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Engineering geological investigations of the Trishuli–Galchhi Hydroelectric Project

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ABSTRACT

The study area lies on the northern limb of the Mahabharat Synclinorium. It consists of the crystalline rocks of the Kathmandu Complex with underlying metasedimentary rocks of the Nawakot Comples, separated by the Main Central Thrust. The reservoir area of the project reveals the good site for the large storage capacity and seems feasible. The headworks site is fairly suitable for the dam structures. The intake canal, desander basin and the approach canal will be located on flat alluvium terrace. Common rock types along the headrace tunnel are slate, quartzite, phyllite, dolomite, dolomitic limestone and chlorite-schist. Generally rock belongs to poor to good class. The semi-underground powerhouse lies on gently dipping terrace deposits. The rock support recommended for the headrace tunnel is combination of local to systematic bolting and reinforced shotcrete as per requirements.

INTRODUCTION

The study area lies within longitude 84º 57' 34" E to 85º 05' 30" E and latitude 27º 47' 25" N to 27º 51' 52' 'N. It is located in Dhading and Nuwakot Districts, Bagmati Zone, Central Nepal (Fig.1). The headworks lies at the Dhodbesi Village, Budhasing VDC, Nuwakot District. The headrace tunnel passes through Budhasing and Taruka VDCs of Nuwakot District and Khalte and Kalleri VDCs of Dhading District. The surge shaft, penstock, outdoor switchyard and the tailrace canal are located at the Hadikholatar Village, Kalleri VDC.

The Trishuli–Galchhi Hydroelectric Project is the daily poundage run of river type of the project with an install capacity of 80 MW, design discharge (Q_{40}) of 238 m^3/s and design net head of 40 m (K.C., 2010). The unit of headworks comprises of a 5m high and 250 m long free overflow weir, which diverts water into the settling basin. The desander basin is 180 m long and 42 m wide. The horseshoe shaped headrace tunnel is 8102 m long having 8.5 m diameter. The surge shaft has 20 m diameter and 49.64 m height. The penstock pipe is buried steel pipe scheme having diameter of 8 m with the length of 211 m. The proposed powerhouse is a semi-underground structure having the dimension of 50 m × 35.5 m that accommodates three generating units with the capacity of 26.67 MW on each. After the power generation, water will be discharged to the Trishuli River through a trapezoidal shaped concrete culvert tailrace canal (K.C., 2010).

The present study was conducted to collect geological, engineering geological and geotechnical information in order to assess the technical prospect of the proposed project as the part of the pre-feasibility study. The objectives were to study the engineering geological conditions of the area where engineering structures were proposed.

METHODOLOCY

Topographic maps, aerial photographs, published and unpublished reports, literatures, journals, field manuals and established theories were collected from the different sources and studied in detail and made

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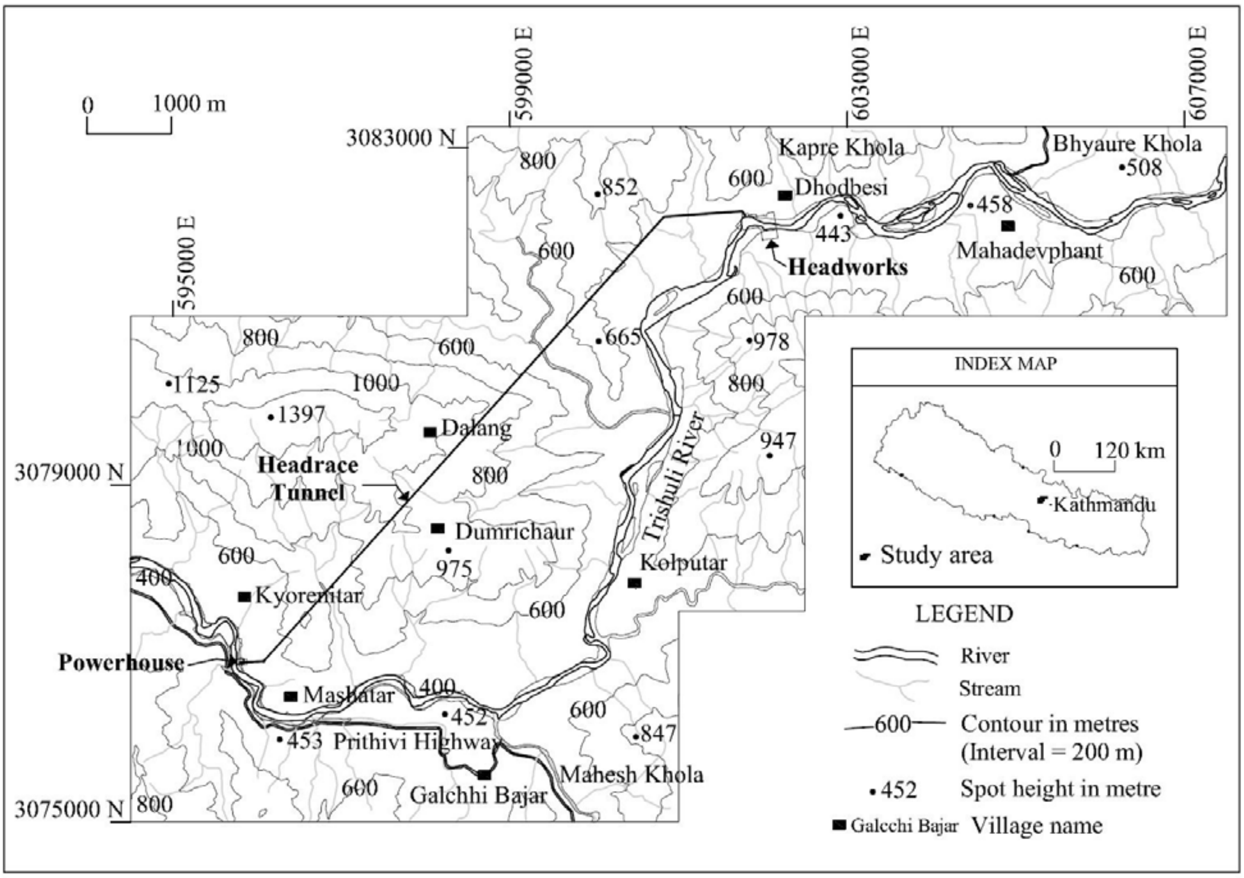

Fig. 1 Location map showing engineering structures of the project

the basis for the site investigations. The representative geological traverses were made along the river, a number of streams and gullies, roads, trails and spurs. Lithological units as well as geological contact between different rock units were depicted in topographic map and geological map was prepared. For the engineering geological study, the traverses were made on and around the proposed reservoir area, headworks, headrace tunnel corridor, power house and the tailrace area. The engineering properties of the rock and soil were noted. From the rock outcrop, the rock type, discontinuities, infilling materials, weathering grade, strength, and seepage condition were recorded. The geomorphological features, types of surface deposit and their depth were also noted in the field. During soil survey, the field identification of soil was conducted. The soil was classified according to their origin and geologic feature i.e. alluvial, colluvial and residual soil. The rock and soil samples were used for visual estimation of geotechnical properties of rock and soil. At the same time representative rock samples were collected for point load test in the laboratory.

Rock mass condition along the headrace tunnel was based on geological mapping and detailed joint mapping on rock outcrops. Geomechanical classifications using both rock mass rating (RMR) (Bieniawski, 1989) and rock tunneling quality index (Q) (Barton et al., 1974) were carried out. Geological strength index (GSI) of rock mass was calculated based on RMR i.e. GSI = RMR–5 (Hoek et al., 1995). Adjusted value of RMR, i.e. adjustment made taking into account of the tunnel orientation with respect to discontinuities and Q value were separately used in the classification of rock mass.

The geotechnical properties of the soil in the proposed reservoir, intake and the powerhouse area were estimated from the field identification from the surface samples. Field tests like shaking test

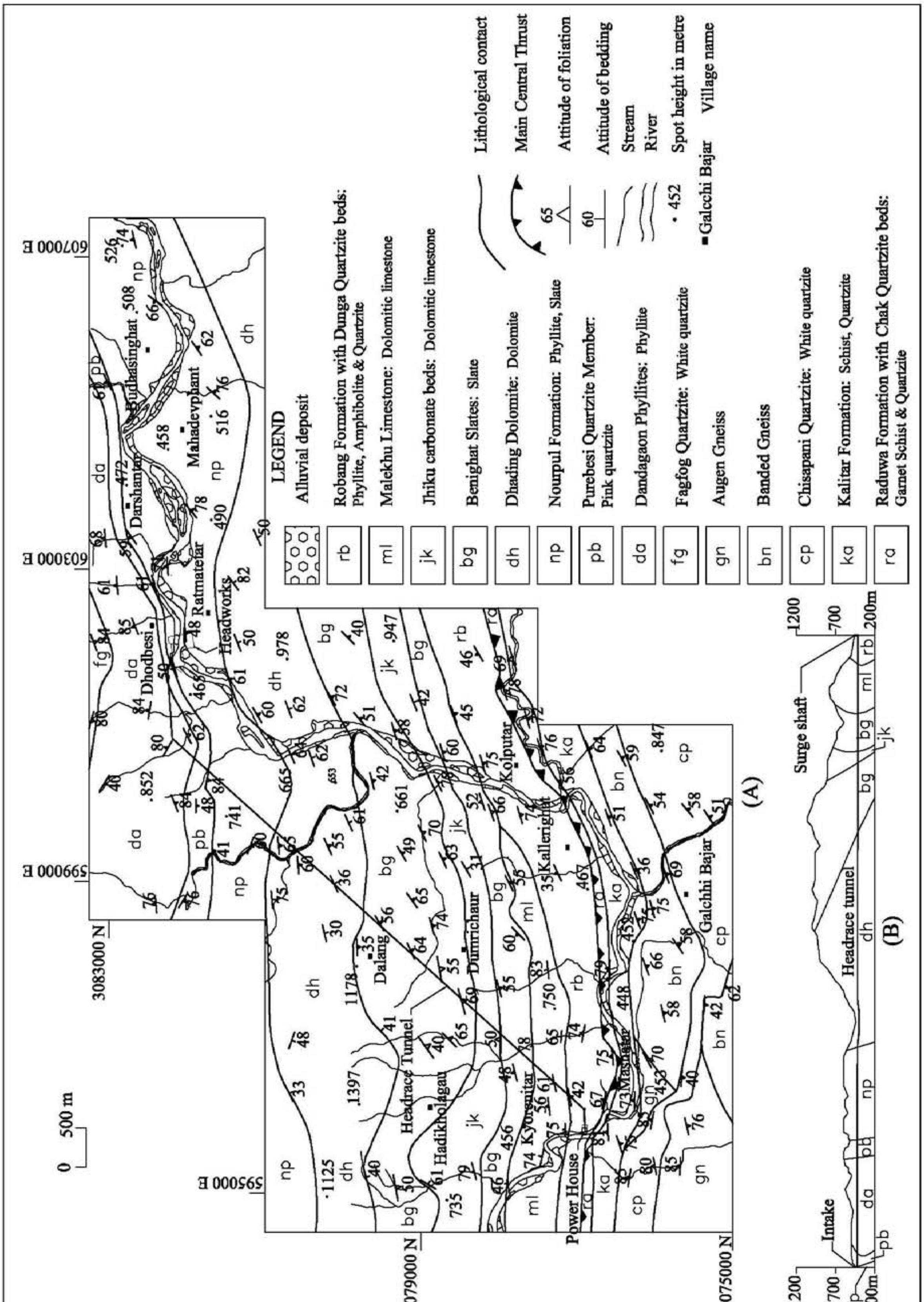

Fig. 2: (A) Geological map of the project area (B) Geological cross section along the headrace tunnel

(dilatancy) breaking test (dry strength), toughness, ribbon test, acid test, shine test, colour, texture, relative density, moisture, grain shape, grain size and gradation by visual examination were carried out that enhance the classification of soil. Soils were classified on the basis of unified soil classification (USC) system.

No geophysical investigations, seismicity survey, core drillings, in-situ stress condition evaluation, detailed rock support designing, and construction material survey were carried out in the present study. Since all necessary parameters for geotechnical studies were not available at the present study, those parameters which were the most essential for the geotechnical studies were determined using empirical relationships. The unconfined compressive strength (UCS) of the rock sample was determined from the corresponding point-load index. The required secondary data such as empirical and constant values for the rock mass were collected from different published and unpublished reports and journals.

GEOLOGICAL SETTING

Most of the study area is situated in the Lesser Himalaya and partly on the Higher Himalaya, Central Nepal (Fig. 2.). These zones are separated by the Main Central Thrust (MCT). In the present study, the lithostratigraphic units after Stöcklin and Bhattarai (1977) and Stöcklin (1980) is adopted. The Nawakot Complex comprises the Fagfog Quartzite, the Dandagaon Phyllites, the Nourpul Formation, the Dhading Dolomite, the Benighat Slates, the Malekhu Limestone and the Robang Formation (Fig. 2). The major rock types are pelitic, psammitic and calcareous metasediments rarely exceeding the sericite-chlorite grade such as quartzite, phyllite, slate and schist and carbonate rocks such as dolomite and dolomitic limestone. The relatively high grade metamorphic rock of the Kathmandu Complex comprises the Raduwa Formation, the Kalitar Formation and the Chisapani Quartzite (Fig. 2). These formations mainly comprise of the high to the low grade schist and quartzite. The gneiss injections associated with the high grade crystalline rocks are also observed around Galchhi (Fig. 2).

RESULTS

Engineering geological investigations include the engineering geological mapping of the major hydraulic structures of the project and rock mass classification of the headrace tunnel area. Geotechnical studies include preliminary stress analysis and rock excavation support desing along the headrace tunnel.

Reservoir area

The area on upstream of the proposed dam reveals good site for the large storage capacity. The area below elevation of 435 m will be submerged by the construction of the dam. The total length of the reservoir is about 3 km which extends from Dhodbesi to the confluence of the Bhyaure Khola and the Trishuli River. The site has no major tributaries that can influx the large quantity of sediments on the reservoir. But, the tributaries like the Bhyaure Khola and the Kagune Khola show the evidence of occasional debris flow. The hill slopes on both banks of the river are fragile due to the steep sloping terrace scrap and weak rocks i.e. slate and phyllite. There are no major solution cavities, karst topography, weakness zones, potential shear zone, active faults and major instabilities along the river at the proposed reservoir area. The river valley is almost wide and covered with alluvium terraces. Alluvium terraces are divided into the upper, the middle and the lower terrace based on elevation and sediments type (Fig. 3). The upper terrace consists of soil ranging from clay to sand with traces of pebble, cobble and boulder. It is generally covered by 3–5 m a thick residual soil. The middle terrace predominantly consists of sand, and the lower terrace is the youngest (recent flood) deposits with variable sized sediments ranges from silt to boulder. In some section colluvium covers the middle and the upper terrace deposits, whereas on other parts they are eroded. The patches of rock outcrop consist of dark grey, laminated, crenulated, thin- to medium-banded, slightly weathered, moderately strong slate with phyllite partings.

Headworks

The diversion barrage is located at a straight course of the Trishuli River (Fig. 4). The slope at both abutments varies considerably. The right bank is characterised by the flat terrace and moderate sloping hill whereas the left bank is characterized by the steep slope terrace scrap. Along the left bank, the rock exposure extends up to 250 m upstream of the

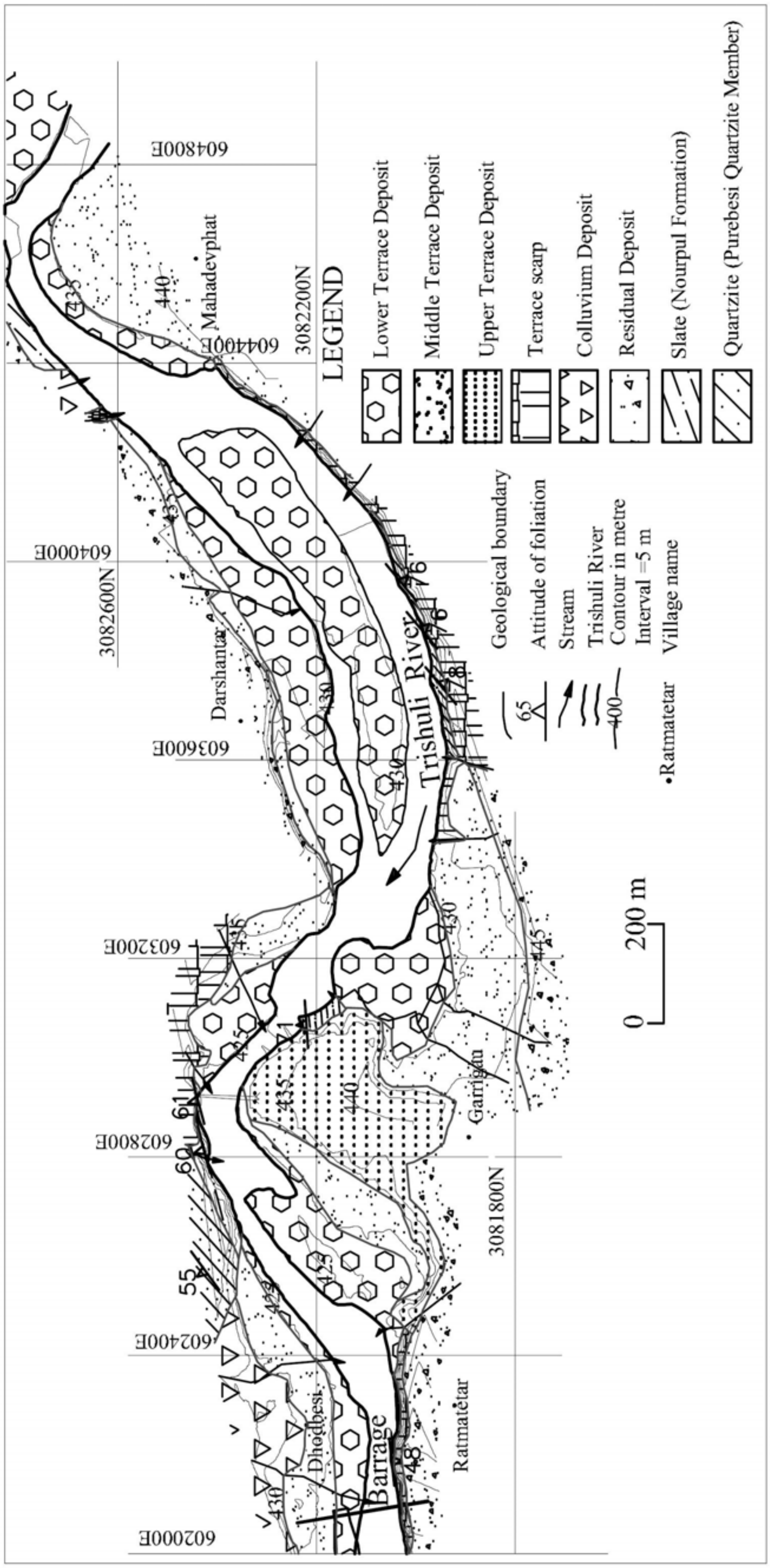

Fig. 3 Engineering geological map of the reservoir area

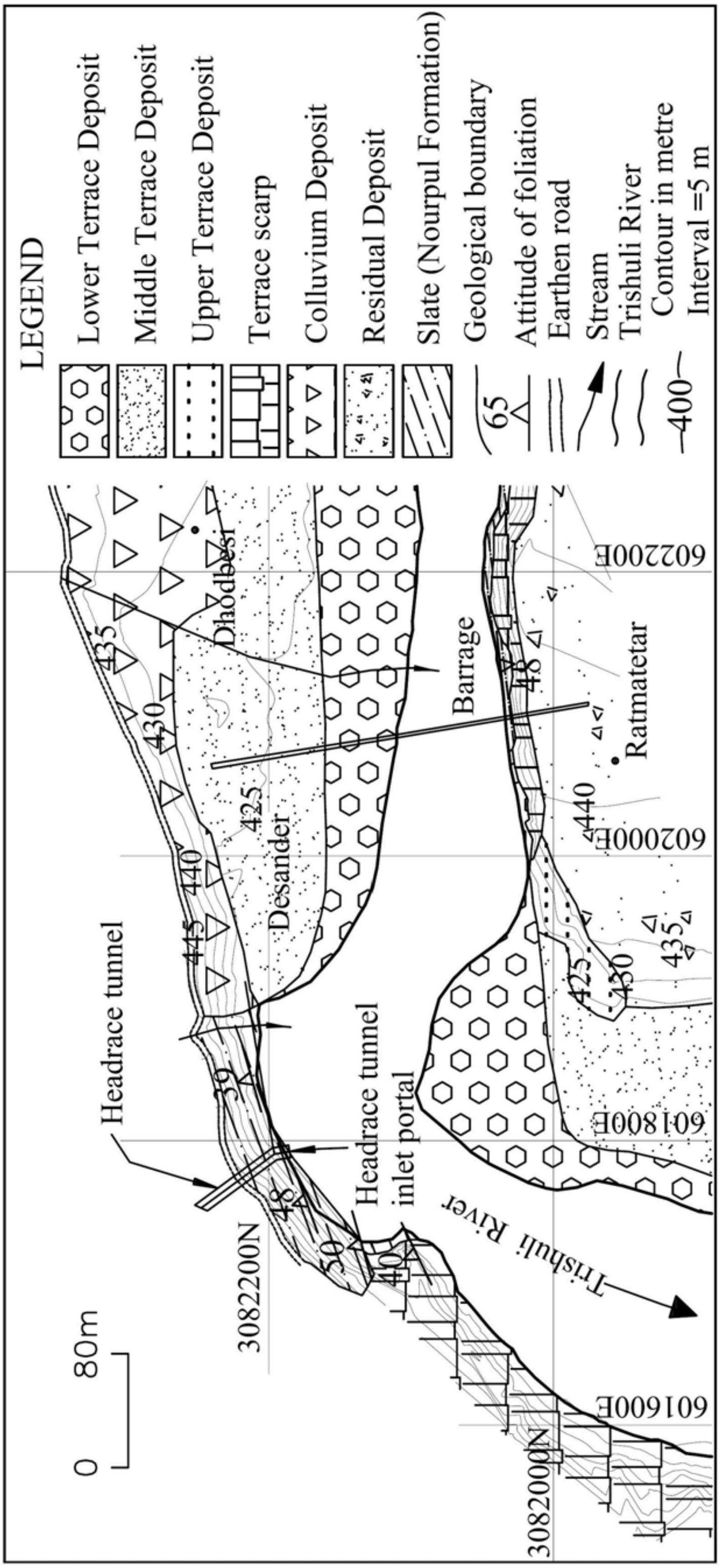

Fig. 4 Engineering geological map of the headworks

Table 1: Table showing rock mass classification and estimation of in-situ deformation modulus, in-situ stress and excavation support along the headrace tunnel

Chainage (m)	***Rock type***	***RQD (%)***	***RMR***	***Q***	***GSI***	***Rock mass based on***		***z***	E_m	s_v	***k***	s_h	***Excavation support***		
						RMR	***Q***						***Rock bolts***	***Shotcrete***	***Steel sets***
0+010–0+075	Quartzite	76	75	12.79	70	Good	Good	56.6	38.84	1.53	5.32	8.14	Locally bolts in crown, 3m long spaced 2.5 m with occasional mesh	50mm in crown where required	None
0+075–0+183	Quartzite	68	54	11.45	49	Fair	Good	74.06	19.53	2	2.23	4.46	Systematic bolts 4m long, spaced 1.5-2 m in crown and walls with mesh in crown	50-100 mm in crown, 30mm in sidewalls	None
0+183–1+002	Phyllite with slate	45	46	2.28	41	Fair	Poor	154.15	8.45	4.16	0.69	2.88	Systematic bolts 4m long, spaced 1.5-2 m in crown and walls with mesh in crown	50-100 mm in crown, 30mm in sidewalls	None
1+002–1+405	Phyllite	56	72	25.14	67	Good	Good	169.98	39.5	4.59	2.15	9.88	Locally bolts in crown, 3 m long spaced 2.5 m with occasional mesh	50 mm in crown where required	None
1+405–1+637	Quartzite	78	66	23.34	61	Good	Good	164.18	33.1	4.43	1.89	8.39	Locally bolts in crown, 3m long spaced 2.5m with occasional mesh	50 mm in crown where required	None
1+637–2+559	Argillaceous phyllite	52	60	11.44	55	Fair	Good	176.58	23.23	4.77	1.33	6.36	Systematic bolts 4m long, spaced 1.5-2m in crown and walls with mesh in crown	50-100 mm in crown, 30mm in sidewalls	None
2+559–2+822	Graphitic slate	38	40	2.78	35	Poor	Poor	176.09	8.36	4.75	0.64	3.05	Systematic bolts 4-5 m long, spaced 1-1.5 m in crown and walls with wire mesh	100-150 mm in crown, and 100mm in sides	Light ribs spaced 1.5m where required
2+822–2+904	Dolomite	64	59	4.69	54	Fair	Fair	88.22	17.39	2.38	1.75	4.17	Systematic bolts 4m long, spaced 1.5-2 m in crown and walls with mesh in crown	50-100 mm in crown, 30 mm in sidewalls	None
2+904–4+300	Phyllite with schist and dolomite	68	45	1.72	40	Fair	Poor	211.84	6.69	5.72	0.52	2.96	Systematic bolts 4m long, spaced 1.5-2 m in crown and walls with mesh in crown	50-100 mm in crown, 30 mm in sidewalls	None
4+300–5+571	Dolomite	65	59	7.29	54	Fair	Fair	541.09	19.78	14.61	0.64	9.41	Systematic bolts 4m long, spaced 1.5-2m in crown and walls with mesh in crown	50-100 mm in crown, 30 mm in sidewalls	None
5+571–6+303	Graphitic slate	22	39	1.48	34	Poor	Poor	628.58	4.78	16.97	0.34	5.72	Systematic bolts 4-5m long, spaced 1-1.5m in crown and walls with wire mesh	100-150 mm in crown, and 100 mm in sides	Light ribs spaced 1.5m where required
6+303–6+322	Dolomite	62	57	6.96	52	Fair	Fair	380.38	17.53	10.27	0.7	7.14	Systematic bolts 4m long, spaced 1.5-2m in crown and walls with mesh in crown	50-100 mm in crown, 30 mm in sidewalls	None
6+322–6+465	Graphitic slate	18	39	1.48	34	Poor	Poor	380.4	4.78	10.27	0.37	3.82	Systematic bolts 4-5m long, spaced 1-1.5m in crown and walls with wire mesh	100-150 mm in crown, and 100mm in sides	Light ribs spaced 1.5m where required
6+465–6+615	Dolomitic limestone	85	56	6.24	51	Fair	Fair	337.14	15.94	9.1	0.69	6.3	Systematic bolts 4m long, spaced 1.5-2m in crown and walls with mesh in crown	50-100 mm in crown, 30 mm in sidewalls	None
6+615–7+096	Graphitic slate	24	46	1.32	41	Fair	Poor	299.34	5.48	8.08	0.42	3.37	Systematic bolts 4m long, spaced 1.5-2 m in crown and walls with mesh in crown	50-100 mm in crown, 30 mm in sidewalls	None
7+096–7+732	Dolomitic limestone	74	67	6.23	62	Good	Fair	361.45	26.93	9.76	0.96	9.37	Locally bolts in crown, 3m long spaced 2.5 m with occasional mesh	50 mm in crown where required	None
7+732–7+761	Amphibolite	87	87	52.07	82	Very good	Very good	116.36	58.46	3.14	4.18	13.12	Generally no support required except for occasional spot bolting		
7+761–8+102	Psammitic phyllite	73	64	24.58	59	Good	Good	72.98	31.38	1.97	3.48	6.86	Locally bolts in crown, 3m long spaced 2.5m with occasional mesh	50 mm in crown where required	None
7+761–8+102	Quartzite	74	66	12.46	61	Good	Good	55.42	29.69	1.5	4.21	6.3	Locally bolts in crown, 3 m long spaced 2.5 m with occasional mesh	50 mm in crown where required	None

proposed dam axis, 5 m above the river bed level. The rest of the slope is formed by the terrace scrap. The proposed intake canal is located on the right bank of the Trishuli River in the flat alluvium terrace (Fig. 4). The desander basin is proposed in the flat middle terrace (Fig. 4). The terrace consists of a thick accumulation of alluvial deposits comprising of light grey, gritty textured, angular to sub-rounded, coarse-grained soil. The moderately permeable and loose silty sand are inherent at near surface, followed by highly permeable boulder and gravel mix sand on the greater depth. Colluvium rests over the river terrace. The hill slope is covered by colluvium with vegetation and sparse trees. Colluvial deposits comprise of various sized boulders of quartzite and psammitic phyllite. The depth of colluvium is assumed as 5–10 m. The hill slopes ranges between 30º and 75º. Though there is an old landslide deposit (talus) on the hill slope, no any instability is observed. The approach canal passes by an edge of the alluvium terrace.

Headrace tunnel

The tunnel will pass through various rock types. Common rock types are slate, quartzite, phyllite, dolomite, dolomitic limestone and chlorite-schist (Fig. 2). The tunnel passes through a thin overburden, generally less than100 m between the inlet portal and the Koshi Khola Crossing. This section seems to be problematic due to the thin overburden. There will be good rock cover i.e. more than 200 m after the Koshi Khola Crossing up to the outlet portal. No major structural disturbances such as fault and major shear zones are observed in the area but thin bands of shear and fractured zones are expected along the tunnel in rock of the Benighat Slates. A shallow landslide can be seen on hill slope at Batase near the tunnel alignment, but no any deep landslide is found to intersect the tunnel. Generally, bedding/foliation (average bedding/foliation: 157º/58º) is oblique to the proposed tunnel axis with dip toward the drive, which is favorable for excavation.

Rock mass condition along the headrace tunnel is based on geological mapping and detailed joint mapping on surface rock outcrop. Geomechanical classification using both rock mass rating (RMR) (Bieniawski, 1989) and rock tunneling quality index (Q) (Barton et al., 1974) has been carried out. Geological strength index (GSI) of rock mass is calculated based on RMR i.e. GSI = RMR-5. Adjusted value of RMR (adjustment made taking into account of the tunnel orientation with respect to discontinuities) and Q value are separately used in classification of rock mass. Value of rock quality designation (RQD), RMR, GSI, Q and rock mass class obtained on different chainage is given in Table 1. Generally, rock belongs to poor to good. Adjusted RMR ranges between 39 and 87, which deduce poor to very good rock (Table 1). Q ranges between 1.32 and 52.07, which falls on poor to very good rock (Table 1). Since, the results from both RMR and Q systems seem quite similar, either of the systems can be adopted for rock mass classification along the headrace tunnel.

Surge shaft

The proposed surge shaft lies in the slope which is characterized by residual soil and colluvium. The latter ranges from 3 to 6 m thickness (Fig. 5). An outcrop is white, grey to green, medium- to coarse-grained, medium-banded, highly weathered, medium strong psammitic phyllite and quartzite with partings of argillaceous phyllite. Thickness of quartzite band ranges between 5 and 147 cm and phyllite ranges between 3 and 70 cm. The attitude of foliation ranges from 85º–110º/70º–75º NW–NE. Soil is red-brown, floury textured, sub-angular, coarse-grained, clayey sand.

Penstock

The proposed penstock initially runs on gently dipping topography then on flat river terrace (Fig. 5). The sloping land (15º–20º) used for cultivation is characterized by thick i.e. > 6 m residual soil with frequent rock fragments. The patch of outcrop is also exposed on the slope (Fig. 5). Outcrop consists of white to grey, coarse-grained, medium-banded, slightly weathered, fractured, very strong quartzite. Joints are close- to moderate-spaced, very low to medium persistence, tight to open aperture and smooth to slightly rough surface. The attitudes of joints are FP: 12º/81º, J1: 295º/73º, J2: 112º/12º, J3: 220º/18º and J4: 118º/84º. Soil is grey to red-brown, organic ordoured, floury to sharp textured, angular to rounded,

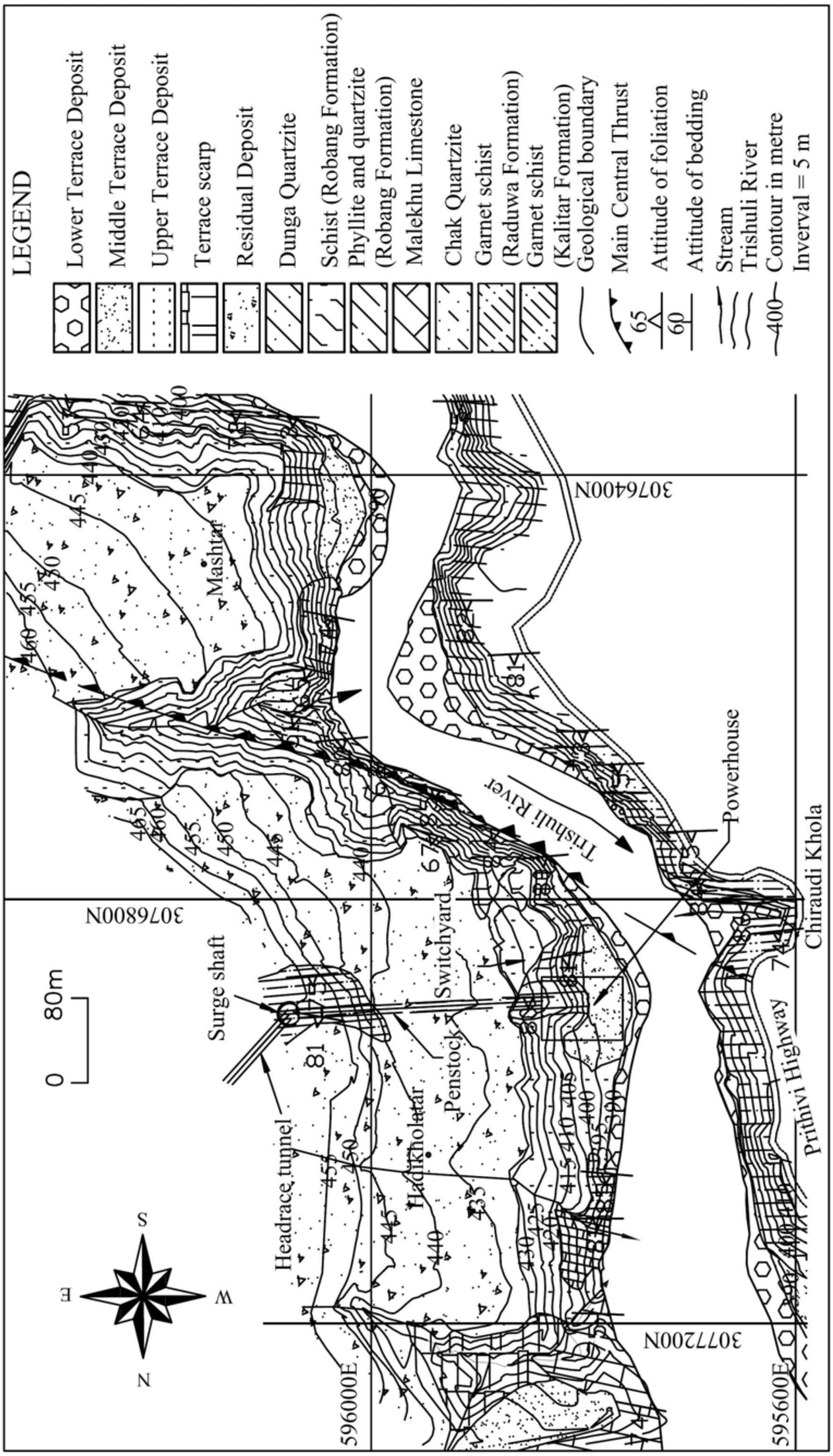

Fig. 5 Engineering geological map of the powerhouse

fine- to coarse-grained inorganic silty clay to well-graded sand.

Powerhouse

The proposed semi-underground powerhouse site is located about 70 m downstream from the confluence of the Trishuli River and the Chiraudi Khola at Hadikholatar (Fig. 5). The recent flood plain deposits (lower terrace) are observed along the right bank of river in and around the powerhouse site. It consists of light grey, organic ordoured, sharp-textured, sub-angular to sub-rounded, coarse-grained, well-graded gravel. On the uphill side, the lower terrace gradually changes into the middle terrace. The middle terrace consists of grey, organic ordoured, gritty textured, angular to rounded, coarse-grained, silty sand. The uphill side of the proposed powerhouse is the upper terrace. The slope ranges from 25º to 35º. Soil on the slope is grey to brown, organic ordoured, angular to rounded, coarse-grained, and well-graded sand. The patches of outcrop on the hill slope around the powerhouse area consist of grey, coarse-grained, medium-banded, slightly to moderately weathered, strong, crenulated phyllite and white to grey, coarse-grained, medium-banded, slightly weathered, fractured, very strong quartzite with partings of schist. The trend and plunge of foliation vary respectively from 80º to 93º and from 80º NW to 83º NW. Joints are close- to moderate-spaced, low to medium persistence, tight to very wide aperture and slightly rough to rough surface. Joint apertures are filled with sand, silt and clay particles.

Tailrace canal

The tailrace canal is proposed to run through the recent flood plain deposits (lower terrace) along the right bank of the Trishuli River. It is composed of light grey, organic ordoured, sub-angular to sub-rounded, coarse-grained, well-graded gravel.

Switchyard

The proposed switchyard lies on the flat upper terrace on Hadikholatar (Fig. 5). The terrace consists of thick i.e. 3–6 m unconsolidated alluvium deposits. Soil is grey, angular to rounded, coarse-grained, well-graded sand.

STRESS ANALYSIS ALONG THE HEADRACE TUNNEL

An attempt was made for the analysis of stress condition produced by overburden rock body along the headrace tunnel. This included determination of in-situ stress deformation modulus, in-situ stress condition, elastic and plastic behaviour and failure criteria.

Estimation of in-situ deformation modulus and in-situ stress condition

An empirical method was used for the evaluation of in-situ stress along the headrace tunnel. Analysis using rock cover was a very simplified approximation method to analyze in-situ stresses. Vertical stress acting on the tunnel ($_v$) was estimated from a simple relationship i.e. $_v$ = z, where is unit weight of overlying rock body (~ 0.027 MN/m3) and z is depth below a surface. Horizontal stress acting on the tunnel ($_h$) at a depth z below a surface was estimated as, $_h$ = k $_v$. Sheory (1994) gave an empirical equation to estimate the value of k as, k = 0.25+7E_m (0.001+1/z), where E_m is average deformation modulus of upper part of earth crust's measured in horizontal direction in GPa. In-situ deformation modulus of a rock mass (Em) was determined empirically using the relations which are based on RMR and Q:

(i) Em = 2RMR–100

(for 55<RMR<90; Bieniawski, 1978),

(ii) Em = 10 $^{(RMR - 10)/40}$

(for 30<RMR<55; Serafim and Pereira, 1983), and

(iii) $E_m = 25 \log_{10} Q$

(for Q>1; Grimstad and Barton, 1993).

E_m, $_v$, $_h$ and k along the headrace tunnel is calculated and presented on Table 1.

Determination of elastic and plastic behaviour of rock

Different stress parameters like vertical stress, maximum tangential boundary stress, in-situ deformation modulus and ratio of horizontal to vertical stress are used to find out elastic and plastic behaviour of rock along the headrace tunnel. The damage index is given by a relation, $D_i = {}_{max}/ {}_{c}$, where max represents maximum tangential boundary stress and c is unconfined compressive strength. If D_i 0.4, rock behaves as elastic and if D_i 0.4 rock behaves as plastic. Damage index for the headrace tunnel is estimated as 0.01–0.37. Since the value of D_i along the headrace tunnel is <0.4, the rock mass behaves as an elastic behaviour. This concludes that there is no possibility of damage in the tunnel due to overburden rock body.

Rock excavation support design

The proposed rock evaluation along the headrace tunnel is a conventional drilling and blasting. Design is mainly based on classification of rock mass quality along the tunnel. Combinations of rock bolts, fibre-reinforced and steel mesh-reinforced shotcrete and cast concrete lining can be used as dictated by rock mass quality encountered under excavation. In present study, the support system based on the RMR system seems more reliable than that based on the Q system. The rock excavation support based on the RMR system is presented on Table 1.

CONCLUSIONS

Most of the study area lies on the Lesser Himalaya with the soft and highly weathered rocks and is challenging for the underground engineering structures. The study area mainly comprises of quartzite, phyllite, slate, chlorite- and garnet-schist, dolomite, dolomitic limestone. The proposed sites for the surface structures such as intake and powerhouse are quite challenging, since they lie on the thick unconsolidated alluvial deposits.

The proposed reservoir is characterised by the wide river channel and river valley with thick alluvial deposits. The dam site is fairly suitable. The unit of headworks lies on flat alluvial terrace and is feasible for the construction. The detailed hydrological analysis is needed in order to finalise the location of the headworks structures. They should be protected from bank erosion with construction of suitable retaining structures. Common rock types along the headrace tunnel are slate, quartzite, phyllite, dolomite, dolomitic limestone and chlorite-schist. Generally, bedding/foliation is oblique to the proposed headrace tunnel axis which is favorable for excavation. Rock along the headrace tunnel belongs to poor to good class. There are no major structural disturbances such as fault and major shear zones along the headrace tunnel. The proposed penstock, power house and the tailrace canal is feasible for construction. The powerhouse site is located on gently sloping alluvium terrace consists of grey, gritty textured, angular to rounded, coarse-grained silty sand.

Average in-situ deformation modulus, unconfined compressive strength, vertical stress, horizontal stress, and horizontal to vertical stress ratio along the headrace tunnel range from 4.78 to 58.46, 29.98MPa to 241.55MPa, 0.87MPa to 16.97MPa, 2.44MPa to 13.12MPa and 0.34 to 5.32, respectively. Damage index along the headrace tunnel is less than 0.4 i.e. rock mass behaves as an elastic. Support design for construction of the headrace tunnel suggests the combination of local to systematic bolting and reinforced shotcrete as per requirements. Some geological problems which may occur during construction of the headrace tunnel are over-break in shear/weak zones, rock squeezing, water leakage (in permeable ground and jointed rock with open joints, and below stream and gullies).

The study area comprises the rocks the Fagfog Quartzite, Dandagaon Phyllites, Nourpul Formation, Dhading Dolomite, Benighat Slates, Malekhu Limestone, Robang Formation, Raduwa Formation, Kalitar Formation and the Chisapani Quartzite. The Main Central Thrust lies at about 330 m upstream from the proposed powerhouse site and about 4km downstream of the proposed headworks. The reservoir lies on wide river channel and river valley. There is no major active debris flow in vicinity of the dam site. The dam site seems fairly suitable. Common rock types along the headrace tunnel are slate, quartzite, phyllite, dolomite, dolomitic limestone and chlorite-schist. Rock along the headrace tunnel belongs to poor to good according to RMR and Q. The powerhouse site is located on gently sloping alluvium terrace consists of grey, gritty textured, angular to rounded, coarse-grained silty sand.

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