Chapter II: PROJECT DESCRIPTION

2.1 Project Location

KAHEP is located on the Kabeli River Basin in Eastern Nepal (Figure No. 2.1). The Kabeli River at the project site is designated as a natural border between the Panchthar and Taplejung districts. The project site is approximately 620 km east of Kathmandu, the capital city of Nepal.

The weir of the project is located at the border of Amarpur VDC of Panchthar and Thechambu VDCs of Taplejung district (Figure 2.2). The approximate longitude and latitude of the proposed intake is 87°44'56"E and 27°16'40"N. The intake, desilting basin, tunnel alignment, surge shaft, penstock pipe, powerhouse and tailrace canal of the project fall within the jurisdiction of Amarpur VDC in the Pachthar District (Figure 2.2).

The geographical grid assigned in the survey license for the project does not fall inside the boundary of any National Park, Wildlife Reserve, Hunting Reserve, Wildlife Sanctuary and conservation area.

2.2 Project Access

The access to the project area is through an all season 228 km long Mechi Highway connecting Charali at the East West national highway and Taplejung (Figure 2.3). The Mechi Highway starts from Charali, located 4 km east from Birtamod Bazaar in Jhapa District and reaches Kabeli Bazaar (202 km) north on the left bank of the Kabeli River after crossing Phikkal, Ilam, Ranke, Phidim and Gopetar. The 60 km Phidim-Kabeli sector of the Mechi Highway is a gravel road (currently upgrading). Apart from this road, seasonal air services are available from Biratnagar to Taplejung that is further 26 km (gravel road) north from the Kabeli Bazaar along the Mechi Highway.

The Headworks and powerhouse are the major sites of KAHEP, which are to be connected by motorable roads for the transportation of construction materials. The proposed sites are presently
accessed by foot trails only. The access road to the headworks starts at Chainage 59+900 km (Mechi Highway) at Kabeli Bazaar whereas to the powerhouse starts at the Chainage 52+000, Mildanda area near Singhapur village of Amarpur VDC at Mechi Highway.

**Figure 2.2: Location of the Key Project Structures in relation to the Project Districts and VDCs**

![Map showing the location of key project structures in relation to the project districts and VDCs.](image)
2.3 Salient Features of the Project

The project is PRoR type with a proposed installed capacity of 34.70 MW with a design discharge 37.73 m$^3$/s. The diversion dam with provisions for ponding will be constructed at 2.5 km upstream of Kabeli Bazaar at Dhuseni village of Amarpur VDC on the left bank and Khudurke Ban of Thechambu VDC on the right bank. The intake on the left bank will feed the underground settling basin and is diverted to the Powerhouse located at Tamor River bank close to Pinase village through a 4.322 km long headrace tunnel. A surface powerhouse will be constructed on the left bank of the Tamor River. The salient features of the project are presented in Table 2.1.
**Table 2.1: SALIENT FEATURES of KAHEP**

<table>
<thead>
<tr>
<th>SN</th>
<th>Items</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Project Name</td>
<td>Kabelli-A Hydroelectric Project</td>
</tr>
<tr>
<td>2.</td>
<td>Location</td>
<td>Amarpur and Panchami VDCs of Panchthar District and Thechambu and Nangkholyang of Taplejung District</td>
</tr>
</tbody>
</table>
| 2.1 | Project Boundaries | East 87° 45’ 50” E  
West 87° 40’ 55” E  
North 27° 17’ 32” N  
South 27° 13’ 41” N |
| 3 | Type of Development | Peaking Run-of-the-river (PROR) |
| 4 | Hydrology at intake | Catchment area 864 km²  
100 year flood ($Q_{100}$) 1920 m³/s  
Probable maximum flood ($Q_{1000}$) 2750 m³/s  
Mean monthly flow 51.75 m³/s  
40 percentile flow 37.73 m³/s |
| 5 | Headworks | Type/Length of weir Barrage with 6 radial gates including undersluice  
Full supply level 575.3 m  
Crest elevation 561.6m  
Undersluice sill elevation 560.0m  
Gate Size 8.0 m Width * 5.5 m Height each  
Intake type Tunnel intake on left bank  
Intake size at trash rack 2 nos. 5.4m Width * 5.8m Height |
| 6 | Diversion during construction | Diversion flood (5 year dry season flow) 154 m³/s  
Diversion tunnel 360m long; 4.8m diameter D-shaped tunnel  
Coffer Dams 80m at upstream side  
90m long at downstream side  
Cross Section Internal Finished Diameter 3.2 m |
| 7 | Approach Tunnel | Number 2 (1 each starting from either intake)  
Type Inverted D shaped; Concrete lined  
Cross section Internal Finished Diameter 3.2 m |
| 8 | Settling basin | Type Underground settling basin  
Number 2 basins with 2 hoppers in each  
Length of uniform section 75 m  
Total length including transition 113 m  
Width 15.8 m each  
Height 17 m  
Flushing system S4 system |
| 9 | Waterways | 9.1 Pair Tunnels (headrace) Length 32 m  
Type Inverted D shaped; Concrete lined  
Cross section Internal Finished Diameter 3.2 m  
9.2 Headrace Tunnel Length after pair tunnels 4322 m  
Type Inverted D shaped; Concrete lined  
Cross section Internal Finished Diameter 3.85 m  
9.3 Surge Shaft Type Underground and exposed to surface  
Internal diameter 11 m  
Height 60.5 m |
| 9.4 | Penstock | Material Mild steel  
Length before bifurcation 218.6 m  
Length after bifurcation 54.4 m  
Internal Diameter 3.55 m  
Shell Thickness 10-20 mm |
| 10 | Powerhouse | Powerhouse type Surface  
Outer Dimension of PH 32m long and 16.9 m wide |
| 11 | Tailrace | Design tailwater level 458.5 masl |
2.4 Project Components

Figure 2.2 and Figure 2.4 presents the general layout of the project and the location of the key project components. The section below briefly highlights the features of the different project components.

Figure 2.4: Project Layout in the Land Sat Imagery

Figure 2.5 and 2.6 presents the location of the various project components and facilities in the land sat imagery maps.
Figure 2.5: Location of Key Facilities at Headworks

Figure 2.6: Locations of Key Facilities at Powerhouse

2.4.1 Headworks

(1) Barrage

The proposed barrage site is located at Amarpur VDC about 4.60 km upstream of its confluence with Tamor River. The dam will consist of a 14.30 m high and 60m long gated barrage with intake, settling basin and an underground settling basin on the left bank of Kabeli River near Dhuseni village, ward
Environmental Impact Assessment Study of Kabeli 'A' Hydroelectric Project

II - 7

(2) Head Pond

The barrage is so designed that it will not only divert the water of Kabeli but will also create a small pondage area for peaking power. At a full supply water level of 575.3 m the pondage area will cover a surface area of 10.60 ha. The length of the pond at the full supply level will be 1.385 km with an average width of 78.44 m. The height of the full supply level water will vary between 0 to 14.3 m from the existing ground surface. At the minimum drawdown level at 570.5 m, the pondage surface area will shrink to 6.92 ha and will extend about 1.37 km upstream from the barrage with an average width of 62.89 m and above 0 to 9.5 m from the existing ground level.

(3) Inlet Portal

Two side intakes will directly feed two approach tunnels. Two tunnel intakes have been designed to draw 120% of the design flow from the reservoir. The intakes are on the left bank of the river and will off take at a favorable orientation with respect to the barrage axis. The Intake sill has been kept well above the sluice floor to prevent the entry of bed loads even in extreme operating conditions. The trash rack opening is 5.4 m wide by 5.75 m high for each intake. The intake sill is at 564.7 m asl and has a bell mouth opening to join a D-shaped approach tunnel of 3.2 m diameter. Each intake consists of one gate with one stop log. Two intakes can run independently and will feed two different settling basins through two approach canals. The approach canals following the intakes are 80.8 m long each up to the settling basin.

(4) Settling Basin

Two underground settling basins of length 75 m, width 15.8 m and height 17 m is proposed. The approach canal from the Inlet portal will convey water to the settling basin. The minimum trapping efficiency of the settling basin is 90% and could remove sediment sizes of 0.2 mm. The design parameter are: slope of the hopper floor 1 in 150; length of Inlet transition 20 m; slope of Inlet transition 1 in 20; angle of Inlet transition 20°C and length of outlet transition 15 m.

For KAHEP, an intermittent flushing system with 60 minutes time interval between two consecutive flushing cycles has been adopted to minimize water loss. As for the flushing system, the patented flushing system called S4 is proposed for use to enhance the efficiency of flushing. The proposed length of the flushing tunnel is 250 m and the diameter of the flushing conduit is 1.75 m. For flushing system, two flushing hoppers in each basin of 1 m width and 1 in 150 bed slope are proposed.

2.4.2 Waterways

(1) Pair Tunnel

Inverted D shaped pair tunnel of length of 32 m length with an internal finished diameter of 3.2 will convey water from the settling basin to the headrace tunnel.

(2) Headrace Tunnel

The length of the headrace tunnel after the pair tunnel is 4.322 km. The proposed headrace tunnel is an inverted D shaped concrete lined tunnel with an internal finished diameter of 3.85 m.

(3) Access Tunnel for Settling Basin and Construction of Headrace Tunnel

The headrace tunnel excavation is proposed from the headworks and powerhouse side. From the powerhouse site the surge tank portal will be used for the construction of the headrace tunnel. Whereas at the headwork site, an access tunnel common to the settling basin during operation and headrace tunnel during construction will be used. The proposed access tunnels will be D-shaped and 4 m in diameter. The total length of the headwork side access tunnel is 220 m and the tunnel outlet adit portal is located on the downstream left bank of the barrage. The same tunnel also facilitates the
construction of the headrace tunnel as it is required to construct the tunnel and the settling basin simultaneously. During the operation period, the access tunnel is used for access to the gate control chambers. Altogether there are three gate control chambers of 5m by 5m above each gate.

### 2.4.3 Surge Shaft and Outlet Portal

The underground surge shaft is proposed at Pinasi village of Amarpur VDC on the left bank of the Tamor river. The height and internal diameter of the proposed surge shaft will be 60.5 m and 11 m respectively. The topmost part of the surge shaft will be exposed to the ground. Outlet portal of the tunnel is proposed on a rock outcrop on the right bank slope of the Piple khola. Some excavation is necessary to reach the level of the headrace tunnel. The outlet portal will house the initial portion of the penstock.

### 2.4.4 Penstock Pipe

A 245.8 m long steel penstock pipe (218.6m before bifurcation and 27.2 m after bifurcation) is used to convey water from the surge tank to the powerhouse. A buried penstock will run along the ridge separating Tamor and Piple Khola at Pinase. The internal diameter and the thickness of the penstock will be 3.55 m and 10-20 mm respectively.

### 2.4.5 Powerhouse

The powerhouse will be constructed on the left bank of the Tamor River at Pinase village of Amarpur VDC, just upstream of the confluence of Piple Khola with Tamor and on the bank of Piple Khola. It is a 32m long and 16.9m wide structure sufficient to house the turbine floor, generator floor, machine hall and service bay and control room and other utility spaces. The powerhouse contains two units of vertical axis Francis turbine and will be facilitated by the following systems and equipment such as drainage and dewatering system, cooling water system, compressed air system, oil handling system, ventilation system, fire protection systems, elevator and land workshop equipment.

### 2.4.6 Draft Tube and Tailrace Canal

Draft tube with circular inlet and rectangular outlet has been proposed. Flap gates are provided at the end of the draft tubes to allow maintenance of the turbines and to protect the turbines and draft tube from grit entering from the tailrace side due to the backwater effect when the power plant is shutdown.

The tailrace channel is designed as a non-pressure 'closed conduit channel' flow. The tailrace channel would discharge water from the draft tubes into Piple Khola and then later into Tamor River. The size of the proposed tailrace channel is 4.90 m wide, 4.65 m high and 93.10 m long. A bed slope of 1 in 230 of the channel has been set to correspond to the normal depth line at full flow in the channel. The selection of invert level at the discharge point is based on flood levels in the river.

### 2.4.7 Switchyard

The outdoor switchyard area is located close to the powerhouse. The switchyard covers 54.74 m x 34.43 m total area above the powerhouse at an elevation of 472.573 masl.

### 2.5 Project Support Facilities

#### 2.5.1 Internal Access Roads

1. **Access Road to Headworks**

The proposed access road alignment (Alternative II) to the headworks branches from the Mechi Highway near the Kabeli Bazaar and has an approximate length of 7 km. This is an existing motorable earthen road. It will have to be upgraded prior to the start of construction works by the proponent.
(2) **Access Road to Powerhouse**

The selected access road alternatives (Alternative I) to powerhouse take off from Mildanda (around 52 km from Phidim) of Mechi Highway with an estimated length of 12.0 km to the powerhouse at Pinasi. Around 3.5 km stretch (Mildanda to Madibung) of the alternative has an operational motorable track. The local communities have already initiated the track opening for the remaining 8.5 km stretch (Madibung to Pinase). The local communities have formed a road development committee to open up the motorable track (Annex 2.1). Hopefully, this track will be in operation by the start of the project. The project will take care of upgrading and maintenance of road after the completion of the track opening by the community.

### 2.5.2 Construction Power

The construction power required for the project will be based on the diesel generator sets. All together five stations for diesel generators each at the headwork, adit 1(tunnel intake), surge shaft, adit 2 (powerhouse), and powerhouse area are proposed. The estimated unit capacities of the generators are 550, 425, 215, 450 and 562.5 kVA, respectively. The generator sets will be established and operated following best standard practices avoiding risks from electrical shocks, fuel leakages, and noise.

### 2.5.3 Employer’s Camp, Contractor’s Camp and Labor Camp

For the headworks area, one temporary contractor/labor camp site will be located at Rajabesi village near the headworks area of Amarpur VDC. Permanent security and operation housing will be established within the headwork occupied area towards the end of the construction phase.

The powerhouse area will have two camping facilities. One will be a permanent camping facility for the engineers which will be used during the construction and operation phase, while the other will be a temporary camping facility to be utilized by the contractors and labors during the construction phase only. The locations of the camp sites are presented in Photographs 2.1 and 2.2.

Camping facilities permanent and temporary will be established prior to the start of actual construction works. The permanent and temporary camps for project engineers, contractor and labor will be facilitated with adequate office and residential space with provisions of adequate ventilations, water supply, electricity, telecommunication, toilet/bathrooms, kitchens and space for recreations and grocery shops. The temporary camp facilities will be decommissioned at the end of the construction works. The areas occupied by camps will be rehabilitated to the original landscape and returned to the owners.
2.5.4 Quarry Site and Borrow Pits

The construction materials such as sand, aggregates and boulders required for the project will be sourced from the Tamor and Kabeli River’s flood plains. For the headworks area, three locations
(Photograph 2.3) have been identified along the Kabeli River. The total aggregate production capacity of the three sites is estimated to be 426,000 m$^3$ with 164,700 m$^3$ of boulders, 171,400 m$^3$ of cobbles and 25,000 m$^3$ of sand sufficient to meet the headworks aggregate requirements.

For the powerhouse site, two sites have been identified at the Tamor River flood plain for construction aggregate. Of the two sites, the site located on the left bank of Tamor with a total aggregate production potential of 190,000 m$^3$ with 104,500 m$^3$ of boulders, 57,000 m$^3$ of cobbles and 28,500 m$^3$ of sand will be used. The site located on the right bank of the Tamor is an optional site proposed which will be used only if the tunnel spoil is considered to be good for aggregate use does not meet the requirements of the aggregate as envisaged. Nearly 60% of the tunnel muck is considered to be good for the aggregate usage (KEL, 2010).

As the proposed site are river flood plain areas, trenching operation for material quarrying will be prohibited. Quarrying of aggregates will be carried out through striping operations such that the landscape after the quarry will be same as before, however, the land level will change. Besides, quarry operations will be conducted up to the water level of river.

2.5.5 Batching Plants, Aggregate Crushing Plants and Construction Material Storage

The facilities for aggregate crushing, storage of construction materials and batching plants will be located at the headwork and powerhouse site close to the active construction sites. These facilities will be operated with provisions of air pollution control, noise arrest facilities, and water and waste water management facilities. These will be temporary facilities to be demolished at the end of the
construction period. The areas occupied by these facilities will be rehabilitated to original land conditions and returned to the respective owner.

2.5.6 Spoil & Muck Disposal Area

The total amount of the excavation spoil from the barrage, settling basin, headrace tunnel, surge tank, powerhouse and tailrace tunnel is estimated to be 520,000m$^3$. Nearly 60% of the excavated material is envisaged to be used for aggregates. However, if all of the excavated material is found to be unsuitable, these have to be disposed safely. It is based on this assumption, that the spoil disposal sites for the excavated muck have been planned.

In the headworks site with a potential total muck of 270,000m$^3$, two sites have been identified on the flood plain area on the left bank of Kabeli. Similarly, for the powerhouse area, one site has been identified on the flood plain of the Tamor river little upstream of the proposed powerhouse site. Spoil placement in these sites will be planned in such a way that, the fill surface and outward filling slopes will be protected from erosion by runoff and river flood by installing adequate drainage, toe protection against river erosion, and bioengineering measures as required. After the completion of spoil filling these sites will be developed as sites for recreation or afforestation on the consent of the local communities through proper landscaping.

2.6 Construction Associated Activities

2.6.1 River Diversion during Construction

Construction of the weir and side intake on the river will require keeping the working area dry during the construction period. As Kabeli River has high discharges (2000 to over 8000m$^3$/s) during the monsoon season, it will be uneconomical to construct the diversion structure during this season. The flow will be diverted during low flow season only and the construction job is to be completed in two shifts during the season. For the diversion of the flow, a diversion tunnel is to be constructed. The diversion tunnel will be a D-shaped tunnel of 4.8 m diameter. It will have shotcrete and rock bolt lining. Two coffer dams will be constructed one each at the upstream and downstream end. The top of coffer dam will be 5 m wide with elevations of 573 masl for the upstream dam and 565.5 masl for the downstream dam. The tunnel has been designed for a discharge capacity for 5 year return period dry season flood (154 m$^3$/s). The main responsibility for the design and construction methodology for the diversion tunnel is of contractor; however, a conceptual alignment is proposed for the construction of the diversion tunnel as per the construction phase of the headworks. From the diversion tunnel, flow is diverted from the upstream of the headworks to the downstream into the Kabeli River. This diversion tunnel will also be used for the purpose of a test tunnel.

For river diversion purpose, first of all, a 360m diversion tunnel is to be constructed at the right bank of the river and the flow diverted to downstream. The dry seasons have been considered to occur from November to May constituting of 7 months. The upstream cofferdam is 80 m long while the downstream coffer dam is about 90 m. The crest levels of the upstream and downstream cofferdam dams are 573 masl and 563.5 masl respectively. The total time for the completion of the diversion tunnel and coffer dams will be 5 months. The construction of the diversion tunnel should be started as soon as possible. The construction of barrage will be started after the construction of the diversion tunnel and it will take 2 dry seasons. Similarly, the construction of the intake and settling basin can be continued in parallel with the barrage construction.

2.6.2 Civil Works

(1) Headworks Site Civil Work

a. Barrage, Intake and Sluice Bay
The barrage will have a low crest breast wall with 5 gates in the weir bay and 1 gate in the sluiceway structure. The width of each gate is 8 m and height 5.5 m. Individual bays are separated by 2 m wide
piers. The sluiceway bay is separated by a divide wall from the weir bays. The full reservoir level is at an elevation of 575.3 masl.

**b. Settling Basin**
The excavation of the settling basin will commence after the excavation of the approach tunnel, and will require 150 days to complete. The concrete works will be carried out in 2 phases. The erection and commissioning of all hydraulic structures will be completed in one and a half months. A flushing tunnel to the flush settling basin has been proposed. The 2.25 m diameter tunnel will be a D-shaped. The tunnel is assumed to be excavated by using conventional drill and blast method.

c. **Headrace Tunnel**
The excavation of the headrace tunnel is assumed to use a semi-mechanical approach by using drilling machines. Considering the size of the tunnel, the conventional drill and blast method could be employed. The design length of holes will be drilled over the face based on the design blasting pattern and charged with gelatin. Blasting will be done to break the solid rock into small pieces in the required tunnel area. Ventilation will be provided to remove gas and dust produced by blasting and to supply fresh air at the working face. The blasted material i.e. muck will be cleared by using trolleys or trailers. The excavated muck will be disposed in spoil tip area by trolleys. After mucking, the scaling process will be carried out in the newly blasted area. An engineering geologist will be involved to determine rock mass classification, support requirement to hold the rock in place and geological logging of the tunnel. During tunneling work, ventilation, lighting, compressors and dewatering pumps will be needed. The duration of tunneling is estimated assuming an average advance rate of 2.5 m per day per face. Accordingly, it will take about 30 months from each face to complete the tunnel excavation. After excavation, temporary support such as shotcrete and rock bolts will be provided immediately. Afterwards, permanent support will be provided depending on the rock mass quality. Spalling, umbrella grouting, reduction of pull length, water draining, etc. techniques will be applied in extremely poor to exceptionally poor rock class to avoid over breaks. Adit plug and bulkhead door will be placed upon completion of the permanent lining of the tunnel.

d. **Surge Shaft**
The surge shaft is 60.5 m high with 11 m diameter. It will be located near the outlet portal of the headrace tunnel and placed at a few meters offset from headrace tunnel. The excavation of the surge shaft will be carried out from both the top and bottom as the upper portion is exposed to the surface. It is envisaged that a pilot tunnel will be constructed first and then the shaft will be expanded to the required diameter. Shotcrete and grouted rock bolts in pattern will be provided after excavation.

e. **Penstock Alignment and Supports**
A steel penstock pipe of 3.55 m internal diameter and 218 m length will be laid inside the anchor block and thrust blocks and about 27.2 m length of bifurcation. Altogether 3 anchor blocks and 3 thrust blocks will be constructed for the buried penstock support. The steel penstock pipe will be welded in sections and cast into the anchor block.

(2) **Powerhouse Civil Work**

a. **Powerhouse**
The construction of the powerhouse comprise of civil and electromechanical works. This section will briefly discuss about the construction activities on the civil parts only. Electromechanical part will be briefed on section 2.6.2 (3). The main civil works in the powerhouse consists of excavation and concreting works. Excavators, loaders and dump trucks will be used for excavation of the surface powerhouse. The substructure or the first stage concrete will be placed before the erection of the Francis turbine units. The erection of the units will follow one after the other for efficient use of human resources and to save erection time. The size and position of columns, beams and roofs are designed such that there will be enough space for the installation and movement of the powerhouse crane. The remaining part of the structure can then be completed with the use of the main crane. As soon as the
finishing works are completed, the erection of the auxiliary equipment will be started and then, the second stage structural concrete will be cast. Concreting work will be completed in 8 months.

b. Tailrace
The major work in the tailrace includes excavation and concreting. The total length of the tailrace canal is 93 m. The excavation quantity of the tailrace is about 1800 m$^3$. The excavation and the concreting will take about 4 months.

c. Switchyard
The outdoor switchyard is located close to the powerhouse. The switchyard covers 55 m x 35 m total area above the powerhouse at an elevation of 472.6 masl. The civil works for the switchyard will be completed in 5 months.

(3) Electromechanical Equipment
The construction activities of the electromechanical works will involve design and manufacturing of the auxiliaries by the supplier at the factory. The supplier will be responsible for the erection, installation and commissioning at the project site. The successful bidder/s will take 12 months for design, fabrication and delivery of the equipment. After completion of the necessary foundation works, the erection of the electromechanical equipment like turbines, generators, transformers and auxiliaries will commence. The erection of electromechanical equipment will take about 6 weeks.

(4) Transmission line
Transmission facilities can be viewed as a separate entity of the project. NEA is responsible for construction of the transmission line for evacuating the power generated from Kabeli-A. The transmission line is expected to be completed by the time of project completion.

2.6.3 Construction Traffic
Two types of vehicular traffic is expected in the area. One that brings construction materials from the south confined to the Mechi Rajmarga while the other that facilitate day to day construction works confined to the construction site vicinity. The former traffic comprising heavy vehicles with high pay loads are slow moving. Expected vehicular traffic of this type will be a maximum of 30 to 35 in a day during the construction period in the Mechi Rajmarga corridor. The later traffic confined to the active construction sites comprises both light and heavy vehicles. Expected vehicle number in the construction site is more than 100. This traffic is also expected to frequently pass through the Mechi Rajmarga and might cause problems to the traffic conditions of the Rajmarga.

For the transportation of the fuels (diesel and other petroleum products) required for the project, the contractor will make an special arrangements with the Nepal Oil Corporation, only authorized institution of the government of Nepal to deal on the fuel handling and trade in Nepal. The proponent will assist the contractor for such arrangements. The Nepal Oil Corporation fuel transport and delivery vehicles will deliver the fuel up to the storage yards of the project site.

Explosives transport, delivery, and handling is totally regulated and controlled by the government of Nepal under the Explosive Act. The security during transport and even in the storage yard and in the active construction site is provided by the government of Nepal, however, arrangements for transport vehicle, permanent storage yard and temporary storage yard is the responsibility of the developer and the contractor.

2.6.4 Construction related Environmental Pollution
The key environmental pollution related to the construction activities are air, water, noise, and land pollution. Air and noise pollution is expected from all excavation, blasting drilling, civil construction, and construction machinery and traffic related activities. Water pollution is expected from the aggregate crushing and washing, tunnel water discharge, batching plants, camps, mechanical yard, fuel storage yards, and construction activities that interfere the water course and water bodies. Land pollution
through solid waste coming from construction sites and camps is one of the critical pollution issues of the construction projects.

2.7 Project Requirements

2.7.1 Construction Materials

The main construction materials required are blasting materials and detonators, cement, brick or concrete blocks, steel pipe and angles, stone/boulders, gabion, geo-textiles, reinforcement bars and timber, fuels, coarse and fine aggregate, cohesive materials and admixtures, backfill and rock fill materials, rock bolts, mechanical and electrical items such as conductor wires.

Cement, reinforcement and steel use in the project are estimated to be about 40000, 4000 and 500 MT, respectively (HCPL, 2010). The purchase of these materials should be done on a bulk basis. Fine aggregates will be obtained from the nearby quarries at the headworks and powerhouse whereas coarse aggregates will be processed from the nearby respective sites at the headworks and powerhouse. The materials for backfill and rockfill will also be processed from the excavated materials and tunnel muck. The protection at Piple khola and powerhouse uses lot muck from the excavated material of the tunnel. The boulder will be directly selected from the river/river side (bagar).

2.7.2 Land Requirement

A total of 47.718 ha of land will be required for the project. Of the total, 22.508 ha is permanent land while temporary land is 25.21ha (Table 2.2). In terms of land use, 61.10 % is the riverine area including river beds, river flood plains and elevated banks. Agricultural land required is 35.60 % followed by 3.30% of the forest land including community forests, private forests and leasehold forests. Of the land use types, only 7.678 ha of agricultural land and 1.57 ha of forest land will be required permanently. The rest of the permanent land (13.26 ha) required is the riverine area.

Table 2.2: Land Requirement for Various Project Structures and Facilities

<table>
<thead>
<tr>
<th>SN</th>
<th>Name of Project Structure and Facilities</th>
<th>Land Required (Hectare)</th>
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<th>Temporary</th>
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<th>Land Use</th>
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<td></td>
<td></td>
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<td>Forest</td>
<td>River</td>
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<td>9.973</td>
<td>0.293</td>
<td>0.57</td>
<td>9.11</td>
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<td>A.2</td>
<td>Barrage, Operating Platform, Intake</td>
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<td>3.654</td>
<td>0.954</td>
<td>0.03</td>
<td>2.67</td>
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<td>A.3</td>
<td>Sensor Building</td>
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<td>0.01</td>
<td>0.11</td>
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<td>A.4</td>
<td>Powerhouse and Switchyard</td>
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<td>3.922</td>
<td>2.182</td>
<td>0.27</td>
<td>1.47</td>
</tr>
<tr>
<td>A.5</td>
<td>Penstock Pipe and Surge Shaft</td>
<td>0.70</td>
<td>0.70</td>
<td></td>
<td>0.70</td>
<td>0.70</td>
</tr>
<tr>
<td>A.6</td>
<td></td>
<td>Sub-total (A)</td>
<td>18.259</td>
<td>0</td>
<td>18.259</td>
<td>3.429</td>
</tr>
<tr>
<td>B</td>
<td>Project Facilities</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B.1</td>
<td>Access Road to Headwork</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>B.2</td>
<td>Quarry Site (Headworks)</td>
<td>3.50</td>
<td>3.50</td>
<td></td>
<td></td>
<td>3.50</td>
</tr>
<tr>
<td>B.3</td>
<td>Quarry Site (Powerhouse)</td>
<td>4.31</td>
<td>4.31</td>
<td>1.01</td>
<td></td>
<td>4.31</td>
</tr>
<tr>
<td>B.4</td>
<td>Spoil/Muck Disposal</td>
<td>4.60</td>
<td>4.60</td>
<td></td>
<td></td>
<td>4.60</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td></td>
<td>18.259</td>
<td>0</td>
<td>18.259</td>
<td>3.429</td>
</tr>
</tbody>
</table>
### 2.7.3 Human Resources Requirement

Following assumptions were made in the assumption of man power requirement:

- Project construction period of about 4 years and
- Work operation by 8 separate workforce team in different locations

A reasonable estimate based on the consultant’s experience in Middle Marsyangdi Hydroelectric Project for skilled, semi skilled and unskilled human resources for a project of this size is about 600 to 800 during the peak construction period.

### 2.8 Implementation Schedule

An estimated total of four years is envisaged for the construction of the KAHEP. A tentative construction schedule is presented in Table 2.3.

#### Table 2.3: Implementation Schedule of KAHEP

<table>
<thead>
<tr>
<th>SN</th>
<th>Construction Activities</th>
<th>Years</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>1.</td>
<td>Pre-construction works (access roads and contractual works)</td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>Construction mobilization</td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>Diversion facilities</td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td>Weir and barrage</td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td>Intake structure and settling basin</td>
<td></td>
</tr>
</tbody>
</table>
6. River Training works at headworks
7. Tunnel and surge shaft
8. Powerhouse and tailrace
9. Hydro mechanical parts
10. E & M equipment
11. Switchyard
12. Testing and commissioning

Source: KEL, 2010

2.9 Project Operation Modality

The proposed project is a PROR Project. A typical ROR project generates energy at a reduced capacity during the whole day, whereas a PROR project can be designed to operate at full (installed) capacity for a specified number of hours. Considering the available river flow and the riparian water release, this project is designed for two slot peaking mode of 2 hours in the morning and four hours in the evening peaking hours with a reduced capacity. A detailed calculation showing the results for a two slot operation is shown in Annex 2.1, 2.2 and 2.3 and presents the calculations for 2 hour peaking and 4 hour peaking separately. Table 2.4 presents the available mean monthly flow, flow that will be diverted for electricity generation and flow released in the Kabeli River downstream barrage for the different months.

Table 2.4: Flow Regulation of the Kabeli River during Operation of the Project

<table>
<thead>
<tr>
<th>Months</th>
<th>Mean monthly flow available m³/s</th>
<th>Flow diverted for energy generation m³/s</th>
<th>Flow released from Barrage m³/s (10% of annual monthly minimum)</th>
<th>Flow released from tailrace m³/s</th>
</tr>
</thead>
<tbody>
<tr>
<td>January</td>
<td>9.93</td>
<td>9.12</td>
<td>0.81</td>
<td>37.73 for 5.8 hours a day</td>
</tr>
<tr>
<td>February</td>
<td>8.25</td>
<td>7.44</td>
<td>0.81</td>
<td>37.73 for 4.7 hours a day</td>
</tr>
<tr>
<td>March</td>
<td>8.11</td>
<td>7.3</td>
<td>0.81</td>
<td>37.73 for 4.6 hours a day</td>
</tr>
<tr>
<td>April</td>
<td>11.83</td>
<td>11.02</td>
<td>0.81</td>
<td>37.73 for 7 hours a day</td>
</tr>
<tr>
<td>May</td>
<td>25.92</td>
<td>25.11</td>
<td>0.81</td>
<td>37.73 for 16 hours a day</td>
</tr>
<tr>
<td>June</td>
<td>72.42</td>
<td>37.73</td>
<td>35.05</td>
<td>37.73 for 24 hours a day</td>
</tr>
<tr>
<td>July</td>
<td>142.08</td>
<td>37.73</td>
<td>104.35</td>
<td>37.73 for 24 hours a day</td>
</tr>
<tr>
<td>August</td>
<td>151.09</td>
<td>37.73</td>
<td>113.36</td>
<td>37.73 for 24 hours a day</td>
</tr>
<tr>
<td>September</td>
<td>106.31</td>
<td>37.73</td>
<td>68.58</td>
<td>37.73 for 24 hours a day</td>
</tr>
<tr>
<td>October</td>
<td>49.49</td>
<td>37.73</td>
<td>11.76</td>
<td>37.73 for 24 hours a day</td>
</tr>
<tr>
<td>November</td>
<td>21.95</td>
<td>21.41</td>
<td>0.81</td>
<td>37.73 for 13.4 hours a day</td>
</tr>
<tr>
<td>December</td>
<td>13.61</td>
<td>12.80</td>
<td>0.81</td>
<td>37.73 for 8.1 hours a day</td>
</tr>
</tbody>
</table>

Source: KEL, 2010

2.10 Project Costs

Estimated construction cost of the project is about 66.355 Million US$ equivalent to 5 billion Nepali rupees at the exchange rate of 75 NRs/$ (Updated Feasibility Report 2010). The above cost incorporates 75 million NRs. of environmental and resettlement and rehabilitation costs.