standard conversion factor)

(1) Initial Investment Costs (economic price)

Initial investment costs by facility are shown in **Table 13.1.2-1**. The annual investment amount for major items, including the Engineering and Administration Cost as well as Contingency, is summarized in **Table 13.1.2-2**:

Table 13.1.2-2 Annual Investment Amount for Major Items

(Unit: 1000US$)

	Civil and preparatory works	Hydromechanical and electromechanical equipment	Transmission line	Environmental cost	Total Cost
1st year	16,053	0	0	24,027	40,079
2nd year	32,277	0	0	0	32,277
3rd year	27,988	13,339	1,986	0	43,313
4th year	73,096	14,187	1,986	0	89,269
5th year	68,214	34,321	4,864	1,227	108,727
6th year	2,377	9,090	993	2,339	14,799
Total	220,006	70,937	9,929	27,592	328,464

(2) Operation and Maintenance Cost (economic price)

The operation and maintenance cost was calculated by multiplying the construction cost of each work item by a certain rate, which was determined according to the experiences with similar projects by the Consultant (see **Table 13.1.2-3**).

Table 13.1.2-3 O&M Costs at Economic Price

(Unit: 1,000US$)

Item	Construction Cost	Rate	Amount
Civil Works	220,006	0.5%	1,100.0
Equipment	70,937	1.5%	1,064.1
Transmission Line	9,929	1.5%	148.9
Total			2,313.0

Replacement cost of equipment and transmission line after fulfilling the service life will be separately considered, referring to the initial investment cost.

Table 13.1.2-1 Initial Investment Cost (at Economic Price)

(unit: US$1000)

Year		0	1	2	3	4	5	Total
1. Preparatory Works	FC	0	0	0	0	0	0	0
	LC	2,016	0	0	0	0	0	2,016
Civil Works	FC	7,540	19,483	16,287	39,351	37,025	694	120,380
	LC	4,164	8,105	7,635	23,125	21,278	1,337	65,643
Eng. and Administration	FC	528	1,364	1,140	2,755	2,592	49	8,427
	LC	433	567	534	1,619	1,489	94	4,736
Contingency	FC	754	1,948	1,629	3,935	3,703	69	12,038
	LC	618	810	763	2,312	2,128	134	6,766
Total	FC	8,822	22,795	19,056	46,041	43,319	812	140,845
	LC	7,231	9,482	8,933	27,056	24,895	1,565	79,161
	Total	16,053	32,277	27,988	73,096	68,214	2,377	220,006
2. Hydromechanical Equipment	FC	0	0	2,715	2,858	5,716	3,001	14,290
	LC	0	0	401	421	864	421	2,107
Eng. and Administration	FC	0	0	190	200	400	210	1,000
	LC	0	0	28	29	60	29	147
Contingency	FC	0	0	136	143	286	150	715
	LC	0	0	20	21	43	21	105
Total	FC	0	0	3,041	3,201	6,402	3,361	16,005
	LC	0	0	449	472	968	472	2,360
	Total	0	0	3,489	3,673	7,370	3,833	18,365
3. Electromechanical Equipment	FC	0	0	8416	8956	22930	4478	44,780
	LC	0	0	378	432	1134	216	2,160
Eng. and Administration	FC	0	0	589	627	1,605	313	3,135
	LC	0	0	26	30	79	15	151
Contingency	FC	0	0	421	448	1,147	224	2,239
	LC	0	0	19	22	57	11	108
Total	FC	0	0	9,426	10,031	25,682	5,015	50,154
	LC	0	0	423	484	1,270	242	2,419
	Total	0	0	9,849	10,515	26,952	5,257	52,573
4. Transmission Line	FC	0	0	1530	1530	3825	765	7,650
	LC	0	0	243	243	607.5	121.5	1,215
Eng. and Administration	FC	0	0	107	107	268	54	536
	LC	0	0	17	17	43	9	85
Contingency	FC	0	0	77	77	191	38	383
	LC	0	0	12	12	30	6	61
Total	FC	0	0	1,714	1,714	4,284	857	8,568
	LC	0	0	272	272	680	136	1,361
	Total	0	0	1,986	1,986	4,964	993	9,929
5. Environmental Cost	FC	0	0	0	0	0	900	900
	LC	22,883	0	0	0	1,168	1,328	25,378
Eng. and Administration	FC	0	0	0	0	0	0	0
	LC	0	0	0	0	0	0	0
Contingency	FC	0	0	0	0	0	45	45
	LC	1,144	0	0	0	58	66	1,269
Total	FC	0	0	0	0	0	945	945
	LC	24,027	0	0	0	1,227	1,394	26,647
	Total	24,027	0	0	0	1,227	2,339	27,592
6. **Total Construction Cost**	FC	8,822	22,795	33,236	60,986	79,686	10,990	216,515
	LC	31,258	9,482	10,077	28,284	29,040	3,808	111,948
	Total	40,079	32,277	43,313	89,269	108,727	14,799	328,464
Conversion factor for LC:	0.9							

13.1.3 Economic Benefit of the Project

For the purpose of this study, the following two benefits were adopted:

- Cost for alternative thermal power plant,
- Long range marginal cost for secondary energy.

As to the saved cost of alternative thermal power project, it is an economic benefit measured from a viewpoint of "with project" and "without project". In the case of the Upper Seti Project not being realized, a thermal power plant would be set up to generate the energy with quality and quantity equivalent to the Project. The project cost of such alternative thermal power plant can be considered as an economic benefit for the Project, because it corresponds to the cost saved by implementing the Upper Seti Project. In addition, secondary energy generated during the wet season is also considered as an economic benefit of the Project.

(1) Alternative Thermal Power Plants

Here, a gas turbine was selected as alternative thermal power plant. The reasons are as follows: the Upper Seti Project is a reservoir type power plant designed to serve peak power. Alternative thermal should have such characteristics. Similar to a hydropower plant, a gas turbine has a good response to follow the load fluctuation, and that it has a plenty of service results around the world. Thus a gas turbine was selected.

Characteristics of alternative thermal power plant are set as follows. The installed capacity of the alternative thermal power plant was calculated, which took into account the loss rates described in the **Table 13.1.3-1**, based on the effective dependable capacity of the Upper Seti Project. The unit construction cost was taken from a WB report. In this Project, due to fluctuating water discharge by season, the effective dependable capacity is small compared to the installed capacity. Therefore, from a conservative viewpoint, which requires excessive benefits to be excluded from the estimation, the installed capacity of alternative thermal was set lower than that of the Upper Seti Project (**Table 13.1.3-2**).

Table 13.1.3-2 Characteristics of Alternative Thermal Plant

Item	Gas Turbine
Installed capacity	118.0 MW
Unit cost	US$ 520/kW
Construction cost	US$ 61,360,000
Service life	15 years

a) Construction Cost for Alternative Thermal Plant

The alternative thermal power plant would be constructed in 18 months, and its initial investment cost is shown in **Table 13.1.3-3**:

Table 13.1.3-3 Construction Cost of Alternative Thermal Plant

Item		Gas Turbine
1st year	40%	US$ 24,544,000
2nd year	60%	US$ 36,816,000
Total	100%	US$ 61,360,000

b) O&M Cost for Alternative Thermal Plant

The annual O&M cost for the alternative thermal was estimated by the following fixed and variable costs referring to a WB report (see **Table 13.1.3-4**):

Table 13.1.3-4 O&M Cost for Alternative Thermal Plant

Item	Unit cost	Number	O&M cost
Fixed cost	US$ 61,360,000	3%	US$ 1,841,000
Variable cost	US$ 0.01/kWh	203.54 MWh	US$ 2,035,000
Total	---	---	US$ 3,876,000

c) Fuel Cost for Alternative Thermal Plant

The annual fuel cost for alternative thermal will be outlined below. The basic price for Diesel oil of N.Rp. 49.69/liter (US$ 0.66/liter) is adopted. Nepal relies on import of petroleum products, therefore, unit import price of diesel oil by Nepal Oil Corporation (NOC) from Indian Oil Corporation Ltd. (IOC) as of July 2006 is used as economic price.

Item	Unit cost	Fuel cost
Diesel oil	US$ 0.66/ liter	US$ 37,228,000/year

Table 13.1.3-1 Alternative Thermal Power Plant for Studying Economic Justification

Item	Unit	Gas Turbine		Upper Seti Hydro	
Installed Capacity	MW	118.0		127.0	
Dependable Capacity	MW	118.0		85.8	
Losses	%	33.0%		7.9%	
Effective Dependable Capacity	MW	79.0		79.0	
Annual Energy Production	MWh	210,431		(total)	484,400
				Firm	216,900
				Secondary	267,500
Losses		kW	kWh	kW	kWh
Station service use	%	1.5%	1.5%	3.0%	0.3%
Forced outage	%	20.0%	-	1.0%	0.3%
Scheduled outage	%	15.0%	-	3.6%	2.0%
Transmission loss	%	0.0%	0.0%	0.5%	1.9%
Annual Available Energy (Firm)	MWh	207,274		207,274	
Service Life	year	15		50 (civil)	
				30 (equipment)	
Thermal efficiency	kcal	2,529 /kWh		-	
Calorific value	kcal	9,126 /liter			
Unit fuel price	US$	0.66 /liter		-	
Unit construction cost	US$/kW	520		-	
Constrcution cost	1000US$	61,360		-	
Variable O&M cost	US$	0.01 /kWh		-	
Fixed O&M cost	US$	1,841 year			
O&M cost per year	1000US$	3,945		-	
Variable OM cost per year	1000US$	2,104			
Fixed OM cost per year	1000US$	1,841			
Fuel cost per year	1000US$	38,488		-	

(2) Secondary energy

Benefit for secondary energy is measured with a long run marginal cost (LRMC). Unit price of LRMC in the wet season estimated by Norconsult in 1998 is used.

Item	Unit cost	Annual benefit
267,500kWh	US$ 0.015/kWh	US$ 4,013,000

13.1.4 Economic Evaluation

The total present value of the economic cost during the initial year of the project amounts to US$ 273,154,000 (with a discount rate of 10%; the same will be applied to the following calculations). The total present value of the economic benefit with the alternative thermal is US$ 337,641,000. The net present value (B-C) is calculated as US$ 64,487,000, and the benefit cost ratio (B/C) was 1.24. The economic internal rate of return (EIRR) was calculated as 12.3%. (See **Table 13.1.4-1** for details.)

Evaluation indices like the Net Present Value (B-C) and Benefit Cost Ratio (B/C) at various discount rates, as well as EIRR are summarized in **Table 13.1.4-2**:

Table 13.1.4-2 Result of Economic Evaluation

	Benefit Alternative thermal	Criteria	Discount rate
NPV	US$ 155,470,000	> 0	8%
	US$ 64,487,000	> 0	10%
	US$ 6,250,000	> 0	12%
B/C	1.53	> 1	8%
	1.24	> 1	10%
	1.02	> 1	12%
EIRR	12.3%	> oportunity cost of capital	

If the value exceeds the evaluation criteria, the Project is judged to be feasible. All evaluation indices exceed the evaluation criteria, and the Project can be judged as sound from the economic point of view.

Table 13.1.4-1 Economic Evaluation

NPV	**64,487**
EIRR	**12.3%**
B / C	**1.24**

Cost Items

Upper Seti (Damauli) Project

Installed capacity	127	MW		
Dependable capacity	85.8	MW		
Energy generation (Firm)	216,900	MWh		
(Secondary)	267,500	MWh		
Construction cost	328,464	1000US$	100%	328,464

Discount Rate: 10%

Benefit Items

Alternative thermal (Gas Turbine)

Installed capacity:	118.0	MW		
Investment cost:	61,360	1000US$	100%	61,360
Fuel price:	0.66	US$/liter	100%	0.660
Energy generation (firm):	210,431	MWh		

Secondary energy of Upper Seti

Annual energy	267,500	MWh	100%	267,500
Unit cost	0.015	US$/kWh		

(unidad: US$1000)

No.		Year	COST			BENEFIT								(B) - (C)
			UPPER SETI PROJECT		(C)	SECONDARY ENERGY			ALTERNATIVE PLANT				(B)	
			Consturction Cost	O&M Cost	TOTAL COST	Energy Generation	Unit Cost	Subtotal	Construction Cost	O&M Cost	Fuel Cost	Subtotal	TOTAL BENEFIT	
1		2009	40,079	0	40,079	0	0.015	0	0	0	0	0	0	-40,079
2		2010	32,277	0	32,277	0	0.015	0	0	0	0	0	0	-32,277
3		2011	43,313	0	43,313	0	0.015	0	0	0	0	0	0	-43,313
4		2012	89,269	0	89,269	0	0.015	0	0	0	0	0	0	-89,269
5		2013	108,727	0	108,727	0	0.015	0	24,544	0	0	24,544	24,544	-84,183
6		2014	14,799	0	14,799	0	0.015	0	36,816	0	0	36,816	36,816	22,017
7	1	2015		2,313	2,313	267,500	0.015	4,013		3,945	38,488	42,433	46,446	44,133
8	2	2016		2,313	2,313	267,500	0.015	4,013		3,945	38,488	42,433	46,446	44,133
9	3	2017		2,313	2,313	267,500	0.015	4,013		3,945	38,488	42,433	46,446	44,133
10	4	2018		2,313	2,313	267,500	0.015	4,013		3,945	38,488	42,433	46,446	44,133
11	5	2019		2,313	2,313	267,500	0.015	4,013		3,945	38,488	42,433	46,446	44,133
12	6	2020		2,313	2,313	267,500	0.015	4,013		3,945	38,488	42,433	46,446	44,133
13	7	2021		2,313	2,313	267,500	0.015	4,013		3,945	38,488	42,433	46,446	44,133
14	8	2022		2,313	2,313	267,500	0.015	4,013		3,945	38,488	42,433	46,446	44,133
15	9	2023		2,313	2,313	267,500	0.015	4,013		3,945	38,488	42,433	46,446	44,133
16	10	2024		2,313	2,313	267,500	0.015	4,013		3,945	38,488	42,433	46,446	44,133
17	11	2025		2,313	2,313	267,500	0.015	4,013		3,945	38,488	42,433	46,446	44,133
18	12	2026		2,313	2,313	267,500	0.015	4,013		3,945	38,488	42,433	46,446	44,133
19	13	2027		2,313	2,313	267,500	0.015	4,013		3,945	38,488	42,433	46,446	44,133
20	14	2028		2,313	2,313	267,500	0.015	4,013	24,544	3,945	38,488	66,977	70,990	68,677
21	15	2029		2,313	2,313	267,500	0.015	4,013	36,816	3,945	38,488	79,249	83,262	80,949
22	16	2030		2,313	2,313	267,500	0.015	4,013		3,945	38,488	42,433	46,446	44,133
23	17	2031		2,313	2,313	267,500	0.015	4,013		3,945	38,488	42,433	46,446	44,133
24	18	2032		2,313	2,313	267,500	0.015	4,013		3,945	38,488	42,433	46,446	44,133
25	19	2033		2,313	2,313	267,500	0.015	4,013		3,945	38,488	42,433	46,446	44,133
26	20	2034		2,313	2,313	267,500	0.015	4,013		3,945	38,488	42,433	46,446	44,133
27	21	2035		2,313	2,313	267,500	0.015	4,013		3,945	38,488	42,433	46,446	44,133
28	22	2036		2,313	2,313	267,500	0.015	4,013		3,945	38,488	42,433	46,446	44,133
29	23	2037		2,313	2,313	267,500	0.015	4,013		3,945	38,488	42,433	46,446	44,133
30	24	2038		2,313	2,313	267,500	0.015	4,013		3,945	38,488	42,433	46,446	44,133
31	25	2039		2,313	2,313	267,500	0.015	4,013		3,945	38,488	42,433	46,446	44,133
32	26	2040		2,313	2,313	267,500	0.015	4,013		3,945	38,488	42,433	46,446	44,133
33	27	2041	15,324	2,313	17,637	267,500	0.015	4,013		3,945	38,488	42,433	46,446	28,808
34	28	2042	16,173	2,313	18,486	267,500	0.015	4,013		3,945	38,488	42,433	46,446	27,959
35	29	2043	39,286	2,313	41,599	267,500	0.015	4,013	24,544	3,945	38,488	66,977	70,990	29,391
36	30	2044	10,083	2,313	12,396	267,500	0.015	4,013	36,816	3,945	38,488	79,249	83,262	70,865
37	31	2045		2,313	2,313	267,500	0.015	4,013		3,945	38,488	42,433	46,446	44,133
38	32	2046		2,313	2,313	267,500	0.015	4,013		3,945	38,488	42,433	46,446	44,133
39	33	2047		2,313	2,313	267,500	0.015	4,013		3,945	38,488	42,433	46,446	44,133
40	34	2048		2,313	2,313	267,500	0.015	4,013		3,945	38,488	42,433	46,446	44,133
41	35	2049		2,313	2,313	267,500	0.015	4,013		3,945	38,488	42,433	46,446	44,133
42	36	2050		2,313	2,313	267,500	0.015	4,013		3,945	38,488	42,433	46,446	44,133
43	37	2051		2,313	2,313	267,500	0.015	4,013		3,945	38,488	42,433	46,446	44,133
44	38	2052		2,313	2,313	267,500	0.015	4,013		3,945	38,488	42,433	46,446	44,133
45	39	2053		2,313	2,313	267,500	0.015	4,013		3,945	38,488	42,433	46,446	44,133
46	40	2054		2,313	2,313	267,500	0.015	4,013		3,945	38,488	42,433	46,446	44,133
47	41	2055		2,313	2,313	267,500	0.015	4,013		3,945	38,488	42,433	46,446	44,133
48	42	2056		2,313	2,313	267,500	0.015	4,013		3,945	38,488	42,433	46,446	44,133
49	43	2057		2,313	2,313	267,500	0.015	4,013		3,945	38,488	42,433	46,446	44,133
50	44	2058		2,313	2,313	267,500	0.015	4,013	24,544	3,945	38,488	66,977	70,990	68,677
51	45	2059		2,313	2,313	267,500	0.015	4,013	36,816	3,945	38,488	79,249	83,262	80,949
52	46	2060		2,313	2,313	267,500	0.015	4,013		3,945	38,488	42,433	46,446	44,133
53	47	2061		2,313	2,313	267,500	0.015	4,013		3,945	38,488	42,433	46,446	44,133
54	48	2062		2,313	2,313	267,500	0.015	4,013		3,945	38,488	42,433	46,446	44,133
55	49	2063		2,313	2,313	267,500	0.015	4,013		3,945	38,488	42,433	46,446	44,133
56	50	2064	-26,955	2,313	-24,642	267,500	0.015	4,013	-40,907	3,945	38,488	1,526	5,539	30,181
TOTAL			382,375	115,650	498,025			200,625	204,533	197,250	1,924,400	2,326,183	2,526,808	2,028,783
Present Value i = 10%				**PV (Cost):**	**273,154**						**PV (Benefit):**		**337,641**	**64,487**
													NPV	**64,487**
													EIRR	**12.3%**
													B / C	**1.24**

13.1.5 Sensitivity Analysis

The sensitivity of economic evaluation indices was analyzed for cases with different basic conditions. A discount rate of 10% was used for this analysis. The assumptions shown in **Table 13.1.5-1** were made using alternative thermal cost as benefit:

1) 10% decrease in alternative thermal cost
2) 10% increase in construction cost
3) 10% decrease in alternative thermal cost and 10% increase in construction cost

Table 13.1.5-1 Cases of Sensitivity Analysis

Item	NPV	B/C	EIRR
Case 1	US$ 34,488,000	1.13	11.2%
Case 2	US$ 37,172,000	1.12	11.2%
Case 3	US$ 7,172,000	1.02	10.2%

The indices exceed the evaluation criteria, and it is confirmed that, even in the worse cases, the Project is economically feasible.

13.2 Financial Evaluation

13.2.1 Methodology

Financial analysis aims at measuring the expected return on investment from a viewpoint of an implementing agency. Here, the Discounted Cash Flow method was adopted. The basic approach for this method is as follows: First, the cash outflow (costs) and inflow (benefits) are developed on an annual basis over the project life. Secondly the amount generated during different years will be discounted to the start year of the project and expressed it as an accumulated present value at the same standard year. Then a comparison will be made between the costs and benefits. The evaluation index to be obtained is the Financial Internal Rate of Return (FIRR) on investment. FIRR on investment is not affected by financing conditions; therefore, it is appropriate to evaluate the profitability of the project itself.

13.2.2 Financial Cost and Benefit of the Project

(1) Financial Cost

The financial cost of the Project includes the initial investment cost, the cost for replacement of equipment, and operation and maintenance cost expressed in terms of the market price. The initial investment and the replacement cost were taken from the cost estimation in **Chapter 12**, adding the relevant taxes imposed in Nepal. The operation and maintenance cost was calculated by multiplying the construction cost of each work item (not including

tax) by a certain rate, which was determined based on the experiences with similar projects by the Consultant:

1) Initial investment

Annual investment amount for the major items is shown in **Table 13.2.2-1**.

Table 13.2.2-1 Financial Investment Amount for Major Items

(Unit: 1,000 US$)

	Civil and preparatory works	Equipment and Transmission Line	Environmental cost	Total Cost
1st year	17,314	0	26,696	44,010
2nd year	33,746	0	0	33,762
3rd year	29,339	15,717	0	45,058
4th year	76,981	16,590	0	93,562
5th year	71,812	40,290	1,363	113,453
6th year	2,566	10,350	2,494	15,410
Total	231,757	82,949	30,553	345,256

2) Operation and Maintenance Cost

O&M cost for the Project is shown in **Table 13.2.2-2**.

Table 13.2.2-2 Financial O&M Cost

(Unit: 1,000US$)

Item	Construction Cost	Rate	Amount
Civil Works	228,802	0.5 %	1,144.0
Equipment	71,468	1.5 %	1,072.0
Transmission Line	10,080	1.5 %	151.2
Total	---	---	2,367.2

(2) Financial Benefit

The financial benefit of the Project is the revenue to be earned by the electricity sale. The following is the basic conditions for unit tariff rate and salable energy volume.

- Unit tariff rate

Average tariff rate in FY2005/06 is N.Rp. 6.69/kWh, equivalent to the US$ 0.09299/kWh, using an average exchange rate of N.Rp. 71.99/US$ at that time. In order to exclude the distribution cost from the average tariff rate, the following calculation was made. First, distribution loss as of 2014 is assumed as 17%; then, with this assumption of the average distribution cost being 29.1%, average cost up to the substation was calculated as US$ 0.06593; lastly, annual price escalation of 5% was applied to the tariff and the rate for 2014 was calculated as US$ 0.09730/kWh. This escalation was applied because NEA

is authorized to revise tariff within a range of 5%, and the proposal for its calculation formula has been submitted for approval. As a peak time tariff, 15% increase was added based on the actual tariff system, thus the tariff was obtained as US$ 0.11190/kWh. Refer to **Table 13.2.2-3** for details.

Table 13.2.2-3 Assumption for Electricity Tariff

1. Electricity tariff			
Sales income for FY2005/06	13,155.81	Million NRps.	
Power generation for FY2005/06	1,965.27	GWh	
Average rate	6.694	NRs./kWh	
Average exchange rate	71.99	US$/NRs.	
Average rate in US$	0.09299	US$/kWh	
Cost rate up to transmission	0.709		
Base tariff up to transmission in 2006	0.06593	US$/kWh	
Base tariff up to transmission in 2014	0.09730	US$/kWh	
Peak time tariff (115% * base tariff) in 2014	0.11190	US$/kWh	
2. Energy loss			
	Energy	Energy loss	
Total energy available (GWh)	2,661,788.00		
up to transmission (GWh)	2,528,699.00	133,089.00	5.0%
up to distribution (GWh)	1,935,467.00	593,232.00	23.5%
Total energy loss			28.5%
up to distribution (GWh)	2,209,284.04	―	17.0%
3. Cost rate up to transmission			
Total energy up to distrubution with 17% loss rate	2,209,284	GWh	
Total cost up to distrubution	14,728,517	NRps.	
Cost per unit up to distribution with 17% loss	6.67	NRps.	
Cost per unit up to transmission	4.73	NRps.	
Cost rate up to transmission	70.9%		

- Salable energy volume

Primary energy is assumed to be sold during peak hour, and the secondary energy during average hour. Thus the annual sales income is calculated as shown in **Table 13.2.2-4**:

Table 13.2.2-4 Annual Sales Income

Item	Volume	Unit rate	Annual income
Primary energy	207,274 GWh	US$ 111.90/MWh	US$ 23,193,960
Secondary energy	255,628 GWh	US$ 97.30/MWh	US$ 24,872,600
Total			US$ 48,066,560

13.2.3 Financial Evaluation

The Financial Internal Rate of Return (FIRR) on investment was calculated based on the financial revenue. (See **Table 13.2.3-1**). The result is shown below.

Item	Result	Criteria
FIRR	10.3%	> interest rate

It was found that the Project is financially feasible, assuming that the Project would be financed by the Government using the on-lent loan with the annual interest rate of 8%.

13.2.4 Sensitivity Analysis

(1) Analysis for change in condition

Sensitivity was analyzed for the cases with different basic conditions. Benefit from emission trading scheme was also considered. For the analysis, a discount rate of 10% is used.

1) 10% decrease in annual available energy
2) 10% increase in construction cost
3) 10% decrease in annual available energy and 10% increase in construction cost
4) 10% increase in annual available energy
5) 10% increase in annual available energy and 10% increase in construction cost

Case	1	2	3	4	5
FIRR	9.3%	9.5%	8.6%	11.2%	10.3%

Results of the analysis show that FIRR varies around the 8%-to-11% range: therefore, there is no item that presents particular sensitivity to a change in conditions.

(2) Analysis for Average Tariff

Average tariff level which obtains certain FIRR was calculated as follows:

FIRR	12%	10%	8%
Tariff at transmission end	USc 123.98	USc 100.73	USc 79.79

The case for FIRR = 8% corresponds to the tariff increase of 5% being made three times until 2014.

(3) Analysis at distribution end

FIRR including distribution portion was also examined. Basic conditions used for this examination is as follows:

1) Distribution Cost: assumed as 2% of the initial investment cost. This rate is used in the evaluation report on Kali Gandaki A Hydropower Project (ADB).

2) Electricity tariff at distribution end:
   - Tariff in 1996: NRp. 4.219/56.25 = US$ 0.075/kWh
   - Tariff in 2006: NRp. 6.694/74.40 = US$ 0.090/kWh
   - Average escalation rate for 11 years: 1.84%
   - Tariff in 2014: US$ 0.10413（US$ 0.090 x 1.0184^8）

3) Salable energy: calculated on the assumption that the total loss rate in 2014 is 17%.

As a result, the following result was obtained. （See **Table 13.2.4-1**.）

- FIRR on investment at distribution end：7.3%

Table 13.2.3-1 Financial Evaluation

Upper Seti (Damauli) Project

Installed capacity	127	MW		
Salable energy	462,902	MWh		
Firm energy	207,274	MWh	100%	207,274
Secondary energy	255,628	MWh	100%	255,628
Construction cost	345,256	1000US$	100%	345,256

Electricity tariff

Peak time	111.90	US$/MWh
Average time	97.30	US$/MWh

FIRR 10.3%

(Unit: US$1000)

No.		YEAR	UPPER SETI PROJECT			BENEFIT					(B) - (C)
			Construction Cost	O&M Cost	(C) TOTAL COST	Salable Energy (1) MWh	Energy Unit Cost	Salable Energy (2) MWh	Energy Unit Cost	(B) TOTAL BENEFIT	
1		2009	44,011	0	44,011						-44,011
2		2010	33,762	0	33,762						-33,762
3		2011	45,058	0	45,058						-45,058
4		2012	93,562	0	93,562						-93,562
5		2013	113,454	0	113,454						-113,454
6		2014	15,410	0	15,410						-15,410
7	1	2015		2,367	2,367	207,274	111.90	255,628	97.30	48,066	45,698
8	2	2016		2,367	2,367	207,274	111.90	255,628	97.30	48,066	45,698
9	3	2017		2,367	2,367	207,274	111.90	255,628	97.30	48,066	45,698
10	4	2018		2,367	2,367	207,274	111.90	255,628	97.30	48,066	45,698
11	5	2019		2,367	2,367	207,274	111.90	255,628	97.30	48,066	45,698
12	6	2020		2,367	2,367	207,274	111.90	255,628	97.30	48,066	45,698
13	7	2021		2,367	2,367	207,274	111.90	255,628	97.30	48,066	45,698
14	8	2022		2,367	2,367	207,274	111.90	255,628	97.30	48,066	45,698
15	9	2023		2,367	2,367	207,274	111.90	255,628	97.30	48,066	45,698
16	10	2024		2,367	2,367	207,274	111.90	255,628	97.30	48,066	45,698
17	11	2025		2,367	2,367	207,274	111.90	255,628	97.30	48,066	45,698
18	12	2026		2,367	2,367	207,274	111.90	255,628	97.30	48,066	45,698
19	13	2027		2,367	2,367	207,274	111.90	255,628	97.30	48,066	45,698
20	14	2028		2,367	2,367	207,274	111.90	255,628	97.30	48,066	45,698
21	15	2029		2,367	2,367	207,274	111.90	255,628	97.30	48,066	45,698
22	16	2030		2,367	2,367	207,274	111.90	255,628	97.30	48,066	45,698
23	17	2031		2,367	2,367	207,274	111.90	255,628	97.30	48,066	45,698
24	18	2032		2,367	2,367	207,274	111.90	255,628	97.30	48,066	45,698
25	19	2033		2,367	2,367	207,274	111.90	255,628	97.30	48,066	45,698
26	20	2034		2,367	2,367	207,274	111.90	255,628	97.30	48,066	45,698
27	21	2035		2,367	2,367	207,274	111.90	255,628	97.30	48,066	45,698
28	22	2036		2,367	2,367	207,274	111.90	255,628	97.30	48,066	45,698
29	23	2037		2,367	2,367	207,274	111.90	255,628	97.30	48,066	45,698
30	24	2038		2,367	2,367	207,274	111.90	255,628	97.30	48,066	45,698
31	25	2039		2,367	2,367	207,274	111.90	255,628	97.30	48,066	45,698
32	26	2040		2,367	2,367	207,274	111.90	255,628	97.30	48,066	45,698
33	27	2041	15,326	2,367	17,693	207,274	111.90	255,628	97.30	48,066	30,372
34	28	2042	16,175	2,367	18,542	207,274	111.90	255,628	97.30	48,066	29,524
35	29	2043	39,290	2,367	41,657	207,274	111.90	255,628	97.30	48,066	6,409
36	30	2044	10,084	2,367	12,451	207,274	111.90	255,628	97.30	48,066	35,614
37	31	2045		2,367	2,367	207,274	111.90	255,628	97.30	48,066	45,698
38	32	2046		2,367	2,367	207,274	111.90	255,628	97.30	48,066	45,698
39	33	2047		2,367	2,367	207,274	111.90	255,628	97.30	48,066	45,698
40	34	2048		2,367	2,367	207,274	111.90	255,628	97.30	48,066	45,698
41	35	2049		2,367	2,367	207,274	111.90	255,628	97.30	48,066	45,698
42	36	2050		2,367	2,367	207,274	111.90	255,628	97.30	48,066	45,698
43	37	2051		2,367	2,367	207,274	111.90	255,628	97.30	48,066	45,698
44	38	2052		2,367	2,367	207,274	111.90	255,628	97.30	48,066	45,698
45	39	2053		2,367	2,367	207,274	111.90	255,628	97.30	48,066	45,698
46	40	2054		2,367	2,367	207,274	111.90	255,628	97.30	48,066	45,698
47	41	2055		2,367	2,367	207,274	111.90	255,628	97.30	48,066	45,698
48	42	2056		2,367	2,367	207,274	111.90	255,628	97.30	48,066	45,698
49	43	2057		2,367	2,367	207,274	111.90	255,628	97.30	48,066	45,698
50	44	2058		2,367	2,367	207,274	111.90	255,628	97.30	48,066	45,698
51	45	2059		2,367	2,367	207,274	111.90	255,628	97.30	48,066	45,698
52	46	2060		2,367	2,367	207,274	111.90	255,628	97.30	48,066	45,698
53	47	2061		2,367	2,367	207,274	111.90	255,628	97.30	48,066	45,698
54	48	2062		2,367	2,367	207,274	111.90	255,628	97.30	48,066	45,698
55	49	2063		2,367	2,367	207,274	111.90	255,628	97.30	48,066	45,698
56	50	2064	-26,958	2,367	-24,591	207,274	111.90	255,628	97.30	48,066	72,656
TOTAL			399,172	118,362	517,534	10,363,703	5,595	12,781,418	4,865	2,403,278	9,846,169
										FIRR	**10.3%**

Table 13.2.4-1 Financial Evaluation on Investment (Distribution End)

Upper Seti (Damauli) Project

Installed capacity	127 MW		
Salable energy	393,004 MWh		
Firm energy	175,976 MWh	84.9%	207,274
Secondary energy	217,028 MWh	84.9%	255,628
Construction cost	345,256 1000US$	100%	345,256

Electricity tariff

Firm energy	104.13 US$/MWh
Secondary energy	104.13 US$/MWh

FIRR 7.3%

(Unit: US$1000)

No.		YEAR	UPPER SETI PROJECT				B E N E F I T					(B) - (C)
			Construction Cost	O&M Cost	Distribution Cost	(C) TOTAL COST	Salable Energy (1) MWh	Energy Unit Cost	Salable Energy (2) MWh	Energy Unit Cost	(B) TOTAL BENEFIT	
1		2009	44,011	0		44,011						-44,011
2		2010	33,762	0		33,762						-33,762
3		2011	45,058	0		45,058						-45,058
4		2012	93,562	0		93,562						-93,562
5		2013	113,454	0		113,454						-113,454
6		2014	15,410	0		15,410						-15,410
7	1	2015		2,367	6,905	9,272	175,976	104.13	217,028	104.13	40,924	31,651
8	2	2016		2,367	6,905	9,272	175,976	104.13	217,028	104.13	40,924	31,651
9	3	2017		2,367	6,905	9,272	175,976	104.13	217,028	104.13	40,924	31,651
10	4	2018		2,367	6,905	9,272	175,976	104.13	217,028	104.13	40,924	31,651
11	5	2019		2,367	6,905	9,272	175,976	104.13	217,028	104.13	40,924	31,651
12	6	2020		2,367	6,905	9,272	175,976	104.13	217,028	104.13	40,924	31,651
13	7	2021		2,367	6,905	9,272	175,976	104.13	217,028	104.13	40,924	31,651
14	8	2022		2,367	6,905	9,272	175,976	104.13	217,028	104.13	40,924	31,651
15	9	2023		2,367	6,905	9,272	175,976	104.13	217,028	104.13	40,924	31,651
16	10	2024		2,367	6,905	9,272	175,976	104.13	217,028	104.13	40,924	31,651
17	11	2025		2,367	6,905	9,272	175,976	104.13	217,028	104.13	40,924	31,651
18	12	2026		2,367	6,905	9,272	175,976	104.13	217,028	104.13	40,924	31,651
19	13	2027		2,367	6,905	9,272	175,976	104.13	217,028	104.13	40,924	31,651
20	14	2028		2,367	6,905	9,272	175,976	104.13	217,028	104.13	40,924	31,651
21	15	2029		2,367	6,905	9,272	175,976	104.13	217,028	104.13	40,924	31,651
22	16	2030		2,367	6,905	9,272	175,976	104.13	217,028	104.13	40,924	31,651
23	17	2031		2,367	6,905	9,272	175,976	104.13	217,028	104.13	40,924	31,651
24	18	2032		2,367	6,905	9,272	175,976	104.13	217,028	104.13	40,924	31,651
25	19	2033		2,367	6,905	9,272	175,976	104.13	217,028	104.13	40,924	31,651
26	20	2034		2,367	6,905	9,272	175,976	104.13	217,028	104.13	40,924	31,651
27	21	2035		2,367	6,905	9,272	175,976	104.13	217,028	104.13	40,924	31,651
28	22	2036		2,367	6,905	9,272	175,976	104.13	217,028	104.13	40,924	31,651
29	23	2037		2,367	6,905	9,272	175,976	104.13	217,028	104.13	40,924	31,651
30	24	2038		2,367	6,905	9,272	175,976	104.13	217,028	104.13	40,924	31,651
31	25	2039		2,367	6,905	9,272	175,976	104.13	217,028	104.13	40,924	31,651
32	26	2040		2,367	6,905	9,272	175,976	104.13	217,028	104.13	40,924	31,651
33	27	2041	15,326	2,367	6,905	24,598	175,976	104.13	217,028	104.13	40,924	16,325
34	28	2042	16,175	2,367	6,905	25,447	175,976	104.13	217,028	104.13	40,924	15,477
35	29	2043	39,290	2,367	6,905	48,562	175,976	104.13	217,028	104.13	40,924	-7,638
36	30	2044	10,084	2,367	6,905	19,356	175,976	104.13	217,028	104.13	40,924	21,567
37	31	2045		2,367	6,905	9,272	175,976	104.13	217,028	104.13	40,924	31,651
38	32	2046		2,367	6,905	9,272	175,976	104.13	217,028	104.13	40,924	31,651
39	33	2047		2,367	6,905	9,272	175,976	104.13	217,028	104.13	40,924	31,651
40	34	2048		2,367	6,905	9,272	175,976	104.13	217,028	104.13	40,924	31,651
41	35	2049		2,367	6,905	9,272	175,976	104.13	217,028	104.13	40,924	31,651
42	36	2050		2,367	6,905	9,272	175,976	104.13	217,028	104.13	40,924	31,651
43	37	2051		2,367	6,905	9,272	175,976	104.13	217,028	104.13	40,924	31,651
44	38	2052		2,367	6,905	9,272	175,976	104.13	217,028	104.13	40,924	31,651
45	39	2053		2,367	6,905	9,272	175,976	104.13	217,028	104.13	40,924	31,651
46	40	2054		2,367	6,905	9,272	175,976	104.13	217,028	104.13	40,924	31,651
47	41	2055		2,367	6,905	9,272	175,976	104.13	217,028	104.13	40,924	31,651
48	42	2056		2,367	6,905	9,272	175,976	104.13	217,028	104.13	40,924	31,651
49	43	2057		2,367	6,905	9,272	175,976	104.13	217,028	104.13	40,924	31,651
50	44	2058		2,367	6,905	9,272	175,976	104.13	217,028	104.13	40,924	31,651
51	45	2059		2,367	6,905	9,272	175,976	104.13	217,028	104.13	40,924	31,651
52	46	2060		2,367	6,905	9,272	175,976	104.13	217,028	104.13	40,924	31,651
53	47	2061		2,367	6,905	9,272	175,976	104.13	217,028	104.13	40,924	31,651
54	48	2062		2,367	6,905	9,272	175,976	104.13	217,028	104.13	40,924	31,651
55	49	2063		2,367	6,905	9,272	175,976	104.13	217,028	104.13	40,924	31,651
56	50	2064	-26,958	2,367	6,905	-17,686	175,976	104.13	217,028	104.13	40,924	58,609
TOTAL			399,172	118,362	345,256	862,790	8,798,784	5,207	10,851,423	5,207	2,046,176	7,935,994

FIRR 7.3%

13.3 Cash Flow Analysis

In this section, a cash flow analysis was conducted considering the financing conditions.

13.3.1 Assumptions for Analysis

In order to implement the Upper Seti Project, it is assumed that the project would be developed by NEA and financed by the government:

Assumptions:

1)	Price level:	December 2006
2)	Construction period:	6 years (commissioning in 2014)
3)	Escalation:	2% for foreign currency, 5% for local currency
4)	Taxes:	Corporate tax – 20%; import tax – 1%; local tax – 1%; VAT – 13%
5)	Electricity tariff:	US$ 111.90/MWh for peak time; US$ 97.30/MWh for average time
6)	Royalty:	Energy – 1-15 years: 2%; after 16 years: 10% of income Capacity – 1-15 years: N.Rp.100/kW; after 16 years: N.Rp. 1,000/kW
7)	Evaluation period:	25 years after commissioning
8)	Depreciation:	Straight line method, including contingency
9)	Annual energy sale:	475.11 GWh (excluding sand flushing)
10)	O&M cost:	US$ 2,365,000/year
11)	Interest rate:	8%
12)	Repayment period:	25 years after commissioning
13)	Equity:	15%

13.3.2 Evaluation for Cash Flow Analysis

A cash flow analysis was made in order to evaluate if the financial scheme is profitable, considering the above mentioned financial conditions. Summary table, Interest during construction, and income statement are presented in **Tables 13.3.2-1~3**. Evaluation indices such as Debt Service Coverage Ratio and Loan Life Coverage Ratio have been calculated to evaluate the profitability.

(1) Debt Service Coverage Ratio (DSCR)

Debt Service Coverage Ratio (DSCR) is an index that shows the coverage level of cash flow before repayment of principal and interest in each year. It assesses the creditability of a project from the viewpoint of loan repayment each year.

$$DSCR = \frac{\text{(Annual Cashflow before Repayment of Principal and Interest)}}{\text{(Annual Amount of Repayment and Interest)}}$$

Criteria: DSCR > 1.0 (However, Multilateral Financial Institutions such as the World Bank recommend that the DSCR be higher than 1.5 for financing a project.)

(2) Loan Life Coverage Ratio (LLCR)

Loan Life Coverage Ratio (LLCR) is an index that shows the coverage level of present value of cash flow before repayment of principal and interest over the total loan amount. It assesses the creditability of a project from the viewpoint of loan repayment during loan life. A discount rate to obtain present value corresponds to the interest rate for financing.

$$LLCR = \frac{\Sigma PV(\text{Cashflow before repayment of principal and interest})}{\text{(Total Loan Amount)}}$$

Criteria: LLCR > 1.0

The result of the calculation is shown in **Table 13.3.2-4**:

Table 13.3.2-4 Results of Cash Flow Analysis

Discount rate (for LLCR)	8%	10%	12%
DSCR (Average)	3.94	-	-
LLCR	2.00	1.63	1.36

DSCR and LLCR exceed the evaluation criteria, for the base case of the expected interest rate of 8%, it is confirmed that there will be no problem in profitability.

Table 13.3.2-1 Financial Analysis (1): Summary

Construction Cost 2,719 US$/kW

Finance Proportion	Nepal	Others
	100%	0%
Debt/Equity	Debt	Equity
	85%	15%

Installed Capacity 127.00 MW
Energy Generation 484.40 GWh
Salable Energy 462.90 GWh
Firm 207.27 GWh
Secondary 255.63 GWh

Construction Cost
Before price escalation 345.26 M.US$
After price escalation 373.89 M.US$
Financial Budget 433.32 M.US$

Financial Items	Nepal	Others
Own Finance	56.08	0.00
Loan amount	317.81	0.00
IDC	59.43	0.00
Royalty	0.00	0.00
Total	433.32	0.00

Export/Domestic Ratio for Salable Energy
Export 0%
Domestic 100%

Initial Electricity Tariff
Average tariff 0.11190 US$/kWh
0.09730 US$/kWh

Tariff Escalation 5%

Inflation (in terms of US dollar)
Foreign 2.0%
Domestic 5.0%

Financial Condition
Interest rate for IDC 8.00%
Interest after operation 8.00%
Repayment period 25 years
Grace period 6 years
Gov't own finance 100%

Royalty for Construction Period 0%

Royalty from Operation onwards
Capacity charge 1-15 years 100 NRs.
Capacity charge 16 years - 1000 NRs.
Energy charge 1-15 years 2%
Energy charge 16 years - 10%

Debt Service Coverage Ratio
Average for Finance (I) 3.94
Average for Finance (II) -

Loan Life Coverage Ratio
For Finance (I) 2.00
For Finance (II) -

Table 13.3.2-2 Financial Analysis (2): Disbursement and Loan Amount

Upper Seti (Damauli) Project		Equity Proportions	
		NEA	Private
Capacity:	127.00 MW	100%	0%
Energy Generation	484.40 GWh	Debt	Equity
Salable energy	462.90 GWh	85%	15%
Project cost	2,719 US$/kW		
F/C	216.52 M.US$	Royalty for constructio	
L/C	128.74 M.US$		0%
Total	345.26 M.US$		

Price Escalation per annum		Finance Condition (I)	100%
F/C Portion	2.0%	Interest	8.00%
L/C Portion	5.0%	Repayment Period	25 years
		Grace Period	6 years
		NEA Own Finance	100%
Electricity tariff	$/kWh	Finance Condition (II)	0%
Peak	0.11190	Interest	0%
Average	0.09730	Repayment Period	0 years
		Grace Period	0 years

Total Construction Cost (M.US$)			
Finance Items	NEA	Private	Total
Own finance	56.1	0.0	56.1
Principal Loan	317.8	0.0	317.8
IDC	59.4	0.0	59.4
Total	433.3	0.0	433.3
Equity/Royalty fee	0.0		0.0

Year	Disbursement before escalation		Price Index		Disbursement after escalation		Total Disburse	Debt/Equity Share		Equity Portion			Debt Portion		Loan Cumulative		IDC		Royalty Fee
								85%	15%				Finance I	Finance II	Finance I	Finance II	Finance I	Finance II	
	for F/C	for L/C	for F/C	for L/C	for F/C	for L/C		Debt	Equity	NEA	Private		100%	0%			8.00%	0%	
	M.US$	M.US$	2.0%	5.0%	M.US$	M.US$	M.US$	M.US$	M.US$	M.US$	M.US$		M.US$	M.US$	M.US$	M.US$	M.US$	M.US$	M.US$
-6	8.8	35.2	1.0000	1.0000	8.8	35.2	44.0	8.8	35.2	35.2	0.0		8.8	0.0	8.8	0.0	0.4	0.0	0.0
-5	22.8	11.0	1.0200	1.0500	23.3	11.5	34.8	23.3	11.5	11.5	0.0		23.3	0.0	32.1	0.0	1.6	0.0	0.0
-4	33.2	11.8	1.0404	1.1025	34.6	13.0	47.6	38.2	9.4	9.4	0.0		38.2	0.0	70.3	0.0	4.1	0.0	0.0
-3	61.0	32.6	1.0612	1.1576	64.7	37.7	102.4	102.4	0.0	0.0	0.0		102.4	0.0	172.7	0.0	9.7	0.0	0.0
-2	79.7	33.8	1.0824	1.2155	86.3	41.0	127.3	127.3	0.0	0.0	0.0		127.3	0.0	300.0	0.0	18.9	0.0	0.0
-1	11.0	4.4	1.1041	1.2763	12.1	5.6	17.8	17.8	0.0	0.0	0.0		17.8	0.0	317.8	0.0	24.7	0.0	0.0
	216.5	128.7			229.8	144.1	373.9	317.8	56.1	56.1	0.0		317.8	0.0	317.8	0.0	59.4	0.0	0.0

Table 13.3.2-3 Financial Analysis (3): Income Statement

Upper Seti (Damauli) Project		Financial condition (I)		Firm Energy (GWh)	207.27	OM cost	2.37							Initial F.A. (M.US$)	433.32
Capacity	127.00 MW	Interest rate	8.00%	Sec. Energy (GWh)	255.63			Royalty from operation				Taxes		Life time (years)	50
Energy Generation	484.40 GWh	Repayment (Years)	25	Peak Price ($/kWh)	0.1119	Principal repayment	M.US$	Energy	1-15 years	2%	on revenue	Coporate tax	20%	Initial dep. (M.US$)	8.67
Salable Energy	462.90 GWh	Financial condition (II)		Average Price ($/kWh)	0.0973	for Nepal	317.81	Energy	16 - years	10%	on revenue	Interest tax	6%	F/C escalation	2.0%
		Interest rate	0%	Firm Escalation	5%	for Private	0.00	Capacity	1-15 years	100	NRp./kW	Bonus & welfare fund	2%	L/C escalation	5.0%
Constuction cost	345.26 M.US$	Repayment (Years)	0	Sec. Escalation	5%	Total	317.81	Capacity	16 - years	1000	NRp./kW			Equiv. Escalation	3.1%

Year	Selling Revenue Salable energy Peak	Average	Selling price Peak	Average	Sales Revenue	OM Cost	Royalty on Revenue	Royalty on Capacity	Year start Fixed Asset	Depreci-ation	Year end Fixed Asset	Net Operation Income	Principal Repay-ment	Cum. of Principal Repayment	Interest Payment	Profit before tax	Corporate tax	Profit after tax	Tax on interest	Bonus & Welfare Fund	Net Income after tax	Current Asset in cash	Debt Service Ratio
	GWh	GWh	$/kWh	$/kWh	M.US$	M.US$	M.US$	M.US$	M.US$	M.US$	M.US$	M.US$	M.US$	M.US$	M.US$	M.US$	M.US$	M.US$	M.US$	M.US$	M.US$	M.US$	M.US$
1	207.3	255.6	0.1119	0.0973	48.07	2.37	0.96	0.18	433.32	8.67	424.66	35.89	12.71	12.71	24.41	11.48	2.30	9.19	1.46	0.15	7.57	44.56	1.20
2	207.3	255.6	0.1175	0.1022	50.47	2.49	1.01	0.18	437.90	8.94	428.96	37.86	12.71	25.42	23.39	14.47	2.89	11.57	1.40	0.20	9.97	46.79	1.30
3	207.3	255.6	0.1234	0.1073	52.99	2.61	1.06	0.18	442.34	9.22	433.12	39.93	12.71	38.14	22.37	17.55	3.51	14.04	1.34	0.25	12.45	49.14	1.40
4	207.3	255.6	0.1295	0.1126	55.64	2.74	1.11	0.18	446.63	9.50	437.13	42.10	12.71	50.85	21.36	20.75	4.15	16.60	1.28	0.31	15.01	51.61	1.51
5	207.3	255.6	0.1360	0.1183	58.42	2.88	1.17	0.18	450.76	9.80	440.96	44.40	12.71	63.56	20.34	24.06	4.81	19.25	1.22	0.36	17.67	54.20	1.64
6	207.3	255.6	0.1428	0.1242	61.35	3.02	1.23	0.18	454.71	10.10	444.61	46.81	12.71	76.27	19.32	27.49	5.50	21.99	1.16	0.42	20.41	56.92	1.78
7	207.3	255.6	0.1500	0.1304	64.41	3.17	1.29	0.18	458.48	10.42	448.06	49.35	12.71	88.99	18.31	31.05	6.21	24.84	1.10	0.47	23.26	59.77	1.93
8	207.3	255.6	0.1574	0.1369	67.63	3.33	1.35	0.18	462.03	10.74	451.28	52.02	12.71	101.70	17.29	34.73	6.95	27.79	1.04	0.54	26.22	62.77	2.09
9	207.3	255.6	0.1653	0.1438	71.01	3.50	1.42	0.18	465.36	11.08	454.28	54.84	12.71	114.41	16.27	38.56	7.71	30.85	0.98	0.60	29.28	65.92	2.27
10	207.3	255.6	0.1736	0.1509	74.57	3.67	1.49	0.18	468.45	11.43	457.02	57.80	12.71	127.12	15.25	42.54	8.51	34.03	0.92	0.66	32.45	69.22	2.48
11	207.3	255.6	0.1823	0.1585	78.29	3.86	1.57	0.18	471.27	11.78	459.49	60.91	12.71	139.83	14.24	46.67	9.33	37.34	0.85	0.73	35.75	72.69	2.70
12	207.3	255.6	0.1914	0.1664	82.21	4.05	1.64	0.18	473.82	12.15	461.67	64.19	12.71	152.55	13.22	50.96	10.19	40.77	0.79	0.80	39.18	76.33	2.94
13	207.3	255.6	0.2009	0.1747	86.32	4.25	1.73	0.18	476.07	12.53	463.54	67.63	12.71	165.26	12.20	55.43	11.09	44.34	0.73	0.87	42.74	80.16	3.22
14	207.3	255.6	0.2110	0.1835	90.63	4.46	1.81	0.18	478.00	12.92	465.08	71.26	12.71	177.97	11.19	60.07	12.01	48.06	0.67	0.95	46.44	84.18	3.52
15	207.3	255.6	0.2215	0.1926	95.17	4.69	1.90	0.18	479.58	13.32	466.26	75.07	12.71	190.68	10.17	64.90	12.98	51.92	0.61	1.03	50.29	88.40	3.86
16	207.3	255.6	0.2326	0.2023	99.92	4.92	2.00	0.18	480.80	13.74	467.07	79.09	12.71	203.39	9.15	69.93	13.99	55.95	0.55	1.11	54.29	92.82	4.25
17	207.3	255.6	0.2443	0.2124	104.92	5.17	10.49	1.81	481.63	14.17	467.47	73.28	12.71	216.11	8.14	65.15	13.03	52.12	0.49	1.03	50.60	87.45	4.19
18	207.3	255.6	0.2565	0.2230	110.17	5.43	11.02	1.81	482.04	14.61	467.44	77.31	12.71	228.82	7.12	70.19	14.04	56.15	0.43	1.11	54.61	91.91	4.63
19	207.3	255.6	0.2693	0.2342	115.68	5.70	11.57	1.81	482.01	15.06	466.95	81.54	12.71	241.53	6.10	75.43	15.09	60.35	0.37	1.20	58.78	96.60	5.13
20	207.3	255.6	0.2828	0.2459	121.46	5.98	12.15	1.81	481.51	15.53	465.98	85.99	12.71	254.24	5.08	80.90	16.18	64.72	0.31	1.29	63.13	101.52	5.70
21	207.3	255.6	0.2969	0.2582	127.53	6.28	12.75	1.81	480.51	16.02	464.50	90.67	12.71	266.96	4.07	86.60	17.32	69.28	0.24	1.38	67.66	106.69	6.36
22	207.3	255.6	0.3117	0.2711	133.91	6.60	13.39	1.81	478.98	16.52	462.47	95.59	12.71	279.67	3.05	92.54	18.51	74.03	0.18	1.48	72.37	112.11	7.11
23	207.3	255.6	0.3273	0.2846	140.60	6.92	14.06	1.81	476.89	17.03	459.86	100.78	12.71	292.38	2.03	98.74	19.75	78.99	0.12	1.58	77.29	117.81	7.99
24	207.3	255.6	0.3437	0.2989	147.63	7.27	14.76	1.81	474.20	17.56	456.64	106.23	12.71	305.09	1.02	105.21	21.04	84.17	0.06	1.68	82.42	123.79	9.02
25	207.3	255.6	0.3609	0.3138	155.02	7.63	15.50	1.81	470.88	18.11	452.77	111.96	12.71	317.80	0.00	111.96	22.39	89.57	0.00	1.79	87.77	130.07	10.23

CHAPTER 14 FURTHER INVESTIGATION

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CHAPTER 14 FURTHER INVESTIGATION

Based on the results of the Study, further investigations to be conducted for implementation of the detailed design for the Project are recommended as follows:

14.1 Hydrology

The hydrological features in the Project shall be investigated in further detail in the detailed design stage. Additional investigations are recommended as follows:

(1) River Discharge

1) Continuation of the river discharge measurement

The river discharge measurement shall be continued at No.430.5 and other gauging stations in the basin to ensuret more river discharge data is collected.

2) Measurement of peak river discharge

As well as the regular daily river water level but also short-term fluctuation in the river water level during floods shall also be measured so that peak river discharge and a flood hydrograph at the Project site will be clarified.

(2) Sedimentology

1) Sediment discharge measurement

Sediment discharge measurement shall be continued so that more sediment data will be collected.

2) Hydraulic model test

Local distribution of sediment deposits just upstream of the Dam and around the inlet of the sediment flushing facilities is not estimated in the Study because estimation of those items is beyond the ability of the simulation program. Those items shall be studied through a hydraulic model test during the detailed design stage.

14.2 Geological Investigation

At the detailed design stage, more detailed information is required on the geological and geotechnical conditions of the various civil structure sites proposed in the project design in this report. This following section presents the additional geological investigation works to be conducted.

(1) Dam Site

1) Rock mass condition of the dam foundation

During the upgrading feasibility study stage, the rock mass condition of the dam foundation is evaluated based on the geological reconnaissance and the investigation drillings. However, the characteristic of the dam foundation rock should be clarified by the observation and the rock evaluation of the exploratory adits during the detailed design stage. It is recommended that the exploratory adits should be excavated on both banks of the dam.

2) Mechanical properties of the dam foundation rock

During the upgrading feasibility study stage, the mechanical properties of the dam foundation rock are estimated based on the rock evaluation of the outcrops and drilled cores. However, the mechanical properties, shear strength and deformability of the foundation rock, should be obtained by the in-situ rock tests for dam stability analysis during the detailed design stage. It is recommended that the block shear tests should be carried out in the exploratory adits mentioned in 1).

3) Groundwater level and permeability of the mountain in both banks

During the upgrading feasibility study stage, the groundwater level is confirmed to be rising up toward the mountain side on both banks, although the groundwater level and permeability in the deep portions of both banks remains unclear. To examine the depth and the extent of the grouting, the groundwater level and permeability should be clarified during the detailed design stage. The investigation drillings, which include permeability tests and measuring of groundwater level based on the adits mentioned in 1) is recommended.

(2) Underground Powerhouse (Option-IIIb)

1) Rock mass condition of the underground powerhouse

During the upgrading feasibility study stage, the rock mass condition of the underground powerhouse is evaluated based on the geological reconnaissance. However, it is necessary to confirm the rock mass condition of the powerhouse site via the exploratory adit and drilling from the same.

2) Mechanical properties of the foundation rock of the underground powerhouse

During the upgrading feasibility study stage, the mechanical properties of foundation rock are estimated based on the rock evaluation of the outcrops. However, the mechanical properties, shear strength and deformability of the foundation rock, should be obtained by the in-situ rock tests for stability analysis of the cavern and support designs. It is recommended that the block shear tests and the plate bearing tests should be carried out in the exploratory adits mentioned in 1).

3) In-Situ Stress of the underground powerhouse site

The in-situ stress of the underground powerhouse site is required for the stability analysis of the underground cavern. It is recommended that the measurement of the in-situ stress should be carried out, e.g. via a hydraulic fracturing test in the drill hole which is bored from the adit mentioned in 1).

(3) Upstream Area of the Reservoir

Countermeasure or mitigation against the erosion are necessary for curtain terrace cliffs from Bhimad Bajar to Jaruwapan in the upstream area of the reservoir. During the detailed design stage, the detailed geological mapping using the topographic maps at a scale of 1/1,000 to 1/5,000 is recommended to facilitate examination of the detailed extent and method of the mitigation or countermeasures.

(4) Construction Material

During the NEA's feasibility study stage, the investigations of the concrete aggregate were carried out for the river deposit of the Seti and the Madi Rivers, and these river deposits are evaluated for use as the concrete aggregate with the quality and quantity in mind. However, it is necessary to reevaluate the potential of the Alkali-aggregate reactivity of the material, using a method such as a Mortar-bar test or the Rock-cylinder method of ASTM C586-05., which are suitable for the carbonate rock like dolomite.

During the detailed design stage, the excavated rock of the dam foundation should be examined to check whether it is usable or not for the concrete aggregate, in addition to the river deposits. Meanwhile, the concrete aggregate test, such as specific gravity, absorption, soundness, abrasion loss and the Alkali-aggregate reactivity tests should be carried out using the rock samples collected from the exploratory adits mentioned in (1) 1). As for the Alkali-aggregate reactivity tests, the same test methods mentioned above are recommended because the dam foundation is composed of dolomite.

The recommended additional geological investigation works are shown in **Table 14.2-1** and **Fig.14.2-1**, **Fig.14.2-2** and **Fig.14.2-3**.

14.3 Environmental Survey

The following are surveys to be performed at the detailed design stage and recommendations regarding environment and social considerations

1) Underground water level measurement in the project facility area to confirm the effects on water sources used by habitants against construction works of the underground structures.

2) Continuation of water quality tests to monitor the fluctuation of water quality

3) Revision of information on locations and utilization of the community forests.

4) Discussions with the Department of Forest on forest compensation

5) Preparation of a seeding program

6) Execution of detailed surveys on the population and activity ranges of wildlife and preparation of the necessary rescue programs

7) Detailed study on expansion of the hatchery at the Kaligandaki-A Hydropower Plant

8) Study on fish species living in the Seti river other than those considered in the above hatchery plan

9) Revising the information included in the resettlement plan and the social action plan proposed in the Study and making the plans more detailed.

10) Obtaining cadastral maps of Jumene DVC, for which the Study Team could not obtain cadastral maps in the Study, executing surveys on the affected land lots and habitants, and incorporating the results into the resettlement plan and the social action plan.

11) Inventory survey on the affected structures within the Risk Zone II of the reservoir area such as Wantang Khola, Phedi Khola, and Tittuwa and at the project facility area located downstream of the dam, and incorporating the results into the resettlement plan and the social action plan.

12) Reflecting the environmental mitigation measures and improvement measures proposed in the Study in the bidding documents and contracts for the construction works, in order that the contractors should take those measures under their own responsibilities.

14.4 Design

(1) Intake

A hydraulic model on the intake is proposed for the examination and confirmation of detailed portal structures of Intake and incorporation of the results into its design in the same way as the existing similar projects, in order to ensure the intake takes power discharge even at water levels steadily near the MOL.

(2) Powerhouse

As described in **11.1** of **Chapter 11**, the location of the underground powerhouse is selected based on the information available in May 2007 when NEA is conducting investigation drilling in vicinity of the powerhouse site. Re-study on the location of the powerhouse should be required base on information available during the detailed design stage.

Table 14.2-1 Recommended Additional Geological Investigation Works for D/D

1. Dam site

Kind of Works	Name	Elevation	Length	Inclination	Location	Remarks
Exploration Adit	ADR-1	420m	150m	—	Right Bank of Dam	Including the ovservation and the evaluation of the rock mass of the Adit wall
	ADL-1	420m	100m	—	Left Bank of Dam	
Investigation Drilling	BAR-1	420m	100m	Vertical	In the Adit of ADR-1	Including Permeability tests and Measuring of the Groundwater level
	BAR-2	420m	100m	40(*-1)	In the Adit of ADR-1	
	BAL-1	420m	100m	Vertical	In the Adit of ADL-1	
	BAL-2	420m	80m	40*-1	In the Adit of ADL-1	
In-Situ Rock Test	Block Shear Test				In the Adit of ADR-1	1 set*-2
	Block Shear Test				In the Adit of ADL-1	1 set*-2

2. Powerhouse of Option-IIIb

Kind of Works	Name	Elevation	Length	Inclination	Location	Remarks
Exploration Adit	AP-1	420m	250m	—	Right Bank of Dam	Including the ovservation and the evaluation of the rock mass of the Adit wall
Investigation Drilling	BAP-1	420m	150m	Vertical	In the Adit of AP-1	Including Permeability tests and Measuring of the Groundwater level
	BAP-2	420m	150m	Vertical	In the Adit of AP-1	
In-Situ Rock Test	Plate Bearing Test				In the Adit of AP-1	2 tests
	Block Shear Test				In the Adit of AP-1	1 set*-2
	Measurement of In-Situ Stress				In Drill hole of BAP-1	The test such as Hydraulic Fracturing Tests

< Note > *-1: The angle from the horizontal Plain, *-2: 1set consists of 4 blocks

3. Upstream Area of the Reservoir

The detailed geological mapping using the topographic map scale of 1/1,000 to 1/5,000 is recommended to examine the detail extent of the mitigation or countermesure against the erosion of some terrace cliffs from Bhimad Bazzar to Jaruwapan of the upstream area of the reservoir.

4. Construction Material

The test of the concrete aggregate for the material collected from the exprolatory adit. The test includes soundness, abration, density, absorption and Alkali Aggregate Reaction test of Carbonate rocks. The Alkali Aggregate Reaction test should be carried out by the method such as Mortar -bar test or Rock-cylinder method of ASTM C586-05.