### 11.4 Electromechanical Equipment

Generally, a turbine-generator is said larger unit capacity has more economical merit of scale. However, the optimum unit size of turbine-generator is determined in consideration of the "Influence caused by the unit capacity to the power system", "Transportation route for heavy parts of equipment", etc.

It is obviously that item a. "Influence caused by the unit capacity to power system" is the most important factor to be considered for the examination of unit capacity in this project. It is concluded that the number of unit should be two (2) with unit capacity of 63.5 MW.

(1) Hydraulic Turbine

The rated turbine output is designed as 65.1 MW per unit at 100% gate open with a rated effective head of 112.5 m.

Generally, the turbine type is determined by relation between effective head and output. The vertical-shaft, single-runner, Francis type is selected as turbine type in consideration of the above in the project.

For the Francis runner components are specified 13-4 Cr.Ni stainless steel having high abrasion resistance to suspended solids. One spare runner will be provided for repairing work.

Then the revolving speed of turbine is obtained as 300 r/min based on the specific speed of Ns 208 m-kW.

(2) Generator

The generator is of rated capacity of 74,700 kVA, a type of a vertical shaft, 3-phases synchronous generator, brushless exciter with AVR (Automatic Voltage Regulator). The generator stator and rotor windings are provided with epoxy insulation of class F type. The generator ventilation is performed with heat exchanger and self circulation.

(3) Main Transformer

The power transformer of two (2) units is to be installed in the transformer room in the underground powerhouse.

The transformer capacity is 74,700 kVA. There are four types of power transformer such as single-phase type, three-phases type, special-three-phases type and package three-phases type. The type is selected in consideration of the transportation limitation of the weight, efficiency and installed spaces, etc. The proposed transportation route to the project site is capable of carrying a maximum load of 24.8 tons (including weight of trailer). If the package transformer, which can divide to several parts such as winding, core, tank, etc., for transportation to the site and re-assemble those ports at the site, is adopted, it is possible to transport the main transformer of total weight of 100 tons with divided maximum weight 13 tons. Therefore, package three-phase type is selected.

(4) Switchyard Equipment

The switchyard is located outdoor on EL. 370 m and connected with 220 kV power cables approximate 680 m in length from main transformer secondary terminal in the underground transformer room. The administration office including the control room is located near the switchyard.

GIS (Gas Insulated Switchyard) consists of 220 kV single bus system including gas circuit breakers, disconnecting switches and necessary apparatus. The outgoing lines from the switchyard are to be connected to the first transmission tower of 220 kV transmission lines to evacuate power to the New Bharatpur switchyard.

(5) Generation Facility for Environmental Flow

The feature of generation facility is as follows;

| | | |
|---|---|---|
| Rated output power | : | 1,900 kW |
| Rated effective head | : | 95 m (Normal Water Level: EL. 405 m, Normal Tail Water Level: EL. 310 m) |
| Rated discharge | : | 2.4 $m^3/s$ |
| Transmission line Voltage | : | 11 kV or 33 kV |

## 11.5 Transmission Line

(1) Transmission Line Route

The electric power generated at Upper Seti Hydropower Station is to be evacuated with a new 220 kV transmission line to Bharatpur area and the new Transmission Line will be connected to 220 kV Hetauda- Bardghat Transmission Line.

The starting point of the transmission line is Upper Seti Hydropower Station and its terminal point is a connecting point of 220 kV Hetauda- Bardghat Transmission Line in Bharatpur area. The route survey of this transmission line was carried out by NEA.

Transmission line route is evaluated from the viewpoint of economic, deforestation etc. The final route is shown in **Fig.11.5-1**.

(2) Connection at Bharatpur

The power generated at Upper Seti Hydropower Station is to be evacuated to Bharatpur and connected to 220 kV Hetauda-Bardghat Transmission Line there.

In 220 kV Hetauda- Bardghat Transmission Line Project for which Yen Credit was applied by the Government of Nepal. A plan to connect Hetauda- Bardghat Transmission Line and Upper

Seti- Bharatpur Transmission Line in Bharatpur is not included. It is recommended that two transmission lines should be connected by switchyard.

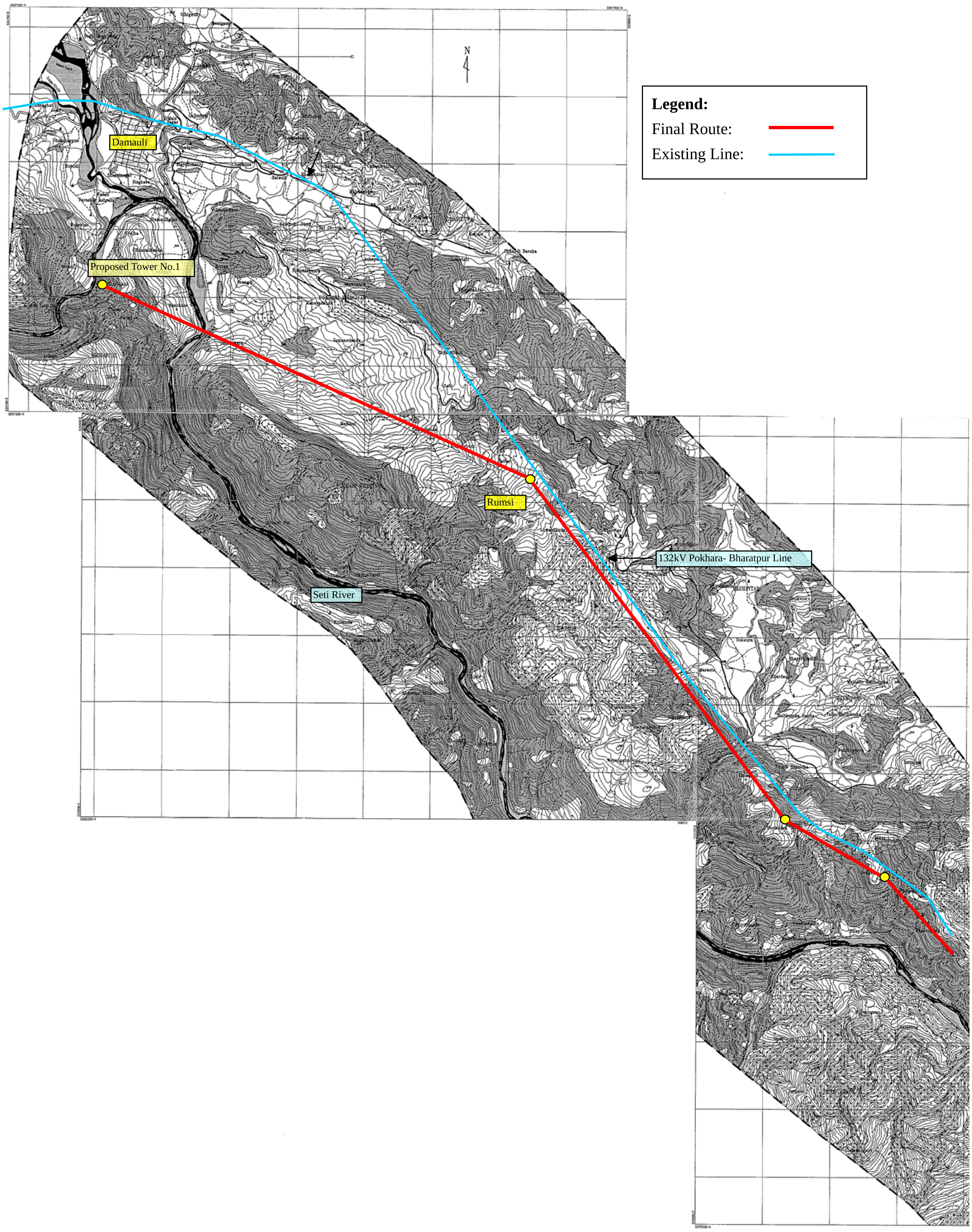


**Fig. 11.5-1 (1)    Final route-1**

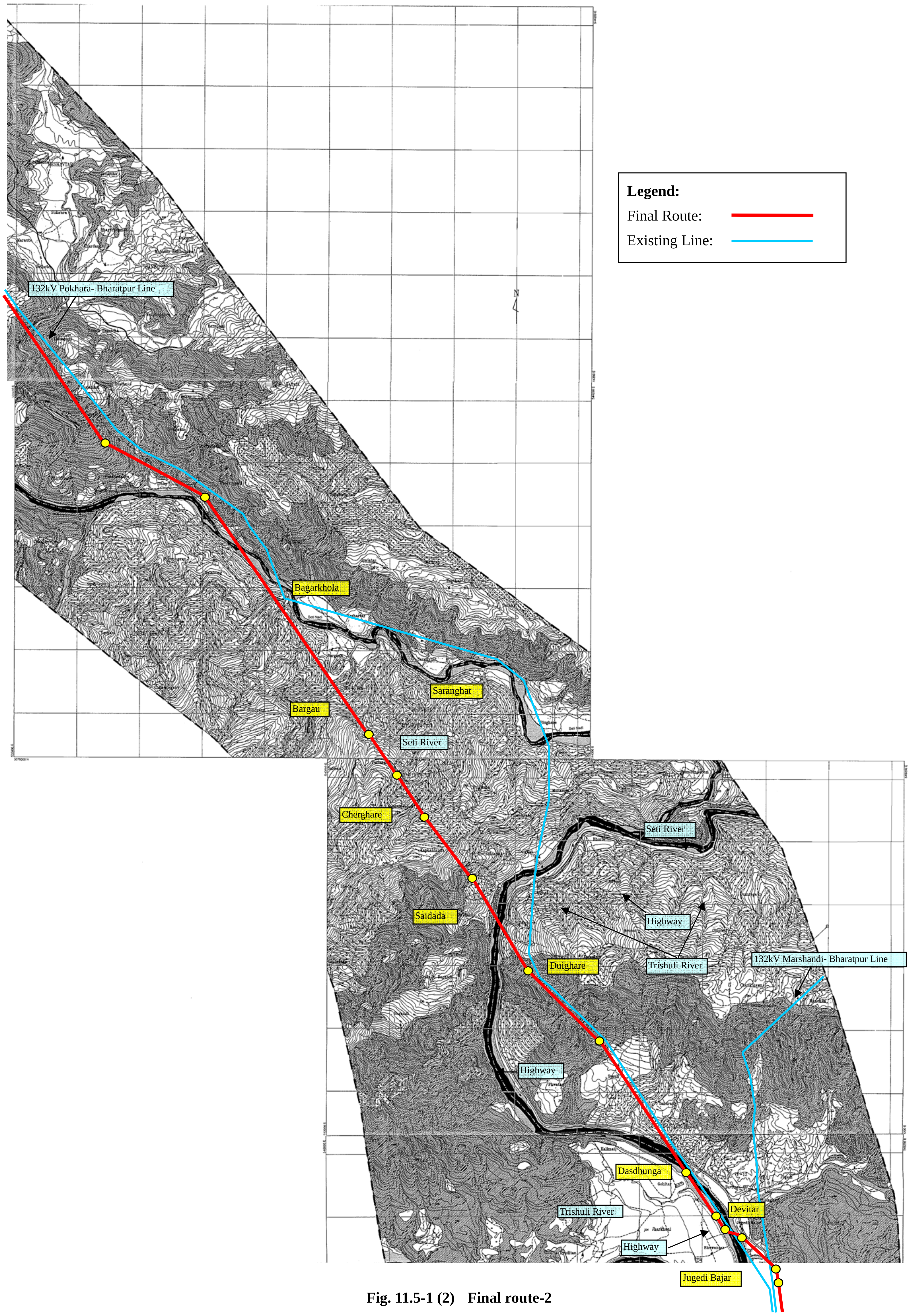


**Fig. 11.5-1 (2)　Final route-2**

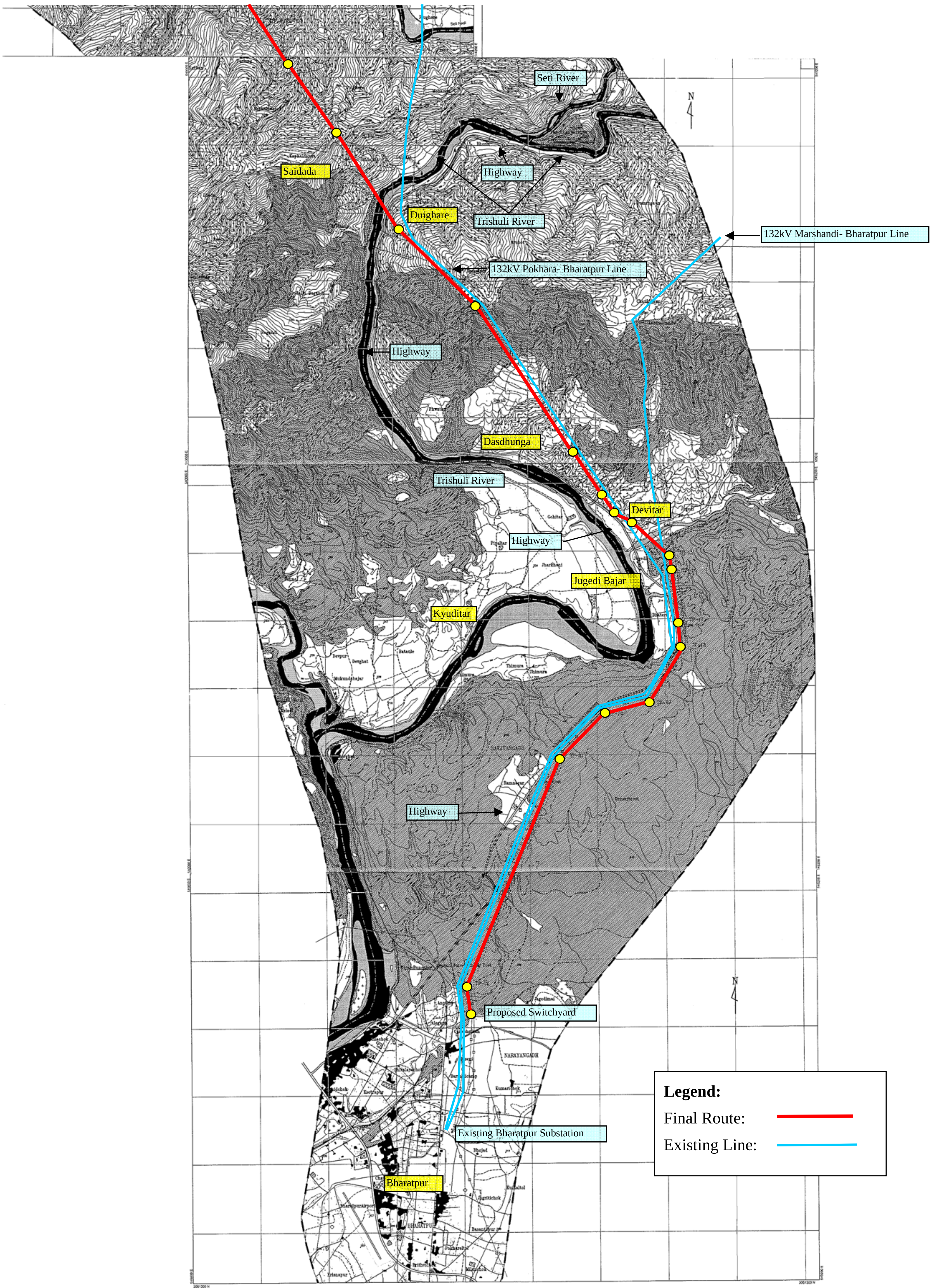


**Fig. 11.5-1 (3) Final route-3**

(3) Basic Specification of Transmission Facilities

1) Specification

| | |
|---|---|
| Section of Transmission Line: | From: Upper Seti Hydropower Station<br>To: New Bharatpur switchyard |
| Route Length: | Approximately 40 km |
| Nominal voltage: | 220 kV |
| Electrical System: | AC, Three- phase Three-wire system |
| Number of circuit: | 2 circuits |
| Structure of phase conductor: | Single conductor |
| Number of overhead ground wire: | 2 wires |
| Frequency: | 50 Hz |

2) Conductor

The size of conductor, number of phase conductor, thermal capacity of transmission line and corona influence are studied for the adoption of conductor. As this result, ACSR Bison single conductor is selected.

ACSR Bison single conductor;

| | |
|---|---|
| Conductor allowable current: | 670A (at 80°C) |
| Thermal capacity of transmission line: | 240 MW per circuit (continuous) |

(4) Overhead Ground wire

For the overhead ground wire, EHS wire is adopted. EHS wire is usually used by NEA. Two overhead ground wires are to be installed.

EHS;

| | |
|---|---|
| Stranding: | 7/35 |
| Diameter: | 10.05 mm |

(5) Outline of Insulation Design

| | |
|---|---|
| Number of insulators: | 250 mm Ball socket disc type insulator (standard)<br>17 insulators, Connection length 146 mm |
| Minimum insulation gap: | 1,500 mm |
| Standard insulation gap: | 2,300 mm |

(6) Insulator Assembly

Insulator assembly:

| | |
|---|---|
| Single suspension insulator strings: | 70 kN 250 mm Ball socket disc type 17 insulators × 1 |
| Double suspension insulator strings: | 70 kN 250 mm Ball socket disc type 17 insulators × 2 |
| Double tension insulator strings: | 120 kN 250 mm Ball socket disc type 17 insulators × 2 |

The arcing horn is included in the insulator assembly.

6(7) Support

The support is considered to be of square type tower.

(8) Foundation

The following basic types are assumed, though the tower foundation depends on foundation conditions in the field.

- Pad and Chimney type
- Rock anchor type
- Pile type

### 11.6 Annual Energy

The calculation of the effective head with the optimum diameters described Section **11.3** is attached in Appendix Chapter11, and the installed capacity of the Project is 127 MW.

The result of annual energy calculation with the sediment flushing operation is summarized below:

| | | |
|---|---|---|
| Upper Seti Hydropower Plant | Primary: | 216.9 GWh |
| | Secondary: | 252.5 GWh |
| Generation Facility for Environmental Flow | Secondary: | 15.0 GWh |
| | Total of Secondary: | 267.5 GWh |
| | Total: | 484.4 GWh |

# 12 CONSTRUCTION PLAN AND COST FOR CONSTRUCTION

## 12.1 Implementation Plan and Schedule

### 12.1.1 Basic Conditions

Main structures to be constructed in this project are the concrete gravity dam whose height is 140 m, 1 line of a headrace tunnel with inner diameter of 7.8 m, penstock, a tailrace tunnel, an 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 is 104,000 $m^3$. Land utilization plan for implementation is shown in **Fig. 12.1.1-1**.

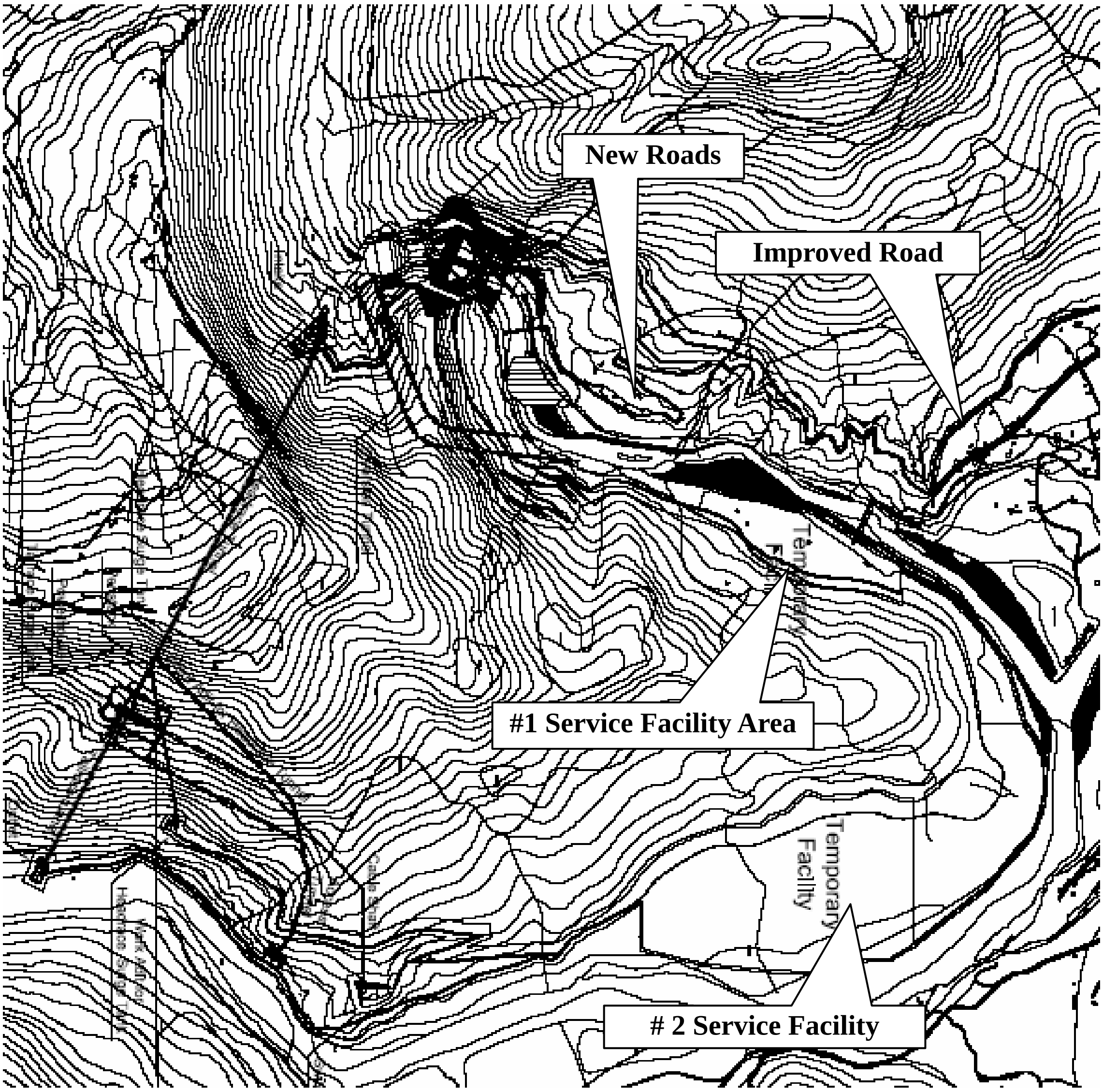


**Fig. 12.1.1-1 Land Utilization Plan**

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

(1) Construction Materials

As there are cement factories in Nepal, cement can be procured inside Nepal. But it should be procured 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 reinforce bar, steel and etc. will be procured from foreign countries.

(2) Concrete Production Plant

As shown in **Fig. 12.1.1-2,** concrete production plant is set at #1 service facility area located at the right abutment downstream of dam.

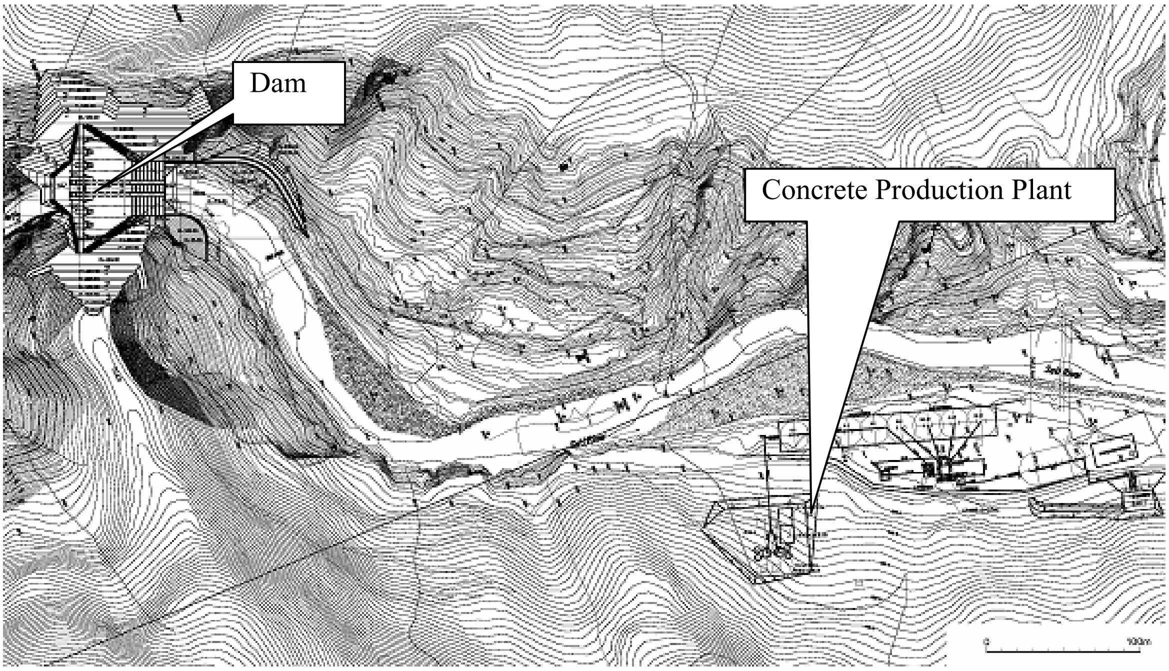


**Fig. 12.1.1-2 Location of Concrete Production Plant**

Capacity of concrete production plant is decided based on past records of concrete gravity type dam construction works, and construction schedule. Rocks excavated rocks in the dam area and in the waterways are stocked at #1 service facility area properly, and concrete aggregates are also produced by a crashing plant set here. Cement silo, batcher plant, cooling plant and etc. are also installed there.

### 12.1.2 Implementation Plan and Schedule

The Project is expected to be completed at the end of 2014 based on discussions with NEA.

Based on above described basic conditions and work quantities, implementation plan and schedule are prepared. Construction period is estimated as 6 years. The critical path of this project is Dam construction Work. The construction schedule is as shown in **Fig. 12.1.2-1**.

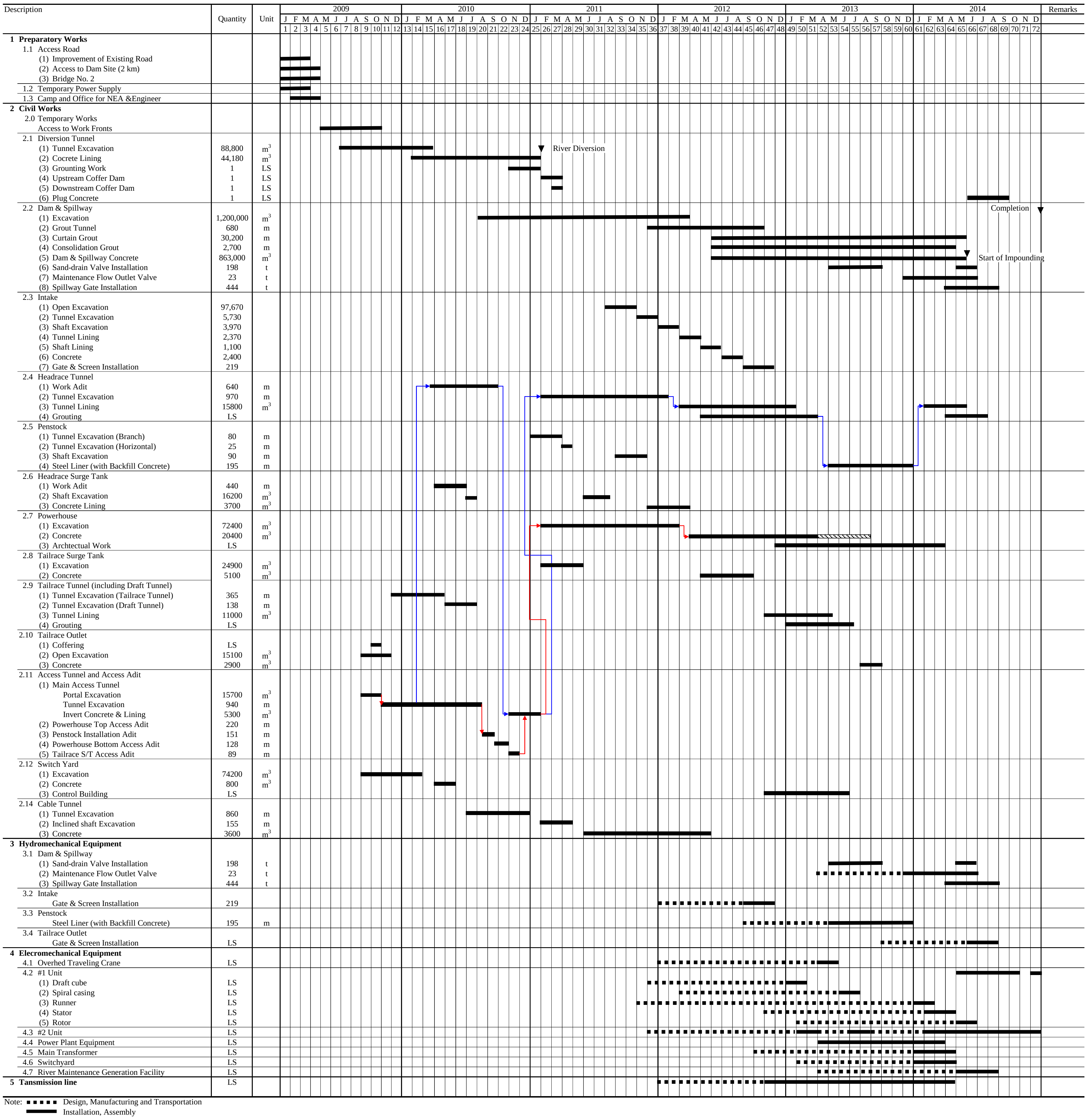


**Fig. 12.1.2-1 Construction Schedule**

## 12.2 Construction Cost

The construction cost has been calculated by applying the following basic criteria and reflecting the site's meteorology and geology, general area conditions and the construction scale.

### 12.2.1 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.

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, hydromechaical 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 hydromechaical 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 and interest during the construction period are not included in the project cost.

### 12.2.2 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) |

### 12.2.3 Project Construction Cost

Construction cost (direct cost) estimated with conditions described in **12.2.1** and **12.2.2** above consists of costs for preparatory works, civil works, hydromechanical 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 12.2.3-1**.

**Table 12.2.3-1 Construction Cost**

| | Item | (Million US$) |
|---|---|---|
| 1 | Preparatory Works | 2.24 |
| 2 | Civil Works | 193.32 |
| 3 | Hydromechanical Eq. | 16.63 |
| 4 | Electromechanical Eq. | 47.18 |
| 5 | Transmission Lines | 9.00 |
| 6 | Environmental Cost | 29.10 |
| 7 | Admin. & Engineering Fee | 18.79 |
| 8 | Contingency | 24.64 |
| 9 | Total | 340.90 |

### 12.2.4 Disbursement Schedule

The annual required funding (disbursement schedule) is indicated in **Table 12.2.4-1**.

**Table 12.2.4-1 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.

# 13 ECONOMIC AND FINANCIAL EVALUATION

## 13.1 Economic Evaluation

### 13.1.1 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.

### 13.1.2 Economic Cost of the Project

Construction cost and Operation & Maintenance cost will be included in the cost stream.

### 13.1.3 Economic Benefit of the Project

For the purpose of this study, the following two kinds of benefits were adopted: one is the saved cost of alternative thermal power project (gas turbine), and the other is the long run marginal cost during wet season for the secondary energy.

### 13.1.4 Economic Evaluation

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 13.1.4-1**

**Table 13.1.4-1 Results of Economic Evaluation.**

| | Benefit | Criteria | Discount rate |
|---|---|---|---|
| | Alternative thermal | | |
| 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 | |

It was found out that any evaluation index exceeds the evaluation criteria, and the Project can be judged as sound from economic point of view.

## 13.2 Financial Evaluation

### 13.2.1 Methodology

Financial analysis aims at measuring the expected return on investment from a viewpoint of implementing body. Here Discounted Cash Flow method was adopted. Evaluation index to be obtained will be Financial Internal Rate of Return (FIRR) on investment. FIRR on investment will not be 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

Financial cost of the Project includes the initial investment cost, cost for replacement of equipment, and Operation and Maintenance cost expressed at the market price.

(2) Financial Benefit

Financial benefit of the Project is the revenue to be earned by the electricity sale. With annual salable energy is calculated as 207,274 GWh for primary energy and 255,628 GWh for secondary energy, and the average sale price estimated for 2014（5% raise per annum due to NEA's semi-automatic adjustment） is US$ 111.90/MWh (for peak time) and US$ 97.30/MWh (for average time). Here the annual revenue was calculated as US$ 48,066.6 thousand based on these values.

### 13.2.3 Financial Evaluation

Financial Internal Rate of Return (FIRR) on investment was calculated based on the financial revenue. The result is shown below. It was found that the softer loan condition is required to implement the project.

| Item | Result | Criteria |
|---|---|---|
| FIRR | 10.3% | > interest rate |

As a result, it was found out that the Project is found out to be financially feasible, when compared with the expected interest rate of 8% for use of on-lent loan from the Government.

According to the sensitivity analysis, FIRR is estimated as 8% in the case that the tariff will raise by 5% three times up to 2014.