Draft Environmental Impact Assessment Report

Rongnichu Hydro-Electric Project (115 MW)
East Sikkim District, Sikkim

Section 1(c)(i) River Valley Project, Category "A"

M/s. Madhya Bharat Power Corporation Ltd.

January, 2020

Submitted by:

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Study Period: Pre-monsoon, Monsoon& Post-monsoon, 2019

UID: EQMS/EIA/RHEP/1(c)A/PR592/012020

DECLARATION OF PROJECT PROPONENT

HYDRO POWER
In partnership with river

MADHYA BHARAT POWER CORPORATION LTD.

Project Office : D.D. Sharma's Building (2nd Floor) Near State Bank of India, Duragaon, Tadong, Pin 737102, Gangtok, East Silkkim • Tel.: 03592-233070

DECLARATION OF PROJECT PROPONENT

This is to confirm that the contents (information and data) given in EIA report belong to our project "Rongnichu Hydro-Electric Project (115 MW)East Sikkim District, Sikkim" only and it has not been copied from any other EIA reports.

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Designation: Director
Madhya Bharat Power Corporation Ltd.

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DISCLOSURE OF CONSULTANT ENGAGED

Declaration by Experts contributing to the EIA: Rongnichu Hydro Electric Project (115 MW), East Sikkim District, Sikkim

I, Yamesh Sharma, hereby certify that I was a part of the EIA team in the following capacity that developed the above EIA.

EIA coordinator	
Name:	S.K.Jain
Signature	
Period of Involvement:	May 2019 till date
Contact Information:	skjain@eqmsindia.org

Functional area experts:

S.No.	F.A.	Name of experts	Involvement (period and task)	Signature and date
1	AP	S K Jain	May 2019 till date Air pollution monitoring. Identification & assessment of quantum of emission and its mitigation measures.	
2	WP	S K Jain	May 2019 till date Water Quality monitoring network designing. Sampling of water samples. Monitoring of water quality. Identification & assessment of quantum of water pollution and its mitigation measures.	
3	SHW	S K Jain	May 2019 till date Identification of hazardous and non-hazardous wastes. Reuse and recycling of solid wastes	
4	SE	Anil Kumar	May 2019 till date Baseline socio economic survey Evaluation of socio-economic development status of the area. impact identification and mitigation measures.	Anil Kumar
5	EB	Ratnesh Kotiyal	May 2019 till date Conducted Ecological survey & preparation of ecology report. Identification & assessment of ecological impact due to proposed project and its mitigation measures.	
6	HG	Yamesh Sharma	May 2019 till date Surface hydrology and Hydro geological inputs in respect of project and impacts due to barrage construction on river and hydrology and ecological flows	
7	GEO	Hardik Patel	May 2019 till date Regional and project geology aspects/inputs	

8	SC	Manoj Sharma	May 2019 till date Site Visit, soil sampling plan, identification of impact and mitigation measures including preparation of FAE report.	MCthar
9	AQ	Sanjeev Sharma	May 2019 to Sept 2019 Meteorological parameter measurement. Air Quality modelling to determine GLC due to project construction and suggest mitigation measures.	
10	NV	Sanjeev Sharma	May 2019 to Sept 2019 Monitoring of noise levels of the project site and surrounding area. Assessment of noise level and vibration potential due to proposed project and its mitigation measures.	
11	LU	Anil Kumar	May 2019 till date Development of land use maps of study area using GIS / related tools, site visit for ground truth survey, finalization of land use maps	Anil Kumar
12	RH	S K Jain	May 2019 till date	
Functional Area Associates				
1	SE	Kaleem Qureshi	May 2019 till date As support for socio-economic report and R&R	Kaleem
Team Member				
1	NV	Shweta Gupta	May 2019 till date As support for NV report	Shweta Gupta
2	AQ	Hitendra Kela	May 2019 till date As support for AQ report	Hitendra

Declaration of association in the EIA

Declaration by the Head of the accredited consultant organization/ authorized person

I, S.K. Jain hereby, confirm that the above-mentioned experts prepared the "EIA/EMP Report of Rongnichu HEP (115 MW) in District East Sikkim, Sikkim". I also confirm that the consultant organization shall be fully accountable for any mis-leading information mentioned in this statement.

Signature:	
Name:	S.K. Jain
Designation:	Director, Technical
Name of the EIA Consultant organization	EQMS India Pvt. Ltd.
NABET Certificate No.	NABET/1619/SA 070
Issue Date:	17th July, 2018

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1 INTRODUCTION AND BACKGROUND

1.1 BACKGROUND

Rongnichu Hydroelectric Project (115 MW) on Rongnichu stream in East Sikkim district of Sikkim, is being developed by M/s. Madhya Bharat Power Corporation Ltd. (MBPCL). The Barrage complex is located about 2km downstream of Namli village and 16km south of Gangtok city along NH-31A. The project envisages construction of a 120m long x 35m wide x 14m high Barrage across Rongni Chu. A surface Desilting Basin is located on the left bank of the river, just upstream of the Barrage axis. The Desilting complex has 2 chambers of which one will be in service and the other will be stand by. The Desilting basin has a collection chamber at its end for collection of desilted water. A Power Intake Structure located near the left end of this chamber feed a 12.581 km long Head Race Tunnel (HRT) leading to a Surge Shaft at its tail end and a Pressure Shaft, which will terminate at the valve house. The water from Penstock shall feed 2 units of 48 MW (Pelton Turbines), installed in a surface Powerhouse proposed on the right bank of Rangpo river 2.5 km from Rangpo town by the side of Rangpo- Rongli State Highway. The proposed scheme will provide a gross head of 423 m and a net head of 405m for power generation and is intended to operate as a run-of-river scheme providing a daily maximum of 6 hours of firm peak energy during the non-monsoon season and during the monsoon season the generating units will operate continuously for several weeks. The present project having an installed capacity of 96 MW will generate approximately 384 GWh of electricity (gross) per annum in a 90 % dependable year with 95 % machine availability. Techno-Economic Clearance of 96MW Rongnichu HEP DPR was granted by Government of Sikkim vide letter dated 01.10.2008 to expedite the implementation of the project.

The EC was accorded on 4.4.2007 to Rongnichu HEP (96MW) for a period of 10 years as per the provisions of EIA Notification, 2006. After obtaining the EC in April 2007, there has been an initial delay of more than 3 years to start the actual construction. The geological difficulties of lower Himalayan region resulted in slower pace of excavation of underground works. Viewing the delays being encountered, M/s. Madhya Bharat Power Corporation Ltd., had applied for extension of validity of EC for 3 years. The Ministry vide letter dated 16.6.2017 granted extension of validity of EC initially for six months and vide letter No J-12011/56/2006-IA-I dated 9.11.2017 accorded extension of validity for two and half year i.e. up to 3.4.2020.

For completion of E&M works of Powerhouse two separate contracts have been awarded for (a) Turbines & Turbine Auxiliaries and (b) Generator & Generator Auxiliaries with due consideration of delivery period and design of the equipment matching the already constructed civil foundation with higher continuous overload capacity of 30%.

Now/s. Madhya Bharat Power Corporation Ltd. intends to enhance the installed capacity of power house from 96 MW to 115MW owing to higher inflows available during 5 10-daily blocks in monsoon period and in the light of enabling provision of running machines at 20% overload as stipulated in power potential studies carried earlier

1.2 CHANGES IMPLEMENTED

In the implementation stage of the project, following changes in certain components became inevitable considering the technical, environmental and socio-political ground realities.

•In lieu of horse shaped concrete lined HRT with a finished diameter of 4.0 m was changed from horse shoe to D-shaped, keeping the diameter 4.5 m.

•An additional Adit (Adit-2B)has been introducedbetween Adit -2 and Adit-3 at RD 7572.00m of the HRT culminating into increase in length from 1304.76m to 1866 m.

•The surface penstock followed by 80m deep Vertical Shaft and 138m long Horizontal Shaft was changed to a 318m deep Vertical Pressure Shaft followed by 924m long "Horizontal Pressure Shaft". This change was necessitated by geological conditions.

•Change in HRT alignment following an incident of cavity formation in Face – 5. The total length of HRT up to Surge Shaft is now 12.581 K.M. as against the 12.302 K.M in DPR.

All the above changes have already been informed to the EAC and the EAC observed in its meeting dated 3rd March 2017 that the minor deviations encountered while taking-up the project may not be treated as violation

1.3 REASONS FOR CAPACITY ENHANCEMENT

The original DPR was approved by Government of Sikkim as the cost of project was less than Rs 500 crores. The provision under section 7 pertaining to power potential studies, sub section 7.10 Is reproduced hereunder:

"There are 9 (nine) 10-daily blocks in monsoon period in which river flows are higher and power more than 96 MW can be generated during these 10-daily blocks. In order to utilize their high inflows during monsoon period it is proposed to provide 10% and 20% overload capacity in each of the two units resulting in 2x (48+10%) =105.6 say 106 MW and 2x (48+20%) = 115.2MW."

It is evident that at DPR stage itself 115.2 MW maximum continuous capacity of generation was found technically feasible with regards to the inflows available. However, at that stage, considering capital cost considerations station capacity of 96 MW (2x48 MW) was found more viable.

The hydrological data (inflows/river discharge) as provided in the approved DPR was reassessed with respect to the prevailing e-flow norms i.e. a discharge of 15% of the average of concerned period/season as Environmental Discharge and following was observed:

Table 1-1: Ten Daily Blocks Where Higher Inflows Are Available

Dependability	Dependable Year	No of 10-daily blocks where inflow is available for higher power generation @115.2 MW
50%	1979-80	5
75%	2006-07	7
90%	1996-97	3

Thus, it is imperative that the project capacity is amended to 115 MW (already found feasible in the original DPR) to derive advantage of obtaining higher generation which will benefit both the developer and Govt. of Sikkim (beneficiary of Higher royalty i.e. free power @12% of the deliverable energy). Considering the present circumstances, equipment capable of generation 124 MW on a continuous basis has been already installed.

1.4 DEMAND-SUPPLY GAP

The annual power supply position in terms of energy requirement (1,36,522 MU) vis-à-vis energy availability (1,35,490 MU) of various States/ Systems during the year 2017-18 as assessed by CEA reveals that there was a deficit of 0.8% energy in eastern region which inter alia includes State of Sikkim. The annual energy requirement of Sikkim has been assessed as 486 MU vis-à-vis energy availability (485MU), which reveals that there was a deficit of 0.2% energy. Actual power supply position in terms of Peak Demand vis-à-vis peak met of various in the state of Sikkim neither there is surplus nor deficit.

1.5 PURPOSE OF REPORT

The purpose of environmental impact assessment of the proposed Hydro-electric project is to identify and evaluate the nature, magnitude and significance of the potential adverse environmental impacts arising during construction and operation of the project and formulation of site specific Environmental Management Plan (EMP) shall for avoiding, mitigating, checking the adverse impacts envisaged during EIA studies on various environmental components during construction and operational phase of the project.

1.6 IDENTIFICATION OF PROJECT AND PROJECT PROPONENT

1.6.1 Project Proponent

M/s Madhya Bharat Power Corporation Limited, E-585, Greater Kailash-II, Ground Floor, New Delhi-110048is the project Proponent.

1.6.2 EIA Consultant

The task of preparation of EIA/EMP report of the project has been awarded to M/s EQMS India Pvt. Ltd., 304-305, 3rd floor, Rishabh Corporate Tower, Community Center, Karkardooma, Delhi-110092. The organization is accredited with NABET/ Quality Control of India to conduct the Environment Impact Assessment Studies for river valley projects among others (NABET/EIA//1619/SA **(Annexure-I).**

1.7 BRIEF DESCRIPTION OF NATURE, SIZE, LOCATION AND IMPORTANCE

1.7.1 Brief Description of Nature of Project

Rongnichu Hydroelectric Project (96 MW) on Rongnichu stream in East Sikkim district of Sikkim, being developed by M/s. Madhya Bharat Power Corporation Ltd. (MBPCL), is a run-of-river hydro development project.

1.7.2 Sector Classification

As regards the hydroelectric power generation, the project activities are covered under river valley project S.N.I(c)(i)

1.7.3 Size of Project

As regards the hydroelectric power generation, the project activities are covered under river valley project S.N.I(c)(i) and projects with threshold limit >25 MW and < 50 MW hydroelectric power generation fall under category "B" and all projects with threshold limit >50 MW hydroelectric power generation are categorized as 'A". In so far as hydroelectric power generation from the project shall 115 MW it falls under project category "A".

In terms of IS 11223-1985 the barrage comes under the category of 'Medium' because its height is more than 12 m. The reservoir has gross capacity of 0.33 MCM.

1.7.4 Location

The barrage location is about 2 Km downstream of Namli village and 16 Km south of Gangtok along NH-31A. The powerhouse is proposed on the right bank of Rangpo River 2.5 km from Rangpo Town on Rangpo-Rongli State Highway.

1.7.5 Importance of Project to the Country/Region

The State of Sikkim has vast hydroelectric power potential in its major rivers. The rivers and their tributaries with steep gradient continue to challenge planners and engineers for optimal exploitation of hydropower potential. The rapid generation of hydroelectric power as per its potential will improve the economic health of the state because 12% free power will increase the resources of the state to a significant extent. The need for RongnichuHEP, installed capacity 115 MW, has therefore been considered in context of power shortage in the Eastern region in general and in the country as whole.

1.8 SITE DESCRIPTION

1.8.1 History

It is a green field project and shall be developed as intervention on Rongnichu river for harnessing unutilized hydro power potential of the river.

1.8.2 Topography

The topography is characterized by high ridges, steep to moderately steep slopes broken by occasionally detached scar faces with falls of 20 to 100 m. The area is drained by the tributaries of Rongni Chhu and Rangpo Chhu, the main drainage system.

1.8.3 Geological Setup and Seismicity

Geologically, the project area is located in the Gorubathan Formation of the Daling Group of rocks, which is a monotonous thick assemblage of green slate, bedded and intrusive epidiorites and chlorite feldspathic greywacke at the base of Daling Group. Lingtse granite gneiss is also reported within this group as well as at the contact of this group of rocks with the Central Crystallines exposed north of Gangtok.As per seismic zoning map of India (IS 1893:2002), the project falls within ZoneIV.

1.8.4 Archaeological / Religious / Historical Monuments

No archaeological monument of national importance either lies in the project area or in its submergence area. There is also no structure of national heritage in the area.

1.8.5 Sensitive Area

The description of sensitive ecological Features and receptors is given in **Table 1.2.**The map showingauthenticated distance of project boundary from Fambonglho WLS is shown in **Figure 1.1.**

Table 1-2Environmental Sensitivity

S.N.	Sensitive Ecological Features	Name	Aerial Distance (in km.) from project boundary
1.	National Park/Wildlife Sanctuary	Fambonglho WLS	3.79
2.	Tiger Reserve/Elephant Reserve/ Turtle Nesting Ground	None	0.00
3.	Core Zone of Biosphere Reserve	None	-
4.	Stream/Rivers	Rongnichu	0.00
5.	Estuary/Sea	None	-
6.	Mangroves	None	-
7.	Mountains/Hills		-
8.	Notified Archaeological sites	None	-
9.	Industries/Thermal Power Plants	None	-
10.	Defense Installation	Army station at Bardang	2 km
11.	Airports	Pakyong	45
12.	Railway Lines	New Jalpaiguri	136
13.	National Highway	NH-31A	1 KM

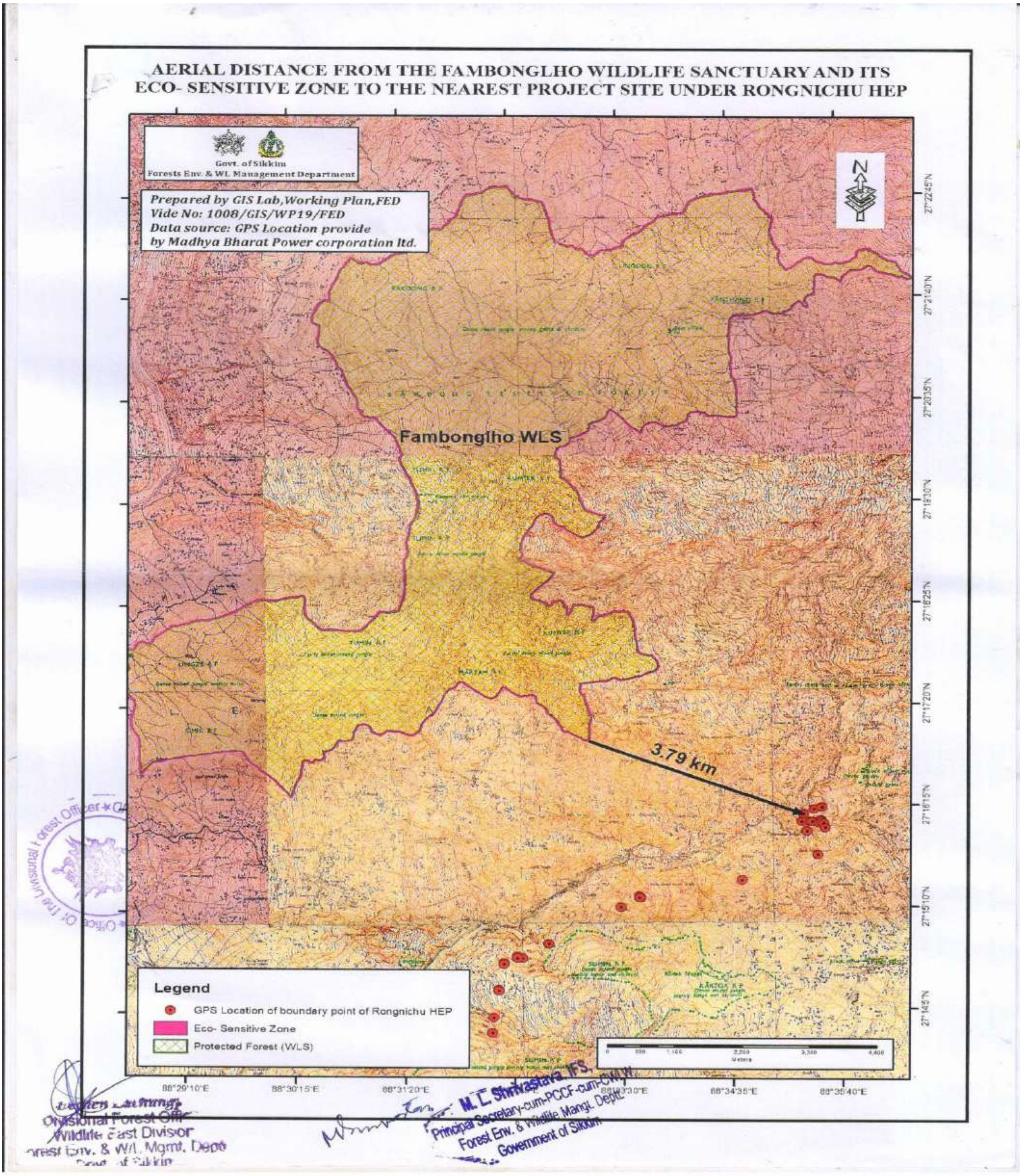


Figure 1.1: Authenticated Distance of Project Boundary from Fambonglho WLS

1.9 POLICY, LEGAL, AND STATUTORY REQUIREMENTS

The emerging environmental scenario calls for requisite attention on conservation and proper use of natural resources and development without destruction. The environmental consideration in any development process has become a necessity for achieving sustainable development. To achieve these goals, the Ministry of Environment & Forests, Govt. of India, has enacted various acts, legislations, guidelines and standards from time to time. The principal environmental regulatory agency in India is the Ministry of Environment & Forests, New Delhi. Ministry of Environment and Forests formulates environmental policies and accords environmental clearances for different projects. The important environmental legislations in India are given in **Table 1.3.**

Table 1.3: Key Environmental Legislations

Name	Scope and Objective	Key Areas	Operational Agencies/Key player
Water (Prevention and Control of Pollution) Act, 1974, 1988	To provide for the prevention and control of water pollution and enhancing the quality of water	Control sewage and industrial effluent discharges	Central and State Pollution Control Boards
Air (Prevention and Control of Pollution) Act, 1981, 1987	To provide for the prevention and control of air pollution	Controls emission of air pollutants	Central and State Pollution Control Board
Forest(Conservation) Act, 1980, 1988	To consolidate acquisition of common property such as forest, halt India's rapid deforestation and resulting environmental degradation	Regulates access to natural resources, state has a monopoly right over land, categories forests, restriction on de-reservation and using forest for non-forest purpose	State Government andCentral Government
Wildlife(Protection) Act, 1972, 1993	To protect wildlife	Creates protected areas (national parks / sanctuaries) categories of wildlife which are protected	Wildlife Advisory Boards, Central Zoo Authorities
Environment (Protection) Act, 1986	To provide for the protection and improvement of environment	An umbrella legislation, supplements pollution laws	Central government nodal agency, MoEF can delegate to state departments of environment
EIA Notification 14th Sep 2006 and amendment thereof	Environmental Impact Assessment	Environmental Protection	Project Development, State and Central Government

Name	Scope and Objective	Key Areas	Operational Agencies/Key player
National Water Policy, 2012	Legislation needed in view of iniquitous distribution and lack of unified perspective in planning, management and use of water resources with due considerationto environmental sustainability and holistic benefit to the people.	To recognize and consider while planning the environmental needs of aquatic eco-system, wetlands and embanked flood plains besides adaptation to strategies to provide a mechanism for dealing with increased variability due to climate change.	State and Central Government
Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement Act, 2013	To address concerns of farmers and those whose livelihoods is dependent on land being acquired and at the same time facilitating land acquisition in a timely and transparent manner and for ensuring comprehensive package for the land owners for calculation of market value of the land besides comprehensive rehabilitation and resettlement package for land owners.	Social issues	Central and State Government
Hazardous and Other Wastes (Management and Transboundary Movement) Rules, 2016	Effective collection, storage, transportation and utilization of Hazardious waste generated during construction and operation.	Used/spent oil	State Government

1.10 STATUTORY REQUIREMENT OF EC FOR THE PROJECT

As per EIA notification 2006, the project comes under category A of Project or activity 1(c) River Valley projects (Hydroelectric power generation ≥ 50 MW) and as such require a Prior Environment Clearance.

The validity of original EC accorded for project (96 MW) on 4.4.2007 for a period of 10 years has ended on 3.4.2017 and further extension of validity of EC has been granted for a total period of three years i.e. up to 3.4.2020. The balance work under project is not likely to be completed by

3.4.2020. Within present frame work of EIA Notifications validity of EC beyond 3.4.2020 is not available to the project developer.

Apart from this M/s. Madhya Bharat Power Corporation Ltd. intends to enhance the installed capacity of power house from 96 MW to 115MW owing to higher inflows available during 5 10-daily blocks in monsoon period and in the light of enabling provision of running machines at 20% overload as stipulated in power potential studies carried earlier. Even if the amendment to the capacity enhancement of earlier EC granted for 96 MW to 115 MW is accorded, the main issue of working beyond the extended EC period shall remain un-resolved. In the wake of this application for seeking prior EC for Rongnichu Hydroelectric Project (115 MW) is furnished de novo such that the balance works may legitimately carried beyond 3.4.2020 and no violation of notification is made.

1.11 SCOPING OF THE PROJECT FOR CAPACITY ENHANCEMENT

The project for enhancement capacity from 96 MW to 115 MW attracts the condition of obtaining prior environmental clearance from MoEF&CC. In consonance with the provision under section-6 of the MoEF&CC notification, dated 14thSeptember 2006, Form-1 including Terms of Reference (TOR) for the EIA study along with Preliminary Feasibility Report (PFR) in prescribed format was submitted to MoEF&CC for obtaining approval from Expert Appraisal Committee under the category of River Valley projects. The ToR for capacity enhancement from 96 MW to 115MW was issued vide letter no. J-12011/14/2017-IA-I dated 16.01.2020 **(Annexure-II)**.

1.12 COMPLIANCE OF TOR

The EIA/EMP report has been prepared in conformity with all issues brought out in detailed TOR and additional ToR issued by MoEF&CC vide letter no. J-12011/14/2017-IA-I dated 16.01.2020. The brief issues involved and their reference of compliance have been provided in **Table 1.4.**

Table 1.4: Clearance Requirements for the Project

Point No.		Reference of compliance
A	**Physical and Chemical Environment**	
1	**Geological and Geophysical Aspects and Seismo-Tectonics:**	
	• Physical Geography, Topography, Regional Geological aspects and structure of the catchment.	Section 3.4.1, 3.4.2, 3.4.3,3.4.4 and 3.4.6
	• Tectonics, Seismicity and History of past earthquakes in the area. A site-specific study of earthquake parameters will be done. The results of the site-specific earthquake design shall be sent for approval of the NCSDP (National Committee of Seismic design parameters, Central Water Commission, New Delhi for large dams.	Section 3.4.5
	• Landslide zone or area prone to landslide existing in the study area should be examined.	Section 3.4.11
	• Presence of important economic mineral deposit, if any.	Section 3.4.10
	• Justification for location & execution of the project in relation to structural components (dam height).	Section 5.5.2
	•Impact of project on geological environment.	Section 4.2.3

Point No.		Reference of compliance
2	**Meteorology, Air and Noise**	
	• Meteorology (viz., Temperature, Relative Humidity, wind speed/direction etc.) to be collected from nearest IMD station. • Ambient Air Quality with parameters viz., Suspended Particulate Matter (SPM), Respirable Suspended Particulate Matter (RSPM) i.e., suspended particulate materials <10-microns, Sulphur Dioxide (SO_2), Oxides of Nitrogen (NOx), in the study area at 6 locations. • Existing noise levels and traffic density in the study area at 6 locations.	Section 3.6.1 through section 3.6.5 Section 3.6.6 Section 3.6.7 and 3.6.
3	**Soil Characteristics**	
	• Soil classification, physical parameters (viz., texture, porosity, bulk density and water holding capacity) and chemical parameters (viz. pH, electrical conductivity, Magnesium, calcium, total alkalinity, chlorides, sodium, potassium, organic carbon, available potassium, available phosphorus, SAR, nitrogen and salinity, etc.,) (at 6 locations).	Section 3.5
4	**Remote sensing and GIS Studies**	
	• Generation of thematic maps viz., slope map, drainage map, soil map, land use and land cover map, etc. Based on these, thematic maps, an erosion intensity map should be prepared. New Configuration map to be given in EIA report	Figure 10.4 through 10.7
5	**Water Quality**	
	• History of the ground water table fluctuation in the study area. • Water quality for both surface water and ground water for (i)Physical parameters'(pH, temperature, electrical conductivity, TSS); (ii)Chemical parameters (Alkalinity, Hardness, BOD, COD, NO2, PO4, Cl, SO4, Na, K, Ca Mg, Silica, Oil & Grease, phenolic compounds, residual sodium carbonate); (iii) Bacteriological parameters (MPN, Total coliforms) and (iv) Heavy Metals (Pb, As, Hg, cd, cr-6, total Cr, Cu, Zn, Fe) at minimum 6 locations. • Delineation of sub and micro-watersheds, their locations and extent based on the All India Soil and Land Use Survey of India (AISLUS), Department of Agriculture, Government of India. Erosion levels in each micro-watershed and prioritization of micro-watershed through silt yield index (SYI) method of AISLUS.	Section 3.8.7 Section 3.7.1 through section 3.7.4 Section 10.1.3 and 10.110
B	**Water Environment & Hydrology**	
	•Hydro-Meteorology of the project viz. precipitation (snowfall, rainfall), temperature, relative humidity, etc. Hydro-meteorological studies in the catchment area should be established along-with real time telemetry and data acquisition system for inflows monitoring. •Run-off, discharge, water availability for the project,	Section 3.8.3 Section 3.8.4

Point No.		Reference of compliance
	sedimentation rate, etc. •Basin characteristic's •Catastrophic events like cloud bursts and flash floods, if any, should be documented. •For estimation of Sedimentation Rate, direct sampling of river flow is to be done during the EIA study. The study should be conducted for minimum one year. Actual silt flow rate to be expressed in ha-m km^2 year-I. •Set-up a G&D monitoring station and a few rain gauges stations in the catchment area for collecting data during the investigation. •Flow series, 10 dailies with 90%, 75% and 50% dependable years discharges. • Environmental flow release should be 20% of the average of 4 lean months of 90% dependable year during the lean season and, 30% of monsoon flow during monsoon season. For remaining months, the flow shall be decided by the committee based on the hydrology and available discharge. A site-specific study on minimum environmental flow should be carried out.	 Section 3.8.1 Section 3.8.8 Section 3.8.5 Section 3.8.3 Section 3.8.4 Section 3.8.11
C	**Biological Environment**	
	Flora: • Characterization of forest types (as per Champion and Seth method) in the study area and extent of each forest type as per the Forest Working Plan. • Documentation of all plant species i.e. Angiosperm, Gymnosperm, Pteridophytes, Bryophytes (all groups). • General vegetation profile and floral diversity covering all groups of flora including lichens and orchids. A species wise list may be provided. • Assessment of plant species with respect to dominance, density, frequency, abundance, diversity index, similarity index, importance value index (IVD, Shannon Weiner index etc. of the species to be provided. Methodology used for calculating various diversity indices along with details of locations of quadrates, size of quadrates etc. to be reported within the study area in different ecosystems. • Existence of National park, Sanctuary, Biosphere Reserve etc. in the study area, if, any, should be detailed. • Economically important species like medicinal plants, timber, fuel wood etc. • Details of endemic species found in the project area. • Flora under RET categories should be documented using International Union for the Conservation of Nature and Natural Resources (IUCN) criteria and Botanical Survey of India's Red Data list along-with economic significance. Species diversity curve for RET species should be given.	Section 3.9.2 through 3.9.4

Point No.		Reference of compliance
	Fauna: Fauna study and inventorisation should be carried out for all groups of animals in the study area. Their present status along with Schedule of the species. • Documentation of fauna plankton (Phyto and zooplankton), periphyton, benthos and fish should be done and analyzed. • Information (authenticated) on Avi-fauna and wildlife in the study area. • Status of avifauna their resident/ migratory/ passage migrants etc. Documentation of butterflies, if any, found in the area. • Details of endemic species found in the project area. • RET species-voucher specimens should be collected along-with GPS readings to facilitate rehabilitation. RET faunal species to be classified as per IUCN Red Data list and as per different schedule of Indian Wildlife (Protection) Act, 1972. • Existence of barriers and corridors, if any, for wild animals. • Compensatory afforestation to compensate the green belt area that will be removed, if any, as part of the proposed project development and loss of biodiversity. • Collection of primary data on agricultural activity, crop and their productivity and irrigation facilities components. • For categorization of sub-catchment into various erosion classes and for the consequent CAT plan, the entire catchment (Indian Portion) is to be considered and not only the directly the draining catchment.	Section 3.9.
D	**Aquatic Ecology**	
	• Documentation of aquatic fauna like macro-invertebrates, zooplankton, Phyto-planktons, benthos etc. • Fish and fisheries, their migration and breeding grounds. • Fish diversity composition and maximum length & weight of the measured populations to be studied for estimation of environmental flow. • Conservation status of aquatic fauna. • Sampling for aquatic ecology and fisheries and fisheries must be conducted during three Seasons-Pre-monsoon (summer), monsoon and winter. Sizes (length & weight) of important fish species need to be collected and breeding and feeding grounds should also be identified along the project site or in vicinity.	Section 3.9.6
E	**Socio-economic**	
	• Collection of baseline data on human settlements, health status of the community and existing	Section 3.10

Point No.		Reference of compliance
	infrastructure facilities for social welfare including sources of livelihood, job opportunities and safety and security of workers and surroundings population. • Collection of information with respect to social awareness about the developmental activity in the area and social welfare measures existing and proposed by project Proponent. • Collection of information on sensitive habitat of historical, cultural and religious and ecological importance. • The socio-economic survey/ profile within 10 km of the study area for demographic profile; Economic Structure; Developmental Profile; Agricultural Practices; Infrastructure, education facilities; health and sanitation facilities; available communication network etc. • Documentation of demographic, Ethnographic, Economic Structure and development profile of the area. • Information on Agricultural Practices, Cultural and aesthetic sites, Infrastructure facilities etc. • Information on the dependence of the local people on minor forest produce and their cattle grazing rights in the forest land. • List of all the Project Affected Families with their names, education, land holdings, other properties, occupation, source of income, land and other properties to be acquired, etc. •In addition to socio-economic aspects of the study area, a separate chapter on socio-culture aspects based upon study on Anthography of the area should be provided.	
7	**Impact Prediction and Mitigation Measures** The adverse impact due to the proposed project should be assessed and effective mitigation steps to abate these impacts should be described.	
	Air Environment	
	• Changes in ambient and ground level concentrations due to total emissions from point, line and area sources. • Effect on soil, material, vegetation and human health. • Impact of emissions from DG set used for power during the construction, if any, on air environment. • Pollution due to fuel combustion in equipment and vehicles • Fugitive emissions from various sources • Impact on micro- climate	Section 4.5.1 and 4.5.2 Section 4.5.3 Section 4.5.4 Section 4.5.4 Section 4.5.6 Section 4.5.7
	Water Environment	
	• Changes in surface and ground water quality. • Steps to develop pisci-culture and recreational facilities • Changes in hydraulic regime and downstream flow. • Water pollution due to disposal of sewage • water pollution from labor colonies/ camps and washing equipment.	• Section 4.4.1 • Section 4.4.9 • Section 4.4.10 • Section 4.4.11

Point No.		Reference of compliance
		• Section 4.4.12
	Land Environment	
	• Adverse impact on land stability, catchment of soil erosion, reservoir sedimentation and spring flow (if any) (a) due to considerable road construction/widening activity (b) interference of reservoir with the inflowing stream (c) blasting for commissioning of HRT, TRT and some other structures. • Changes in land use / land cover and drainage pattern • Immigration of labour population • Quarrying operation and muck disposal • Changes in land quality including effects of waste disposal. • River bank and their stability • Impact due to submergence.	Section 4.3.7 Section 4.3.1 Section 4.3.2 Section 4.3.3 Section 4.3.4 Section 4.3.5 Section 4.3.6
	Biological Environment:	
	• Impact on forests, flora, fauna including wildlife, migratory avi-fauna rare and endangered species, medicinal plants etc. • Pressure on existing natural resources. •Deforestation and disturbance to wildlife, habitat fragmentation and wild animal's migratory corridors. •Compensatory afforestation-identification of suitable native tree species for compensatory afforestation and green belt. •Impact on fish migration and habitat degradation due to decreased flow of water. •Impact on breeding and nesting grounds of animals and fish.	Section 4.8.1, 4.8.2 and 4.8.3
	Socio-economic Aspects:	
	• Impact on local community including demographic profile. •Impact on socio-economic status. •Impact on economic status. • Impact on human health due to water / water borne disease • Impact on increase traffic. •Impact on Holy Places and Tourism. •Impacts of blasting activity during project construction which generally destabilize the land mass and leads to landslides, damage to properties and drying-up of natural springs and cause noise pollution will be studied. Proper record shall be maintained of the baseline information in the post project period. •Positive and negative impacts likely to be accrued due to the project are listed.	Section 4.9.1 Section 4.9.2 Section 4.9.2 Section 4.9.3 Section 4.9.4 Section 4.9.5 Section 4.7.6 Section 4.7.8
8	**Environmental Management Plans**	

Point No.		Reference of compliance
i)	Catchment Area Treatment (CAT) Plan should be prepared micro-watershed wise. Identification of free draining/ directly draining catchment based upon Remote Sensing and Geographical Information System (GIS) methodology and Sediment Yield Index (SYI) Method of AISLUS, Dept. of Agriculture, Govt. of India coupled with ground survey. Areas or watersheds falling under 'very severe' and 'severe' erosion categories should be provided and required to be treated. Both biological as well as engineering measures should be proposed in consultation with State Forest Department for areas requiring treatment. Year-wise schedule of work and monetary allocation should be provided. Mitigation measures to check shifting cultivation in the catchment area with provision for alternative and better agricultural practices should be included.	Section 10.1
ii)	Compensatory Afforestation in lieu of the forest land required for the project needs to be proposed. Choice of plants should be made in consultation with State Forest Department including native and RET species, if any.	Section 10.2
iii)	Biodiversity and Wildlife Conservation & Management Plan for conservation and preservation of endemic, rare and endangered species of flora and fauna to be prepared in consultation with State Forest Department	Section 10.3
iv)	Fisheries Conservation & Management Plan-Fish fauna inhabiting the affected stretch of river, a specific fisheries management plan should be prepared for river and reservoir.	Section 10.4
v)	Resettlement and Rehabilitation (R&R) Plan need to be prepared with due consultation with Project Affected Families (PAFs). The provision of the d R&R plan should be according to the National Resettlement and Rehabilitation Policy (NRRP-2007) as well as State Resettlement and Rehabilitation Policy. Detailed budgetary estimates are to be provided. Resettlements sites should be identified.	Section 10.5
vi)	Plan for Green Belt Development along the periphery of reservoir, colonies, approach road, canals etc. to be prepared in consultation with the State Forest Department. Local plant species suitable for greenbelt development should be selected	Section 10.6
vii)	Reservoir Rim Treatment Plan for stabilization of land slide/land slip zones if any, around the reservoir periphery to be prepared. Suitable engineering and biological measures for treatment of the identified slip zones to be provided with physical and financial schedule.	Section 10.7
viii)	Muck Disposal Plan- suitable sites for dumping of excavated material should be identified in consultation with the State Pollution Control Board and Forest Department. All Muck disposal sites should be minimum	Section 10.8

Point No.		Reference of compliance
	30 m away from the HFL of river. Plan for rehabilitation of muck disposal sites should also be given. The L-section/ cross section of muck disposal sites and approach roads to be given. Financial out lay for this may be given separately	
ix)	Plan for Restoration of quarry sites and landscaping of colony areas, working areas, roads, etc.	Section 10.9 &10.10
x)	Study of Design Earthquake Parameters: A site specific study of earthquake parameters should be done. Results of the site-specific earthquake design parameters should be approved by National Committee of Seismic Design Parameters, Central Water Commission (NCSDP) New Delhi.	Section 10.11
xi)	Dam Break Analysis and Disaster Management Plan: The outputs of Dam Break Model should be illustrated with appropriate graphs and maps clearly bringing out the impact of Dam break scenario. Provision for early warning systems should be provided	Section 10.12
xii)	Water, Air and Noise Management Plans to be implemented during construction and post construction periods.	Section 10.13
xiii)	Public Health Delivery Plan including the provisions of drinking water supply for local community	Section 10.14
xiv)	Labour Management Plan for their Health and Safety.	Section 10.15
xv)	Sanitation and Solid-waste management plan for domestic waste from colonies and labour camps etc.	Section 10.16
xvi)	Local Area Development Plan to be formulated in consultation with the Revenue Officials and Village Panchayats. Local skill development schemes should be given. Details of various activities to be undertaken along with its financial out lay should be provided.	Section 10.17
xvii)	Environmental Safeguards during construction activities including Road Construction.	Section 10.18
xviii)	Energy Conservation Measures	Section 10.19
xix	Environmental Monitoring Programme with physical & financial details covering all the aspects of EMP. A summary of cost estimate for all the plans, cost for implementing all Environmental Management Plans including the cost for implementing environmental monitoring programme should be given. Provision for an Environmental Management Cell should be made	Section 6.1 through Section 6.10
xx)	**A Summary of Cost Estimates for all the plans,** cost for implementing all the Environmental Management Plans.	Section 10.20
9	**Additional ToR**	
(i)	EIA/EMP report should contain the information in accordance with provisions& stipulation as given in Annexure-I	Information is as per Annexure-I attached with Tor
(ii)	The consultant engaged for preparation of EIA/EMP report has to be registered with QCI/NABET	QCI/NABET accreditation certificate is enclosed with

Point No.		Reference of compliance
		the report.
(iii)	Consultant shall include a certificate in EIA/EMP report regarding portion of EIA/EMP prepared by them and data provided by other organization(s)/laboratories including status of approval of such laboratories.Declaration by the consultant that information submitted in the EIA/EMP is factually correct and shall be submitted with report.	Declaration submitted
(iv)	An undertaking from the project proponent shall be submitted as part of EIA report,owning the contents of the EIA report	Certificate submitted
(v)	The draft EIA/EMP report be prepared as per Generic structure(Appendix III of EIA Notification,2006,by incorporating information as per Annexure-I. Fresh EIA/EMPreport shall be uploaded in the public domain for one month at the State Pollution Control Board website,requesting the local affected persons and others who have plausible stake in the environment impacts to send their comments.P.P shall address all comments /issues raised in the EIA/EMP report along with the issues raised in rthe earlier public hearing with detailed present status.	Section 1.13. Report is being uploaded for public domain at the SPCB website.
(vi)	Compliance to the comments received during one month time should be incorporated in report.Final EIA/EMP report should be submitted to the Ministry for EConly after incorporating these issues, before the expiry of validity of ToR.	After incorporating comments from stakeholders Final EIA/EMP shall be submitted.
(vii)	Consolidated EIA/EMP report is to be submitted as per generic structure (Appendix III) given in the EIA Notification,2006.	Section 1.13
(viii)	The ToR will remain valid for a period of 4 years from the date of issue of the letter for submission of EIA/EMP report along with public consultation.The ToR will stand lapsed after completion of 4 years in case final EIA/EMP is not submitted and the validity is not extended.	The report shall be submitted within the validity period.
(ix)	In case the validity is to be extended, necessary application is to be submitted to the Regulatory Authority before expiry of validity priod along with an updated Form-I base on proper justification.	No extension of validity of ToR is required.
(x)	Baselind data shall not be older than 3 years, at trhe time of submission of the proposal, for grant of EC.	Baselind data is for 2019 and is not older than 3 years
(xi)	In case of any change in the scope of the project such as capacity enhancement,change in submergence ,etc., fresh scoping clearance has to be obtained.	No change in the scope of the project is anticipated
(xii)	A copy of TECof the revised DPR for 115 MW should be submitted with the EIA/EMP report.	Shall be submitted.
(xii)	Fund allocation for CER with time line shall be made as per Ministry O.M. No.22-65/2017-IA.III dated Ist May ,2018 for various activities therein,The details of funds allocation and activities for CER shall be incorporated in	Section 10.17

Point No.		Reference of compliance
	EIA/EMP report.	
(xiv)	The EIA/EMP report should clearly mention activity wise EMP and CER cost details and should earmark clear break-up of the capital and recurring cost along with time line for incurring the cpital cost.	Section 10.17
(xv)	Details of the name and number of posts to be engaged by the project proponent for implementation and monitoring of environmental parameters be specified in the report.	The Project Proponent has environmental unit for this purpose.
(xvi)	The EIA/EMP report must contain an index showing details of compliance of all ToR conditions.The index will comprise of page number etc.,vide which compliance of a specific ToR is available. It may be noted that without this index ,report will not be accepted.	Compliance of all Tor conditions made (Section 1.12, Table 1.4)
(xvii)	The PP should complete all the task as per the provisions of EIA Notification,2006 and as amended time to time and submit the application for final clearance within stipulated time.	Shall be complied with
(xviii)	Appropriate Biodiversity Conservation and Management Plan for the Native,Rare and Endangered Floral and faunal species getting affected due to the project shall be prepared.	Section 10.3
(xix)	Land acquired for the project shall be suitably compensated in accordance with the law of the land with the prevailing guidelines.Private land shall be acquired as per provisions of Right to Fair Compensation and Transpareency in Land Acquisition, Rehabilitation and Resettlement Act,2003,if any.	The acquisition of the land was carried out in conson ance with principles enshrined in NRRP,2007.
(xx)	Forest clearance shall be obtained as per the prevailing norms of Forest(Conservation) Act,1980,if any	Forest clearance has been obtained() Section 10.2.3)
(xxi)	In case forest land is further required,application to obtain prior approval of Central Government under Forest(Conservation) Act,1980 for diversion of forest land required shall be submitted as soon as the actual extent of forest land required for the project is known,and in any case,within six months of issuance of this letter.	No futher forest land is required.
(xxii)	As the Fambonglho WLS is 3.87km away from the project boundary, NBWL clearance shall be obtained,if any project component is falling inside the notified ESZ.	NBWL clearance not warrented as no part of project falls inside the notified ESZ.
(xxiii)	A detailed map regarding distance of the project boundary from the nearest wildlife sanctuary,duly authenticated by the Chief Wildlife Warden shall be submitted with the EIA/EMP report.	Submitted as Figure 1.1
(xxiv)	Impact of proposed project on the nearest WLS shall be studied and proper conservation plan/mitigation measures shall be included in the EIA/EMP report.	Section 10.3
(xxv)	Conservation plan for Schediled -I speciesin the project area ,if any, shall be prepared and submitted to the Competent Authority for approval.	Conservation plan for Schedilled -I species has been submitted to the

Point No.		Reference of compliance
		Competent Authority for approval.

1.13 STRUCTURE OF REPORT

Generic structure of environmental impact assessment Document as mentioned in Appendix-III has been followed and report has been compiled in one volume containing chapters as enumerated in **Table 1.5.**

Table 1.5:Structure of Report

Chapter No.	Caption	Chapter Description
1	Introduction	Describes background, identification of project & project proponent, brief description of proposed HEP, policy, legal, statutory and administrative framework, project justification needs for the EIA study, TOR for EIA Studies and structure of EIA & EMP reports.
2	Project Description	This chapter elaborates project type, need, location, size or magnitude of operation, technology and process description including drawings showing project layout, components of project, etc.
3	Description of the Baseline Environment	The chapter defines study area, study period, concept and methodology adopted for baseline data collection, Establishment of baseline for valued environmental components covering physico-chemical and biological and socio-economic components and base maps of all environmental components in the project study area.
4	Anticipated Environmental Impacts & Mitigation Measures	Assessment of anticipated environmental impacts due to project design, construction and operation phases and suggesting measures for mitigating those impacts are the main crux of this chapter.
5	Analysis of Alternatives	The chapter describes alternatives considered for different project components, and selection of most suitable alternative.
6	Environmental Monitoring Programme	Technical aspects of monitoring the effectiveness of mitigation measures including measurement methodologies, frequency, location and budget.
7	Additional Studies	The chapter details extract of Public/ Community Consultation conducted in the project impacted villages and consultation with government stakeholders, risk assessment and SIA

Chapter No.	Caption	Chapter Description
8	Project Benefits	Describes improvements in physical infrastructure including power benefits, improvements in social infrastructure, benefits of the project on income and amenities area, employment potential.
9	Environmental Cost benefit Analysis	If recommended at the scoping stage
10	Environmental Management Plan	This chapter includes all mitigative measures in the form of separate EMP detailed in standard ToR.
11	Summary and Conclusion	This is a brief summary mentioning the gist of the project.
12	Disclosure of Consultant Engaged	This chapter depicts the team of constants engaged in the study.

2 PROJECT DESCRIPTION

2.1 THE PROPOSED PROJECT

Rongnichu Hydroelectric Project (115MW) on Rongnichu stream in East Sikkim district of Sikkim, being developed by M/s. Madhya Bharat Power Corporation Ltd. (MBPCL), is a run-of-river hydro development project.The project envisaged construction of the following project components:

- 120 m long and 14m high barrage with 3 bays of free flow spillway with sill crest level at 728.00 masl, with 3 gates (12.2mx 6.5m).
- Surface desilting basin, fitted with trash rack of 24 panels, with 2 troughs (59m x 35.9m x 9.5m) to exclude sediments >0.2 mm m through 1000m flushing pipe.
- One gated power intake for passing 38.16 cumec
- 12.581 km long D-shape lined HRT of finished diameter of 4.0m
- 88m high and 10 m diameter vertical surge shaft with 1.7m diameter meter orifice
- Underground steel lined Pressure shaft comprising of UHPS (160.8m/3.0m), VPS (318m/3.0m) and LHPS (924m/3.0m)
- Surface powerhouse (61.5mx 45.75mx 38.0m) for housing 2 vertical shaft Pelton turbine

The General Lay Out Plan of project is shown in **Figure 2.1.**

The EC was accorded on 4.4.2007 for a period of 10 years as per the provisions of EIA Notification, 2006.The civil work of head works, desilting complex, power intake, head race tunnel, surge shaft, pressure shaft, power house are either completed or near completion. The balance works at barrage complex are erection of hydro-mechanical component like gates, counter weights, stop- log gates, Stanchion, gate lifting mechanism and top deck of barrage. Balance work of water conductor system involves excavation of HRT in 13.39 m length, lining in 4383.38m length and steel lining of LHPS in 881.324 m length. Balance work under power house complex is 671cum excavation and 6005 cum concreting work besides erection of Electro-mechanical equipment/plant and TRC.

2.2 NEED OF PROJECT

The need for Rongnichu HEP, installed capacity 115 MW, in the Teesta Basin, has therefore been considered in context of power shortage in the Eastern region in general and in the country as whole.The H.E.P. after being operational and capacity enhancement from 96 MW to 115 MW would be able to provide an annual design energy (90% dependability) of 413.78 GWh.

2.3 PROJECT LOCATION AND ACCESSIBILITY

The barrage location is about 2 Km downstream of Namli village and 16 Km south of Gangtok along NH-31A. The powerhouse is proposed on the right bank of Rangpo River 2.5 km from Rangpo Town on Rangpo-Rongli State Highway. The vicinity map of the project is shown in **Figure 2.2.**

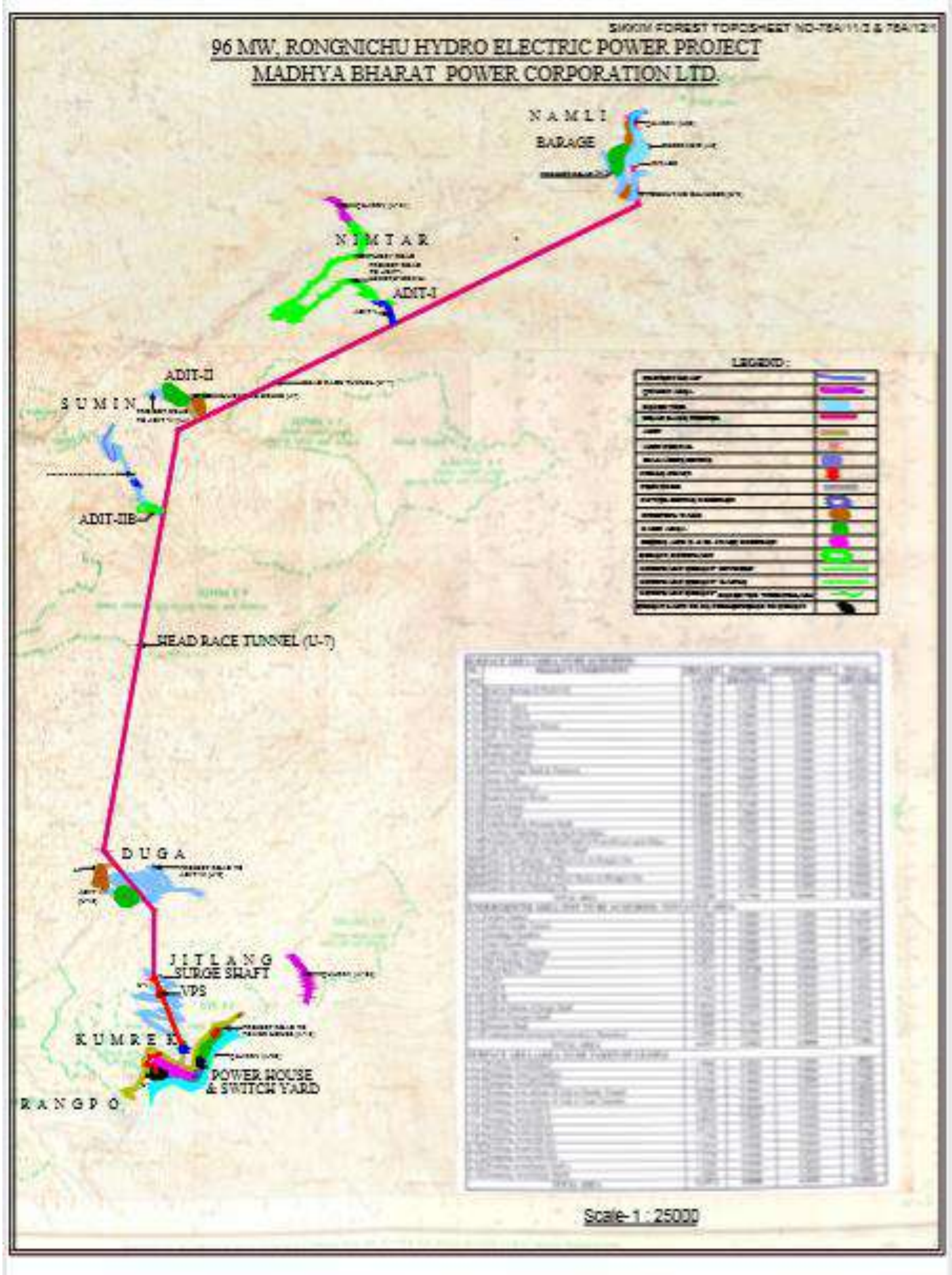


Figure 2.1: Layout Plan of Rongnichu HEP

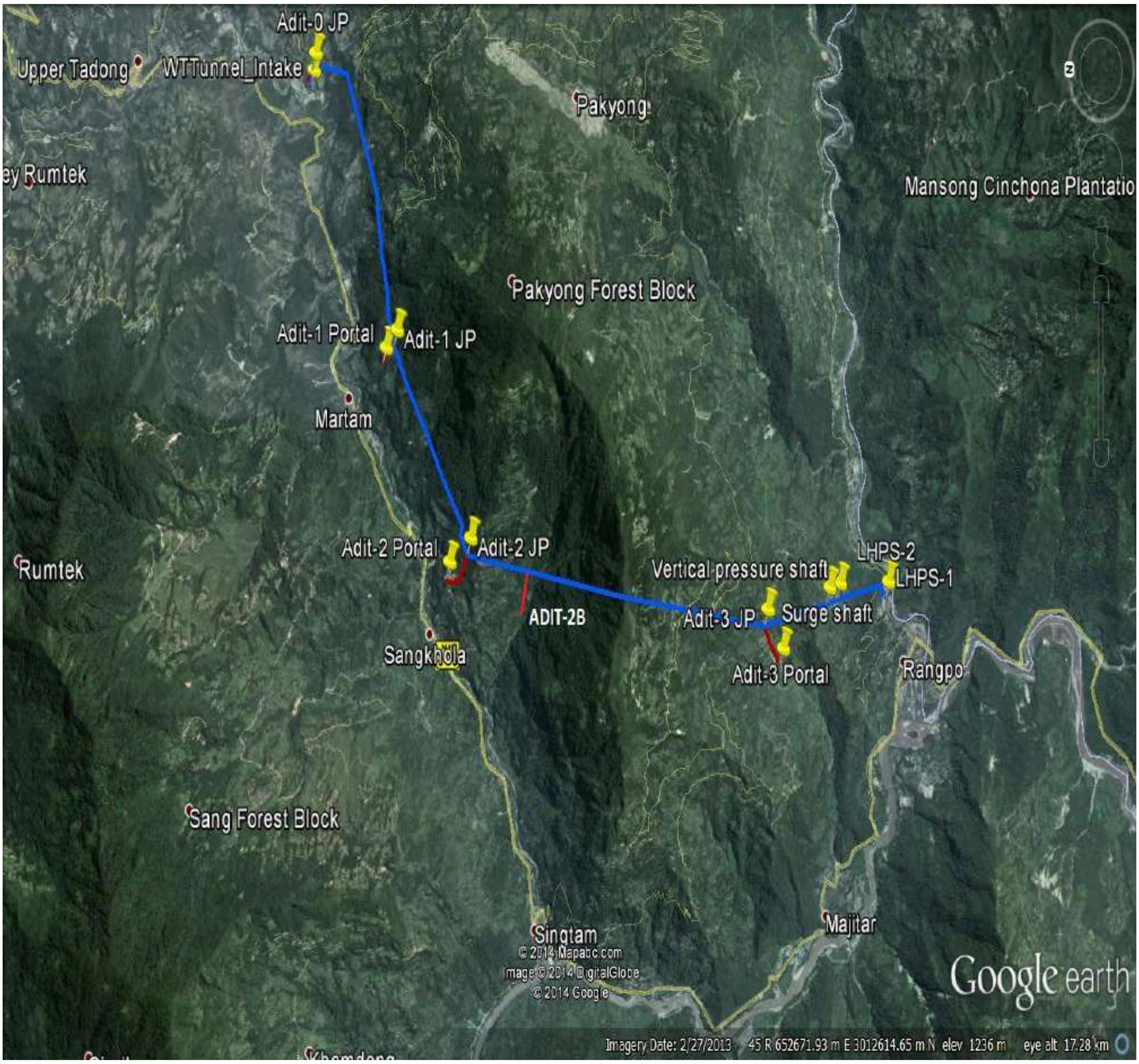


Figure 2.2: Location map of Rongnichu HEP

2.4 PROJECT SALIENT FEATURES

The salient features of project are provided in **Table 2.1.**

Table 2.1:Salient Features of the Project

S. N.	Particular	Details
1	**NAME OF PROJECT**	Rongnichu Hydroelectric Project(96MW)
2	**STATE/DIST./TEHSIL**	Sikkim/East Sikkim /Gangtok
3	**RIVER**	Rongni Chu / Rangpo River
4	**Barrage/Powerhouse SITE**	Near Namli village/ Rangpo village
5	**GEOGRAPHICAL CO- ORDINATES**	
(i)	Barrage Latitude/Longitude	27°16' 6.859" N/88° 35'20.058" E

(ii)	Powerhouse Latitude/ Longitude	27°10' 42.339" N/88° 32'21.577" E
6	**HYDROLOGY**	
(i)	Total Catchment Area at Barrage Site	190.00sq km
(ii)	Average Annual Rainfall	3581mm
(iii)	Average Annual Runoff	3166mm
(iv)	Flood Discharge for River Diversion (Dry Season)	100 cumec
(v)	Probable Maximum Flood (PMF)	1195 cumec
7	**Reservoir**	
(i)	Full Reservoir level (FRL)	El – 740 masl
(ii)	Minimum Draw Down Level (MDDL)	El – 734.5masl
(iii)	Maximum Reservoir Level	El – 741 masl
(iv)	Gross Storage at FRL	0.33 MCM
(v)	Active Storage at MDDL	0.24 MCM
(vi)	Active Storage at MDDL	0.013 MCM
(vii)	Reservoir Area at FRL	10.70 ha
(viii)	Reservoir Area at MFL	11.70 ha
8	**BARRAGE and APPURTENANT WORKS**	
8.1	Barrage	
(i)	Type	Barrage
(ii)	Top of Barrage Elevation	El-742.00 masl
(iii)	Streambed Elevation	El-728.00 masl
(iv)	Maximum Barrage Height	14.0m
(v)	Length of Barrage	120.00 m
8.2	Spillway (incl. Sluice)	
(i)	Type	Free flow
(ii)	Sill Crest Level	El-728.00 masl
(iii)	Gate Type	Fixed Wheel Gate & Stoplog
(iv)	Gate Size (H x W)/ Numbers	12.2m x 6.5m/2+1
(v)	Maximum Head	13.2m
(vi)	Discharge Capacity at EL 740.0	1200 cumec
(vii)	Dissipater Invert Level	El-727.00 masl
(viii)	Dissipater Basin Length	76.50 m
9	**DESILTING BASIN**	
9.1	Basin	Surface
(i)	Number of Troughs/Size (L x W x H)	2/59m x 35.9m x 9.5m
(ii)	Nominal Discharge through Chamber	38.16 cumec
(iii)	Size of Particles to be removed	>0.2 mm
(iv)	Trash rack size/Number of Panels	31.2m x 9.5m/24
9.2	Flushing System	
(i)	Type/Diameter	Sluice Pipe/1000mm
(ii)	Number of Sluice Pipes/Discharge through pipe	2/7.6 cumec
10	**INTAKE STRUCUTRE**	

(i)	Location/Number of openings	Left Abutment/1
(ii)	Top of Structure	El-742.50 masl
(iii)	Nominal Discharge Capacity (Design Discharge + 15% flushing + 10% over load)	38.16 cumec
(iv)	Gate Type/Number of Gates	Fixed Wheel Gate/1
(v)	Dimensions/Sill Elevation	4.0 x 4.0/El-725.70 masl
11	**HEAD RACE TUNNEL& ADITS**	
11.1	Tunnel	
(i)	Shape/Length	D Shape/12.581km
(ii)	Excavation Diameter/Finished Diameter	4.5m/4.0m
(iii)	Slope/Nominal Discharge	1: 400/30.5 cumec
(iv)	Lining Type/Lining Thickness	Plain Cement Concrete/250mm
11.2	Adits	
(i)	Number of intermediate Adits/Total Length	5/1866m
(ii)	Shape /Size	D-shape/6m x 5m to 6m x 5.25m
12	**SURGE SHAFT**	
(i)	Type	Vertical with Restricted Orifice
(ii)	Top Elevation/Bottom Elevation	El-782.50 masl/El-697.50 masl
(iii)	Total Height/Finished Diameter/ Av. Lining	88m/10m/750mm
(iv)	Orifice Diameter/Guard Gate	1.7m/2.5m x 4.0m
13	**VALVE HOUSE**	
(i)	Type	Butterfly
(ii)	Number of Valves/Internal Diameter	1/3.0m
(iii)	Water Head	90m
14	**PENSTOCKS (UHPS, VPS, & LHPS)**	
14.1	Upper Horizontal Pressure Shaft (steel lined)	
(i)	Length/Diameter/Thickness	160.8m/3.0m/25-32mm
14.2	Vertical Pressure Shaft (steel lined)	
(i)	Length / Diameter / Thickness	318m/3.0m/16-32mm
14.3	Lower Horizontal Pressure Shaft (steel lined)	
(i)	Length / Diameter / Thickness	924m/3.0m/16-32mm
14.4	Bifurcation (Y-section)	29.5m/2.2m
(i)	Length / Diameter	
15	**POWERHOUSE**	
15.1	Structure	
	Type/Size (L x W x H)	Surface Station/61.5mx 45.75mx 38.0m
15.2	Turbines	
(i)	Type/Number of Units	Pelton, Vertical Shaft/2
(ii)	Turbine Setting Elevation	El-312.50 masl
(iii)	Rated Discharge per Unit	13.35 cumec
(iv)	Gross head/Rated Head	425.5m/404.1m

(v)	Installed Capacity	48MWx2+30% overload
15.3	Inlet Valve	
(i)	Number of Valves	2
15.4	**Generator**	
(i)	Number of Generators/Type	2/ Suspended
(ii)	Nominal Speed	300rpm
(iii)	Voltage, Frequency	11 kV, 50 Hz
16	**TRANSFORMERS**	
(i)	Transformer Type/Dimensions (L x W)/Number	Three Phase, OFWP/5m x 3.5m/2
(ii)	Unit Capacity	60MVA
17	**SWITCHYARD**	
(i)	Type	Conventional
18	**ESTIMATED COST(Rs.)**	
(i)	Civil Works	78275Lakh
(ii)	E&M Works	19724Lakh
(iii)	Total basic cost	97999Lakh
(iv)	Escalated cost for Civil and E&M works	8122 Lakh
(v)	Total basic cost before IDC	106121.Lakh
(vi)	Interest during construction & Financing Charge	37757Lakh
(vii)	Total cost including escalation and IDC	145334Lakh
	Cost per MW Installed	1263.77Lakh

2.5 CURRENT STATUS OF WORKS AS ON 20.01.2020

Component wise detail of works carried out is as under:

2.5.1 Barrage

1. Entire excavation in barrage has been completed.
2. Cladding wall and cable anchoring works have been completed.
3. Barrage entire RCC structure work (BRG-1, BRG-2, BRG-3, U/S flexible apron abutment, D/S flexible apron abutment, and Right bank Rim treatment) have been completed as per approved drawings except 2 nos deck slabs of approach road bridge.
4. The casting and laying of concrete blocks at upstream and downstream flexible apron is complete.
5. Bridge pier no. 5 raised upto EL 740.5 final level EL 742.5.
6. Barrage Gate grooves 2nd Stage concreting works completed. Gate erection in progress
7. Civil work of Barrage control room work is complete.
8. Construction of protection wall at approach road in progress.

2.5.2 Desilting Basin:

1. Entire excavation in Desilting Basin has been completed.
2. DB-1, DB-2, DB-3 & DB-4 L/S, intermediate & R/S wall completed up to final EL 742.5

3. Collection chamber U/S & D/S wall raised up to final level EL 742.5
4. U/S guide wall block-1, block-2, block-3, block-4, Block-5, Block-6, Block-7 and Block-8 reached final level EL 742.5
5. Desilting basin adjoining Collection Chamber 500mm slab is complete and reached final level 742.5
6. Silt flushing d/s Collection chamber 1.4m diameter pipe 21.692 m length & 1.0m diameter 61.1m length is complete in all respect.
7. Random backfill at Left bank beside Desilting Basin and U/S Guide wall is complete.

2.5.3 Power Intake:

1. Concreting of left abutment completed up to EL 742.0.
2. Power Intake reached final level El 742.5
3. Power intake 650mm thick slab at EL 742.5 is complete

2.5.4 Water Conductor System:

1. Excavation of HRT is100% complete
2. Concrete lining of HRT is completed up to 87.93%.
3. Surge shaft is complete is complete. RCC lining of Surge Shaft vertical cylindrical component is complete. Surge Shaft U/S Transition steel lining is complete (L= 4m)
4. Excavation for VPS and LHPS is complete
5. Steel lining of B2 Bend is complete (Length = 14.999m). Steel lining of VPS in progress.
6. Steel lining of LHPS is 59.92% completed.

2.5.5 Power House Complex:

1. Excavation of Power house complex is almost complete (95.2%) and 1500 cum is balance.
2. Concreting work is about 82.2% completed only 4250 cum is balance.
3. Ground mat laying works in Power house area has been completed on 08.02.2013.
4. Mud matting and PCC in the Service bay area and Unit bay area have been completed.
5. The sand filling work at service bay is complete; ramp preparation works at service bay is complete. Service bay B & D-Line column raised upto El 334.8 is complete. Service Bay inner and outer brick work, lintel & wall plastering in progress. Conceal electrical wiring work and toilet wall tiles fitting work is also in progress. Service bay roofing and sheeting work is complete.
6. Service bay transformer track beam is complete and reached final level 318.0.
7. Transformer deck ballast filling work is complete.
8. Power House RCC boundary wall reinforcement fixing, shuttering & concreting in progress.
9. TRC RCC structure concreting work is complete in all respect.
10. Power House outer boundary wall GI wire mesh fencing work in progress.
11. Service bay DOWN-stream Oil tank (30KL) is complete.
12. Power House building CGI sheet cladding work is complete.
13. Construction of Radiography building is complete.
14. Epoxy painting inside surface of both Generator barrel completed.
15. IPC flooring at Unit 1 & 2 U/S 312.5 floor is complete.
16. Unit 1 & 2 Generator barrel stair construction completed.
17. Unit-1 and Unit-2 B-Line RCC wall and column reached upto EL 324.5 and structural steel column, beam, truss, struts, purlin erection is complete.

18. Unit-1 & Unit-2 Auxiliary bay slab at EL 323 is complete.
19. Unit 1 & 2 Pit liner erection complete.
20. Concreting of Unit-1 and Unit-2 Generator barrel reached final EL 323.
21. Unit-2 grid 12 between B-12 to D-12 RCC wall reached upto EL 318.0.
22. False ceiling, partition wall & door-window frame at Control room fixing work is complete.
23. Unit-1 and 2 Tailrace channel gate groove 2nd stage concrete is complete.
24. Battery room construction under progress
25. CO_2 room construction under progress
26. Staircase SS railing and Generator barrel SS railing work is complete
27. White cement putty at control room is under progress
28. Epoxy flooring at Unit 1 & 2 Machine hall 318 floor completed
29. Power House fire fighting pipeline work in progress
30. Firefighting tank construction under progress
31. Filling of switchyard to raise the level is in progress.
32. Switch yard gantry tower footing construction underway.
33. Casting of foundation & footings at switchyard was taken up on 18.08.2019.
34. 220kV AIS Switchyard 96 nos. equipment structure erection complete and 9 nos. gantry tower erection completed
35. Line-1 and Bus-1 equipment erection work is in progress.

2.5.6 PACKAGE-IV- STATUS OF ELECTRO-MECHANICAL WORKS

1. **<u>For Turbine and Turbine Auxiliaries</u>**
   - Unit 1 &2 turbine housing with pit liner installed & distributor pipe installation and its hydraulic test up to 72 bar pressure is complete.
   - Unit 1 & 2 drainage and dewatering system installation work is complete.
   - Unit 1& 2 HPU pipeline installation for nozzles & deflectors around barrels completed.
   - Erection works of MIV for Unit 1 & 2 has been completed.
   - MIV Unit-1 seal control panel to spherical valve SS pipe clamping work completed MIV Unit-2 in progress
   - Unit 1 & 2 MIV and runner removal opening grating installation complete
   - Cable tray frame fabrication and erection work in progress
   - Drainage and dewatering pump power and control panel installed in position.
   - Unit 1 & 2, HPU and Turbine governor panel shifted at Power House building
2. **<u>For Generator and Generator Auxiliaries</u>**
   - Manufacturing of pole end pieces is in process.
   - Unit-1 Generator cooling water pipes extension work is complete up to Gen. barrel.
   - Unit 1 & 2 Generator barrel cooling water pipelines is complete.
   - Unit 1 & 2 Generator barrel embedment pipe completed upto EL 323.
   - Unit 1 & 2 - Generator stator lower sole plate installation work completed.
   - Unit 1 Generator stator winding, brazing and insulation wrapping work completed.
   - Unit 1 Generator stator winding coil insulation resistance and High voltage test complete upto 25.3Kv before brazing.
   - Unit 1 & 2 Generator barrel cable tray canal fixing work completed.
   - Unit 1 & 2 Upper bracket sole plate installation work completed.
   - Unit 1 & 2 stator lower sole plate fixing work is complete.
   - Unit 1 & 2 Generator barrel embedded pipes installation work is complete.
   - Unit 1 Generator stator 56 nos. winding coil put in slots with wedge fixing.
   - Unit 1 Generator Barrel top ring erection work completed for grating.
   - Erection of Generator stator and lower bracket for Unit 1 is complete.

- Unit 1 & 2 Generator barrels acoustic door installation completed.
- Unit 1 Generator rotor pole (16 nos.) reached at site.
- Unit 1 Rotor reached at Site and shifted to assembly of poles

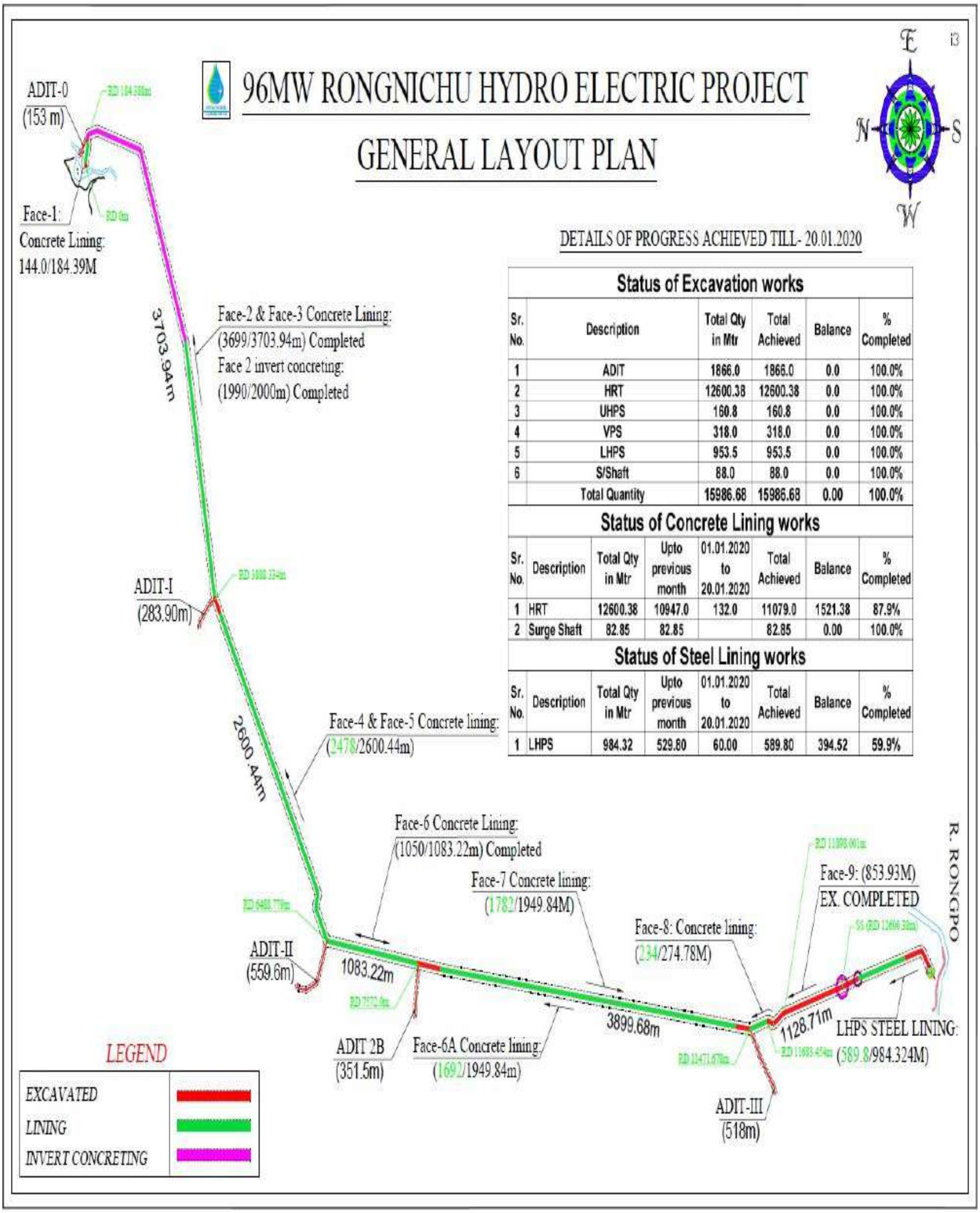
2.5.7 PACKAGE-V: STATUS OF HYDRO -MECHANICAL WORKS:

1. SpillWay (Service gate): Gate erection work in progress
2. SpillWay & Undersluice (Stoplog gate): Gate parts no. 1,2,3,4 ,5 and 6 seal erection work complete
3. Undersluice (Service gate): Gate lowering work is progress
4. Power Intake (Service gate): Gate lowering completed
5. DB (Inlet service gate): Gate lowering completed
6. DB (Inlet and Outlet stoplog gates): Gate lowering and dry test completed
7. Silt Flushing (Emergency and service gate): seal alignment is completed
8. Trash rack gate: Gate lowering completed
9. Track and RDH (Rope Drum Hoist) assembly/ erection work under progress.
10. 98 Nos. of VPS ferrules, 201 Nos. of LHPS ferrules, B2 & B4 Bend reached at site.
11. Erection of 589.8m ferrules with concreting completed as on 20.01.2020.
12. Fabrication of ferrules, orifice, B5 Bend and bifurcation are under progress.

2.5.8 POWER EVACUATION:

1. Tower location no. 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28 & 30 tower erection works completed.Total 27 Towers completed out of 30 Towers
2. Tower location no. 1 & 2 foundation work under progress.
3. Tower location no. 29 tower erection under progress.
4. Out of 7.26Km 220Kv double circuit Transmission line stringing for 5.5Km is complete
5. Power Grid Samardung 220KVA GIS Building extension work completed.
6. Gantry tower foundation is complete.
7. GIB foundation bolt erection complete.
8. GIB erection under progress
9. GIS equipment erection work under progress

The schematic diagram showing the status of excavation of water conductor system, concrete lining and steel lining works is depicted in **Figure 2.3.** The photographic view/glimpses of work component under progress is shown in **Figure 2.4.**



Status of Excavation works

Sr. No.	Description	Total Qty in Mtr	Total Achieved	Balance	% Completed
1	ADIT	1866.0	1866.0	0.0	100.0%
2	HRT	12600.38	12600.38	0.0	100.0%
3	UHPS	160.8	160.8	0.0	100.0%
4	VPS	318.0	318.0	0.0	100.0%
5	LHPS	953.5	953.5	0.0	100.0%
6	S/Shaft	88.0	88.0	0.0	100.0%
	Total Quantity	15986.68	15986.68	0.00	100.0%

Status of Concrete Lining works

Sr. No.	Description	Total Qty in Mtr	Upto previous month	01.01.2020 to 20.01.2020	Total Achieved	Balance	% Completed
1	HRT	12600.38	10947.0	132.0	11079.0	1521.38	87.9%
2	Surge Shaft	82.85	82.85		82.85	0.00	100.0%

Status of Steel Lining works

Sr. No.	Description	Total Qty in Mtr	Upto previous month	01.01.2020 to 20.01.2020	Total Achieved	Balance	% Completed
1	LHPS	984.32	529.80	60.00	589.80	394.52	59.9%

Figure 2.3: **S**chematic Diagram Showing Status of Works

Barrage (Front View)

Glimpse of HRT final concrete lining

Glimpse of Steel Lining work

Glimpse of Unit 1 & 2 Machine Hall

Glimpse of Power House 220Kv AIS Switch Yard

Switch Yard at Pooling station PGCIL Smardung, S-Sikkim

GIS building at PGCIL Smardung, S-Sikkim

Figure 2.4: Photographs Showing Works in Progress

2.6 BRIEF DESCRIPTION OF PROCESS AND TECHNOLOGY

The project has been conceived with chief aim of utilizing power potential of Rongnichu river for generation of hydro power by diverting water from barrage into water conductor system and utilizing the available/regulated discharge and available head at surface powerhouse. The principle of hydropower is that the potential energy of the water stored at great heights is converted into kinetic energy by allowing the water to flow at high speed. Then the kinetic energy of flowing water used to generate electricity. In hydroelectric power station, the flowing water is stopped in high altitude rivers by constructing barrage and is stored in huge reservoir behind the barrage. The water stored possessed very large amount of potential energy. Then the water is made to fall through pipes on the blades of big water called turbines. These turbines are connected to electric generators. When the shaft of the turbines rotates, the generator coil also rotates rapidly and produce electricity.

In present case the potential energy of 409m head of water stored behind barrage shall be changed into kinetic energy by conducting it through closed water conductor system to impinge on blades of 2Pelton turbines at the surface power house to rotate shaft to rotate generator coil and produce annually electricity 413.78 MU in in 90% dependable year.

The operating process involved shall be regulation of barrage, as per regulation manual, by gradually operating the gates to store water in the reservoir without exceeding the FRL, and by surpassing the flood waters through operation of gates without bringing a sudden drawdown in the pond and without exceeding the maximum allowable differential level on either side of divide walls and piers from the structure safety consideration. Utmost round the clock vigil shall be carried out during monsoon season by inspecting the downstream floor of the spillway and cistern, flow pattern of the river on upstream. The regular inspection of barrage and appurtenant works shall be carried out. Regular watch and ward and maintenance of hydro-dynamic and electro-mechanical equipment/power plant besides structures shall be conducted.

2.6.1 Material Balance

Hydro power projects are renewable energy projects which are based on non-consumptive use of water and after utilizing the potential energy of water into kinetic energy to generate electricity release it into river through powerhouse and finally through Tail race Channel into the river.

2.7 SIZE OR MAGNITUDE OF OPERATION

The best indicator for defining the size or magnitude of a project construction activities involved in river valley project are the quantum of excavation involved, numbers of different equipment and machinery deployed, and the volume of concreting involved.

The muck excavated (5.0 lakh) is being utilized as raw material for captive Brick Plant, a part is also being used for filling/levelling low lying area and the balance muck is being disposed of at Pre-Identified Dump yards. On saturation the Muck Dump Yards will be Rehabilitated and Resorted as per pre-defined methodology. The muck shall be carried and disposed at dumping sites by deploying dumpers.

The plant and machinery required in construction of various project components, which is an indicator of the magnitude of work involved, is shown in **Table 2.3.**

Table 2.2: Inventory of Construction Plant/Machinery

Name of Equipment	Consolidated Requirement
Hydraulic Excavator (0.9 m3) or equivalent	3
Backhoe	9
Single boom Hydraulic Jumbo	1
Truck Jumbos/Hydraulic Platform	6
Loader 0.8cum	8
Dumpers (20 T capacity)	8
Crawler Wagon drill	3
Motor grader	2
Air Compressor 838 cfm	16
Air Compressor 600 cfm	8
Dozers (320 HP) or equivalent	4
Dozers (180 HP) or equivalent	7
Electrical Winches 10T/20T	2/4
Tyre Loader (1.5 cum)	2
Rock bolter	6
Water Sprinkle	2
CONCRETE PRODUCTION, TRANSPORTAION AND PLACEMENT EQUIPMENT	
Concrete Batching Plant 30m3 /hr. capacity	2
Concrete Batching Plant 40 m3 /hr. capacity	4

Name of Equipment	Consolidated Requirement
Transit Mixtures	32
Tower Crane	1
Rubber Tyre crane 40T	1
Rubber Tyre crane 8-10T	5
Portable Crane 15T	1
Collapsible Shutters	6
Tippers 4.5cum	60
Trailer 30T	2
Trailer 60T	1
Concrete Pump 30 cum/hr. capacity	14
Grouting Equipment	13
Shotcrete machine	17
Diesel Generators 500KVA	6

2.7.1 Construction Material

The total raw material requirement for sand and stone shall be 1.75 lakh cum and 11.86 lakh ton. Sand and boulder/metal has been met from the approved Quarry and consumptive use of muck retrieved from sites.

2.7.2 Land Requirement for The Project

Total land requirement under the project has been assessed as 59.8720 ha of which private land is 11.3895 ha and forest land 48.4825 ha besides this about 8.1606 ha private land will be temporary acquired on lease basis. The present status of land acquired/ transferred is shown in **Table-2.3.**

Table 2.3: Land Requirement

Category of Land	Total Requirement	Land Acquired or transferred	Balance to be acquired or to be transferred
Private land	11.3895	11.3895	0.00
Forest Land	48.4825	48.4825	0.00
Total	**59.8720**	**59.8720**	**0.00**

2.7.3 Manpower Requirement

During peak construction phase approximately 1000 workers shall be required.

2.7.4 Water Requirement

The total water requirement during construction shall be 115KLD of which 85KLD shall be sourced through tunnel seepage. The domestic requirement shall be 30KLD which shall be met from the filtration plant. Post construction the domestic and Fire Fighting requirement shall be 2 KLD only. There are no competitive users from these sources.

2.7.5 Construction Power Requirement

During construction electricity requirement of 2MW power is being met from the existing transmission network in the area. During operation electricity requirement shall be power 0.50MW.

2.8 INFRASTRUCTURE DEVELOPMENT

A small colony and site office have been be developed at site for the staff looking during construction of the works. Camp area has been created at suitable sites near to work sites. O&M staff complex has been developed near powerhouse. Temporary non-residential buildings like offices, store and fabrication yard have been created. Potable/treated water is being supplied for human consumption at camp area near headworks and also office and O&M staff complex near barrage and powerhouse. The domestic requirement of water (30 KLD) which is being met from the filtration plant. Post construction the domestic requirement shall be 2 KLD only. Labour camps have well designed drainage system along with septic tank attached with soak pits. There is no colony envisaged to be constructed for the project.

2.9 PROPOSED SCHEDULE FOR APPROVAL AND IMPLEMENTATION

2.9.1 Schedule for Approval

The draft EIA / EMP report will be submitted to SPCBfor uploading on their web-site for inviting public comments/suggestion. The final EIA report will be prepared after incorporating the feedbacks of public obtained from SPCB. The final EIA report will be submitted to MoEF&CC for obtaining environmental clearance.

2.9.2 Schedule for Project Implementation

All the works including testing of power plant and other components of project are scheduled to be completed by April 2021.

2.10 PROJECT ASPECTS LIKELY TO CAUSE ENVIRONMENTAL IMPACTS

The project, an intervention on Rongnichu river, is a green field project to be established be in the Teesta basin of East Sikkim. The following are some of overt aspects of the project on environmental aspects.

2.10.1 Change in River Regime

Creation of a pond upstream of the barrage shall bring about changes in the riverine ecology to lacustrine ecology flooding the natural habitats that existed before the construction.

2.10.2 Habitat Loss

Habitat loss due to diversion of25.1388ha of forest land for non-forestry purpose shall along with standing trees.

2.10.3 Change in Land use and Land cover

- The land use class of forest land and agriculture land involved in submergence shall change into waterbody. The change shall be permanent and irreversible. The forest land cover within the submergence area shall reduce due to project during construction.
- The land use class of forest land and agriculture landrequired for project components andforest land internal roads shall have land use class changed to built-up area.

- The land use class of forest landrequired for quarry sites shall remain unchanged as the quarry sites shall later developed with vegetal cover.
- The present land use of private land involved in quarry sites/muck sites shall permanently change into forest land use after completion of the work and creation of vegetal canopy by way of plantation over the spoil tips.
- The land use category of agriculture landacquired for construction of buildings shall change to land use category settlement.

2.10.4 Aquatic Life

The barrage shall act as a barrier between the upstream and downstream habitat of migratory fishes and shall block their migration upstream to spawning areas, threatening to decrease reproduction numbers and reduce the species population.

2.10.5 Land Degradation

Due to excavation activities of project components and roads and quarry of materials and disposal of muck there shall be disturbance to the land profile which may trigger land erosion.

2.10.6 Change in Hydrology

The abstraction of water through intake shall reduce the river flow d/s.

2.10.7 Social Impacts

Due to labour immigration a small change in demographic profile of the area albeit during construction phase only. Fuel and dust emission may cause respiratory problems like asthma. Increased use of existing public infrastructure i.e. road due to vehicular traffic involved in transportation of construction materials and muck and earthmovers may cause congestion on roads. As there shall be no displacement of people thus no Resettlement and Rehabilitation site shall be warranted. The package proposed for the affected families has been completely followed

2.11 MITIGATION MEASURES INCORPORATED INTO THE PROJECT

2.11.1 Minimum Loss to Ecology

At the evolutionary stage of project, the height of barrage has been determined to minimize the submergence of forest and non-forest land thereby taking first mitigation step to bring the loss to ecology to minimum

2.11.2 Lay out of Underground Works

The intake and complete water conductor system has been alignedunderground to cause no displacement and relocation of road.

2.11.3 Minimum Loss of Agriculture land and no displacement of people

The location and height of barrage has been finalized keeping in view minimum/ no displacement of people and minimum requirement of private land.

2.11.4 Sedimentation and formation of shoals

Sedimentation in pond will reduce water-storage capacity due to the exchange of storage space for sediment which is generally reflected by the formation of shoals / islands near tip of pond. The problem of siltation will not be serious as the pond shall be regularly flushed during monsoon when enough water is available for conducting flushing operation though spillways.

2.12 PROJECT COST

The revised cost of Project is 1453.34 Cr. The cost per megawatt has been assessed as 12.637 Cr.

3 DESCRIPTION OF BASELINE ENVIRONMENT

3.1 INTRODUCTION

As a precursor for the prediction of various types of environmental impacts likely to arise due to implementation of this project, it is essential to establish the base line environmental status of the physio-chemical, biological and socio-economic parameters in the project area and within the project influence area.

3.2 STUDY AREA

Study area map comprising direct impact area which includes area covered under 10 km radius from the barrage axis, Powerhouse is shown in **Figure 3.1.**

3.3 METHODOLOGY OF CONDUCTING BASELINE STUDY

The guiding factors for the present baseline study are the Ministry of Environment, Forests & Climate Change's (MoEF&CC) requirements for the Environmental Impact Assessment (EIA) notification and local regulations and directives. The studies were conducted by considering the following:

- The various environmental attributes were divided into primary and secondary studies. Primary attributes such as air environment, water, soil, noise, flora and fauna, and Socio- economic were assessed by conducting field studies, on-site monitoring and review of the past studies conducted.
- Baseline data on environmental attributes (Air, Noise, Water and Soil) have been collected for 3 seasons in the study area. The data has been collected by the EIA Consultant by engaging J P Test & Research Centre, Sahibabad Industrial Area, Ghaziabad, a NABL accredited laboratory for monitoring of ambient air, ambient noise and collecting samples of surface water, ground water and soil **(ANNEXURE-III).**
- Secondary attributes such as land use studies, geology, physiological characteristics, and socio-economic environment have been assessed by literature review of previous studies conducted by various government publications.
- An interdisciplinary team through discussions, criteria questions and professional judgement formulated the scoping and the extent of data generation. The baseline studies started with site visits and reconnaissance survey in the study area for fixing the monitoring locations for the primary data. As a secondary data review, various Government agencies were approached for procuring information and relevant data of the area.

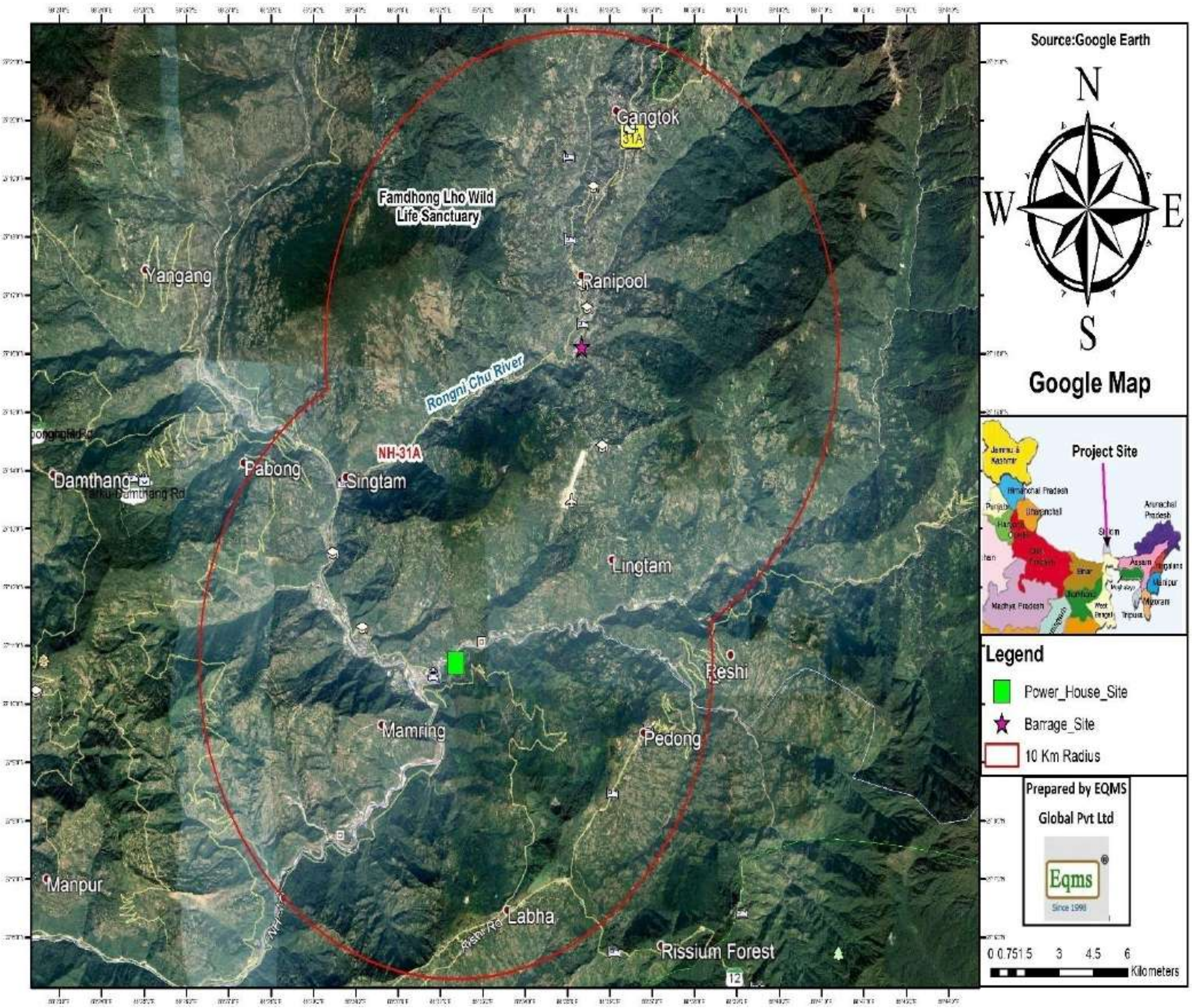


Figure 3.1: Study Area Map

3.3.1 Study Period

To establish the base line environmental status of the physico-chemical, biological and socio-economic parameters in the project area and within the project influence area the baseline study and primary data collection has been carried out during pre-monsoon,monsoon and post-monsoon,2019.

3.3.2 Physical Environment Study

The study related to physical environment shall be conducted through both site visits and review of the secondary sources like the DPR and other published peer information in respect of the topographical and physiographical features, regional and the local geology of the project area, climatology and seismicity. Soil characteristics shall be establishing through physio-chemical tests of the soil samples revalidated though the published literature while land use and land cover, slope of the study area shall be establishing through remote sensing by using GIS tools.

Land use – Landcover Classification

Prior to ground truthing, the satellite data shall be classified using unsupervised classification technique. Further, after collecting ground truth details maximum likelihood classification based on supervised classification method shall be used with remote sensing image data.

After the supervised classification procedure, a land use map shall be prepared and verified in field, and errors or omissions identified.

A reclassification of the land use categories implementing the details and corrections, if any, shall be made. The reclassification output shall be used for the preparation of the final land use classification map. This map after due verification shall be composed and printed, as desired.

Slope

Slope is a measure of change in the value of altitudes over distance, which is expressed in degrees or as a percent. The first step in generation of slope map is to create surface using the elevation values stored in the form of contours or points. Surface is a representation of geographic information as a set of continuous data in which the map features are not spatially discrete, i.e., between any two locations, there are no clear or well-defined breaks between possible values of the map features. Models built from regularly or irregularly spaced sample points on the surface can represent the surface.

- Slope map of the study area shall be prepared using the elevation information for the area from contour heights.
- A Digital Elevation Model (DEM) of the area shall be prepared

Soil

- Based on a 3-tier approach (Landform analysis, field survey and laboratory investigation) soil resource map of study area shall be prepared.
- The taxonomy of soils, as per USDA system of soil classification, shall be adopted.
- The soil map thus prepared shall be used as base map for further analysis.

3.3.3 Air, Noise and Water Environment Study

3.3.3.1 Air Quality Assessment

Under the provisions of the Air (Prevention & Control of Pollution) Act, 1981, the CPCB has notified fourth version of National Ambient Air Quality Standards (NAAQS) in 2009 (Table 3.1). Ambient air is defined as any unconfined part of the Earth’s atmosphere, that the surrounding outdoor air in which humans and other organisms live and breathe.

The “Respirable Dust Sampler shall be used for air monitoring. The dust particulate matter is collected on glass micro fibre filter paper (size GF/A20.3x25.4 cm) and dust cup and the gaseous pollutants collected simultaneously by a known volume of air through a number of bubblers of different flow rate through appropriate solution for absorbing different gases. The collected samples are analysed according to standard method for different pollutants. The particulate matters were analysed by Gravimetric method (by weighing the mass of particle). The SO2 was analysed by Colorimetric method by estimating absorbance of SO2 from the exposed absorbing reagent at 540 nm using spectrophotometer. The NOx was analysed by Colorimetric method by reacting the nitrite ions with phosphorous acid sulphanilamide, and NEDA solution by measuring absorbance of NOx from the exposed absorbing reagent at 540 nm using spectrophotometer.

Table 3.1: National Ambient Air Quality Standards (2009)

Pollutant	Time Weighted average	Concentration in Ambient Air		Method
		Industrial, Residential,Rural and Other Area	Ecologically sensitive area (notified by Central Govt.)	
Sulphur Dioxide (SO_2),µg/m^3	Annual*	50	20	-Improved West and Geake -Ultraviolet fluorescence
	24 hours**	80	80	
Nitrogen Dioxide (NO_2), µg/m^3	Annual*	40	30	Jacob & HochheiserModified (NaOH-$NaAsO_2$) Method -Gas Phase Chemiluminescence
	24 hours**	80	80	
Particulate Matter (size less than 10µm) or PM_{10}µg/m^3	Annual*	60	60	-Gravimetric -TOEM -Beta attenuation
	24 hours**	100	100	
Particulate Matter (size less than2.5µm) or PM2.5 µg/m3	Annual*	40	40	-Gravimetric -TOEM -Beta attenuation
	24 hours**	60	60	
Ozone (O_3) µg/m^3	8 hours **	100	100	-UV photometric -Chemiluminescence -Chemical method
	1 hour **	180	180	
Lead (Pb) µg/m^3	Annual*	0.5	0.5	-ASS / ICP method after sampling on EPM 2000 or equivalent filter paper ED – XRF using Teflon filter
	24 hours**			
Carbon Monoxide (CO)mg/m^3	8 hours**	2	2	-Non-Dispersive Infra-RED (NDIR) Spectroscopy
	1 hour**	4	4	
Ammonia (NH_3) µg/m^3	Annual*	100	100	-Chemiluminescence -Indophenol blue method
	24 hours**	400	400	
Benzene (C_6H_6) µg/m^3	Annual*	5	5	-Gas chromatography based continuous analyzer -Adsorption and desorption followed by GC analysis
Benzo (a) Pyrene (BaP) particulate phase only ng/m^3	Annual*	1	1	-Solvent extraction followed by HPLC / GC analysis
Arsenic (As) ng/m^3	Annual*	6	6	-AAS / ICP method after sampling on EPM 2000 or equivalent filter paper
Nickel (Ni) ng/m^3	Annual*	20	20	-AAS / ICP method after sampling on EPM 2000 or equivalent filterpaper

* Annual arithmetic mean of minimum 104 measurements in a year at a particular site taken twice a week 24 hourly at uniform intervals.

** 24 hourly or 8 hourly or 1 hourly monitored value, as applicable, shall be complied with 98% of the time in a year. 2% of the time, they may exceed the limits but not on two consecutive days of monitoring.

- Note: Whenever and wherever monitoring results on two consecutive days of monitoring exceed the limits specified above for the respective category, it shall be considered adequate reason to institute regular or continuous monitoring and further investigation.

Guidelines for manual sampling and analyses (Volume-1) issued by CPCB IN May,2011, shall be followed for assessment of air quality irrespective of land use pattern.

Sampling and analysis of sulphur dioxide (Improved West and Gaeke method)

Sulphur dioxide from air is absorbed in a solution of potassium tetrachloromercurate (TCM). Adichlorosulphitomercurate complex, which resists oxidation by the oxygen in the air, is formed. Once formed, this complex is stable to strong oxidants such as ozone and oxides of nitrogen and therefore, the absorber solution may be stored for some time prior to analysis. The complex is made to react with para-rosaniline and formaldehyde to form the intensely coloured pararosaniline methylsulphonic acid. The absorbance of the solution is measured by means of a suitable spectrophotometer.

Calculation

C (SO2 µg/m3)= (As – Ab) x CF x Vs/ Va x Vt

Where, C SO2 = Concentration of Nitrogen dioxide, µg/m3

As = Absorbance of sample

Ab = Absorbance of reagent blank

CF = Calibration factor

Va = Volume of air sampled, m3

Vs = Volume of sample, ml

Vt = Volume of aliquot taken for analysis, ml

Sampling and analysis of NOx (Modified Jacob and Hochheiser Method)

Ambient nitrogen dioxide (NO2) is collected by bubbling air through a solution of sodium hydroxide and sodium arsenite. The concentration of nitrite ion (NO-2) produced during sampling is determined colorimetrically by reacting the nitrite ion with phosphoric acid, sulfanilamide, and N-(1-naphthyl) ethylenediamine di-hydrochloride (NEDA) and measuring the absorbance of the highly coloured azo-dye at 540 n m.

Calculation

C (NO2 µg/m3) = (As – Ab) x CF x Vs/ Va x Vt x 0.82

Where, C NO2 = Concentration of Nitrogen dioxide, µg/m3

As = Absorbance of sample

Ab = Absorbance of reagent blank

CF = Calibration factor

Va = Volume of air sampled, m3

Vs = Volume of sample, ml

Vt = Volume of aliquot taken for analysis, ml

0.82 = Sampling efficiency

Sampling and analysis of PM_{10} (Gravimetric Method)

Air is drawn through a size-selective inlet and through a 20.3 X 25.4 cm (8 X 10 in) filter at a flow rate, which is typically 1132 L/min. Particles with aerodynamic diameter less than the cut-point of the inlet are collected, by the filter. The mass of these particles is determined by the difference in filter weights prior to and after sampling. The concentration of PM10 in the designated size range is calculated by dividing the weight gain of the filter by the volume of air sampled.

Calculation

C PM10 µg/m3 = (Wf – Wi) x 106 / V

Where,

C PM10 = Concentration of PM10, µg/m3

Wf = Initial weight of filter in g

Wi = Initial weight of filter in g

106 = Conversion of g to µg

V = Volume of air sampled, m3

Sampling and analysis of $PM_{2.5}$ (Gravimetric Method)

An electrically powered air sampler draws ambient air at a constant volumetric flow rate (16.7 lpm) maintained by a mass flow / volumetric flow controller coupled to a microprocessor into specially designed inertial particle-size separator (i.e. cyclones or impactors) where the suspended particulate matter in the PM2.5 size ranges is separated for collection on a 47 mm polytetrafluoroethylene (PTFE) filter over a specified sampling period. Each filter is weighed before and after sample collection to determine the net gain due to the particulate matter. The mass concentration in the ambient air is computed as the total mass of collected particles in the PM2.5 size ranges divided by the actual volume of air sampled and is expressed in µg/m3. The microprocessor reads averages and stores five-minute averages of ambient temperature, ambient pressure, filter temperature and volumetric flow rate. In addition, the microprocessor calculates the average temperatures and pressure, total volumetric flow for the entire sample run time and the coefficient of variation of the flow rate.

3.3.3.2 Noise Level Measurement

The noise monitoring shall be done following CPCB protocol of Noise Monitoring, July2015, which inter alia include the following cardinal principles:

- The noise measurements shall be made with a Type 1 integrating sound level meter. The station should be located at the ambient level i.e. away from the direct source, away from any vibration and any obstruction.
- Microphone must be placed 1.2 -1.5m above the ground level.
- The instrument should be isolated from strong vibration and shock.
- The monitoring should be carried out minimum 75% of the prescribed Day time (06.00 am to 22.00 pm) and Night time (22.00 pm to 06.00 am).
- During ambient noise monitoring sound comes from more than one direction, it is important to choose a microphone and mounting which gives the best possible omni directional characteristics.
- Noise measurements should not be made in fog and rain.
- A wind shield will always be used to prevent interference of reflecting noise.

3.3.3.3 Protocol for Soil Quality Assessment

Methods Manual of Soil Testing in India, Department of Agriculture& Cooperation, Ministry of Agriculture, Government of India, New Delhi, shall be followed for collection of soil samples, its preparation for testing and analysing various physico-chemical properties of soil.

Soil Sampling

Soils vary from place to place. In view of this, efforts should be made to take the samples in such a way that it is fully representative of the field. Scrap away surface litter; obtain a uniformly thick slice of soil from the surface to the plough depth from each place. A V-shaped cut is made with a spade to remove 1 to 2 cm slice of soil. The sample may be collected on the blade of the spade and put in a clean bucket. In this way collect samples from all the spots marked for one sampling unit. In case of hard soil, samples are taken with the help of augur from the plough depth and collected in the bucket. Pour the soil from the bucket on a piece of clean paper or cloth and mix thoroughly. Spread the soil evenly and divide it into 4 quarters. Reject two opposite quarters and mix the rest of the soil again. Repeat the process till left with about half kg of the soil, collect it and put in a clean cloth / polyethylene bag. Each bag should be properly marked to identify the sample

Storage Technique

Collected Samples are immediately transported to the laboratory. They are shade dried in wooden or enamelled trays (except for the analysis of moisture content) and stored. The dried soils are ground using mortar and pestle (taking care to break only the clods but not the sand and gravel particles) and sieved through a 2mm mesh sieve.

Soil Quality Parameters and Method of Analysis

The analysis of soil properties shall be done as per standard methods as described in the Methods Manual of Soil Testing in India, Department of Agriculture& Cooperation, Ministry of Agriculture, Government of India, New Delhi **(Table 3.2).**

Table 3.2: Methods for Analysis of Soil Properties

S, N.	Parameters	Methods of Analysis
	Physical Parameters	
1	Moisture content (%)	Gravimetric
2	Water Holding Capacity (%)	Gravimetric
3	Bulk Density (%)	Gravimetric
4	Texture	Hydrometer Method
	Chemical Parameters	
5	pH	Electrometric (pH meter)
6	EC (µS/m)	Electrometric
7	Acidity (mg/kg)	Titrimetric
8	Alkanity (mg/kg)	Titrimetric
9	Chloride(mg/kg)	Titrimetric
10	Calcium (mg/kg)	Titrimetric
11	Magnesium (mg/kg)	Titrimetric
12	Sodium(mg/kg)	Flame Photometer
13	Potassium(mg/kg)	Flame Photometer
14	Available Potassium(mg/kg)	Flame Photometer
15	Sulphate(mg/kg)	Spectrophotometer

S, N.	Parameters	Methods of Analysis
16	Nitrate(mg/kg)	Kjedahl
17	Phosphate(mg/kg)	Bray's Extractant
18	Available Phosphorus(mg/kg)	Spectrophotometer
19	Organic Carbon (%)	Wet Digestion

3.3.3.4 Water Quality Assessment

For assessment of baseline data of water quality status, general reconnaissance survey of river upstream and downstream of proposed barrage site will be done. "Protocol for Water Quality Monitoring" notified by Govt of India in conjunction with CPCB Guidelines for Water Quality Monitoring, 2007-08, shall be followed.

Criteria for Sampling Site Selection

Sampling stations should be located upstream and downstream of significant pollution outfalls like city sewage drains and industrial effluent outfalls. Drinking water intake points, bathing Ghats, irrigation canal off-take points should be considered for monitoring. Additional downstream stations are necessary to assess the extent of the influence of an outfall and locate the point of recovery. Stations on both sides downstream are useful to make an estimate of the extent of the mixing zone. In case of groundwater sampling only tube wells, dug-wells and hand pumps which are in use should be selected.

Sampling Frequency

For assessment of baseline data of water quality status of perennial river, a frequency of three to four time a year shall suffice whereas for seasonal rivers 3-4 times (at equal spacing) during flow period. For lakes a frequency of four time a year shall suffice. For ground water the frequency shall be twice a year in pre and post monsoon season.

General Guidelines for Sampling

Grab samples will be collected from well-mixed section of the river (mainstream) 30 cm below the water surface. Samples from reservoir sites will be collected from the outgoing canal, power channel or water intake structure. DO is determined in a sample collected in a DO bottle using a DO sampler. The DO in the sample must be fixed immediately after collection, using chemical reagents. Weighted sample bottle should be used to collect sample from an open well about 30 cm below the surface of the water. Samples from the production tube wells will be collected after running the well for about 5 minutes. Some parameters like pH, dissolved oxygen, temperature, conductivity and turbidity should be analysed in situ.

Sample Preservation and Transport

Samples for BOD and bacteriological analyses should be stored at a temperature below 4^{o}C and in the dark as soon as possible after sampling by placing them in an insulated cool box together with ice or cold packs. Samples collected for chemical oxygen demand (COD) should be preserved below pH 2 by addition of concentrated sulphuric acid. Samples which are to be analysed for the presence of heavy metals, should be acidified to below pH 2 with concentrated nitric acid.

Samples should be transported to concerned laboratory as soon as possible, preferably within 48 hours. Analysis of bacteriological samples should be started and analysed within 24 hours of collection. If samples are being brought to the laboratory, they should be transported in less than 24 hours.

Parameters Considered for Analysis

In general list of parameters to be considered for analysis and frequency of sampling is provided in the "Protocol for Water Quality Monitoring" notified by Govt of India should be followed. In case the specific water quality parameter to be analysed have been prescribed in the ToR, they should be analysed.

3.3.3.5 Water Quality Analysis

The selection of sites for water sampling shall be done considering the location of different project components, junction of streams and river course, spots of high-water velocity and some of the stagnated pools along with the areas having human interference. The sampling shall be carried out for three seasons. The limnological parameters are recorded mainly following the standard methods described by Welch (1948), CSIR (1974). Mackereth et.al. (1978) and APHA, AWWA, WPCF (1995) as following:

Parameters Instrumentation

Ambient temperature	: Digital thermometer (stainless steel Sensor probe)
Transparency	: Seehi dise method (Weleh 1948)
Water velocity	: EMCON digi current meter
Turbidity	: Nephelometer
Total Dissolved Solids	: Titration method
pH	: Digi pH meter (HANNA)
Alkalinity, Acidity, Chlorides, Silicates, DO, Free CO2, Zn, Si, Fe and Nutrients (Phosphorus, Sulphates)	: Aqua Merck / Aqua quant kits
Total Ca and Mg Hardness – EDTA	: Titrimetric methods (Natarajan and Jhingran 1988)
Inorganic phosphates	: Colorimetric Methods
BOD	: Titration
E-Coli and Total Coliform	: MacConkey broth

3.3.3.6 Aquatic Environment

Data on existing aquatic environmental conditions in and around proposed project shall be generated as per following:

- Biological characteristics of river water.
- Inventorization of Phyto benthos and Zoobenthos
- Estimation of coliform organisms.
- Present status of riverine fish fauna: Identification of obligate fish species.
- Their migratory pattern, diseases, feeding and breeding grounds.

Evaluation of Phyto benthos

Samples of periphyton shall be obtained by scraping off 3 sq. cm area of the boulders and preserving it in 1 ml of Lugol's solution. The upper surface of boulders shall be scraped with the help of sharp razor. Three replicates shall be obtained and integrated. Thus, the total area sampled amounts to 9 sq. cm.

Sedge Wick-Rafter cell counts (APHA 1992) shall be made and density recorded as cell mm2. For qualitative studies, the keys of Trivedy and Goel (1984) and Ward and Whipple (1959) are being used for identifying the filamentous and non-filamentous algae.

However, for identifying diatoms, permanent mounts shall be prepared and identified. For computing abundance (as %) 300-400 diatom cells shall be identified in each sample (with BX-40).

Evaluation of Benthic Macro-Invertebrates

Benthic macro-invertebrates shall be collected from the designated sampling sites in riverusing Surber's square foot sampler (Welch, 1948) adopting random sampling device. All collected specimens shall be preserved in 8% formalin solution and identified up to the generic level with the aid of keys given by Usinger (1950), Ward and Whipple (1959), Needham and Needham (1962), Macan (1979), Tonapi (1980) and Edington and Hildrew (1995). The density of benthic macro invertebrates shall be expressed as unit per meter square (unit/m^2).

Benthic macro-invertebrates shall be sampled from an area of one ft2. All the stones of the area shall be collected in a bucket with as little disturbance as possible and washed thoroughly. Three replicates shall be obtained and integrated. The samples were sieved and preserved in 70% alcohol for further analysis. The benthic macro-invertebrates could be identified up to order/family/genus level with the help of keys given by Edmondson (1959) and Pennak (1953). Counts of the identified organisms made in each sample and density recorded as individual's m-2. The spatial variations in community structure shall be recorded by computing percentage abundance.

Evaluation of Total Coliform

To assess the quality of water in terms of pathogenic and parasitic organisms, the use of indicator system is the best method. The coliform organisms are considered to be the best indicators of pathogenic organisms. The standard test for the estimation of number of coliform groups is being carried out generally by multiple tube dilution technique which gives most probable number (MPN) of bacteria. A selective medium is used to develop only coliform bacteria. Coliform ferments lactose and produce acid and gas that could be detected by uplifting of Durham's tube by vision. MPN is not an actual enumeration of coliform bacteria but merely an index of the probable.

Culture Media

A. MacConkey Broth: For Presumptive Test of Coliform

Peptone 20 g.
Lactose 10 g.
Sodium chloride 5 g.
Bile salt 5 g. (may be replaced by sodium taurocholate
or sodium taurogly – chocholate)
Distilled water 1000 ml.

B. EC Medium: This medium is used for the test of presence of coliform group of fecal origin.

Tryptose or trypton	: 20 g.
Lactose	: 5 g.
Bile salt mixture	: 1.5 g.
Bile salt No. 3	
Dipotassium hydrogen phosphate	: 4 g. KH_2PO_4
Potassium dihydrogen phosphate	: 1.5 g. KH_2PO_4

Sodium chloride : 5 g.
Distilled water : 1 lit.

C. Buffered Dilution Water: To prepare stock phosphate buffer solution 34 g of potassium dihydrogen phosphate is to be dissolved in 500 ml distilled water at pH 7.2 with 1N NaOH and be diluted in 1 lit with distilled water. 1.25 ml stock phosphate buffer solution will be added to 1-lit distilled water. Dispense in amounts that will provide 9 ml in 150 x 25 mm test tubes sterilized autoclave at 121 °C for 15 min.

Calculation: Coliform density is determined by using a standard MPN Table. It is convenient to express the results of the examination of replicate tubes and dilution in terms of the Most Probable Number (MPN). In usual practice, the results are expressed in terms of MPN index/100 ml of various combinations of +ve and -ve results generally given in most of the microbiological manuals.

Faecal Coliform (MPN) procedure: For separation of coliform organisms of faecal origin from that of non-faecal, elevated temperature tests is used. Gas formation in subculture of the +ve tubes from presumptive tests of coliform in EC medium at 44.5 ±0.2 0C for 24 hrs gives the + ve test of faecal coliform.

Total Count: Total bacterial count is indicative of the presence of chemosynthetic heterotrophic group of bacteria (Exotic) and is often performed in conjunction with total coliform (MPN) in waters. The test is not differential between pathogens and indicator organisms but is considered affirmative to population.

Total count is often performed to assess:

1. Progress of self-purification in rivers, ponds and lakes in time and space.
2. Efficiency of bacterial removal during storage and treatment processes.
3. Ascertaining quality in general.

Culture Media
Nutrient Agar
Beef extract 3 g.
Peptone 5 g.
Agar 15 g.

3.3.4 Biological Environment

3.3.4.1 Floral Study

The floristic composition along with frequency, density, abundance, relative values of frequency, density and abundancefor each species is calculated by quadrats method. The quadrats are laid out at pre-selected sites to cover different altitudinal zones as also to represent the existing variables within the area.

To study the Phyto-sociological attributes of the area, quadrats of 10m x 10m are laid for tree composition, 5m x 5m for shrubs and quadrats of 1m X 1m for herbs. The Phyto-sociological parameters of different recorded species shall be calculated using the following formulae (Phillips, 1959; Misra, 1966)

Frequency

It is defined as the chance of finding a species in a particular area in a particular trial sample. Thus, a higher frequency value shows a greater uniformity of its spread or dispersion (Ambasht and Ambasht, 2002).

No. of quadrats in which the species occur
Frequency = -- x 100
Total number of quadrats studied

Density

It is, expressed as a numerical strength of a species. However, density is an indicator of the abundance of the species; it does not indicate the distribution of species with regard to space. It helps to identify the dominant and rare species and is also an indicator of the standing biomass and productivity of the region (Ambasht & Ambasht, 2002)

Total no. of individuals of a species in all quadrats
Density = ---
Total number of quadrats studied

Abundance

It is the number of species occurring in a particular site. It does not give a total picture of the numerical strength of a species in an area because only quadrats of occurrence are taken into consideration (Ambasht & Ambasht, 2002). Abundance is analysed to get an idea of distribution pattern of the species.

No. of individuals of the species in all quadrats
Abundance = --
Number of quadrats in which the species occur

Relative values

The relative values of frequency, density and dominance are calculated to understand the ecological importance of the species within the community (Phillips, 1959; Mishra 1968).

No. of quadrats of occurrence of a species
Relative Frequency = -- x 100
Number of occurrences of all species

No. of individuals of the species in all quadrat's species
Relative Density = -- x 100
Total number of quadrats studied

Abundance of a species
Relative Abundance = -- x 100
Sum of Abundance of all the Species

Basal area of a species
Relative dominance= -- X 100
Total basal area of all the species

ImportanceValue Index (I.V.I)

IVI is a statistical quantity, which gives an overall picture of the importance of the species in the plant community. Since the above relative parameters give clues individually, all the parameters are summed up in order to provide the total picture of sociological structure of a species in the community and called as Importance Value Index (IVI). It incorporates three important parameters that are measures of diversity and productivity of every species. -The sum of the IVI of all the species in a forest should not exceed 300.

The Importance Value Index (IVI) for different species is sum of relative frequency, relative density and relative basal cover of each species. (Curtis, 1959).

OR

Importance value Index (IVI) = Relative frequency + Relative density + Relative dominance. The vegetational data collected are used to calculate following indices for each site. The importance value index (IVI) is calculated by adding relative frequency (RF), relative density (RD) and relative abundance (RA) of the species (Philips, 1959).

IVI = RF + RD + RA
Where,
RF = (Frequency of a species / sum frequencies of all species) × 100,
RD = (Number of individual of a species / total number of individual) × 100.
RA = (Abundance of a species / sum abundances of all species) × 100
For the present study Philips, 1959 method is used

Circumference at breast height (CBH)

Circumference of individual tree species in the quadrat, shall be measured at breast height (1.37m) above ground level. In case of shrub and herb species circumference is measured at root collar height.

Diversityindices

The floral diversity of the study area varies gradually with the altitude. It is a measure of information in a group of species, which have different probabilities of being represented and is based on the assumption that individuals are randomly sampled from an infinitely large population. The species diversity is computed using (Shannon- Weiner, 1963) information index as

Shannon- Wiener diversity index (H′)

The index of diversity is computed using Shannon-Wiener information index (Shannon- Wiener, 1963) as:

$H' = \sum (Ni/N)^2 \log (Ni/N)$
Where, N is total number of species.
Ni is individual of a species.

3.3.4.2 Faunal Study

Ground surveys shall be carried out by trekking the impact zone for identification of important animal groups such as butterflies (insects), birds, mammals, reptiles, and some fishes inhabiting the area, along the riverbanks, adjoining forest on the slopes, nallahs, hilltop and agricultural fields.

- For sampling butterflies, the standard ‘Pollard Walk’ methodology is used by recording all the species encountered while trekking along the foot trails between the two sites, daily. Voucher specimens of species were collected by means of a butterfly net for only those species that could not identified in the field besides photographing them for the same purpose. Sampling was done for 1 hour in a stretchon each transect (n = 4).

- For sampling birds 'point sampling' along the fixed transects (foot trails) shall be carried out to record all the species of birds observed with the help of binoculars; field guides and photography for 1 hour on each transect (n=4).
- For sampling mammals, 'direct count on open width (20m) transect' is used on the same transects (n=4) for 1 hour in each transect. Besides, information on recent sightings/records of mammals by the villagers and locals shall also be considered.
- 'Reptiles' mainly lizards shall be sampled by 'direct count on open width transects' (n = 4) for 1 hour ineach transect.
- Seasonal variation in species diversity of different groups of animals (butterflies and birds), shall be evaluated using Shannon-diversity Index (H') to know the season of peak diversity in the area.

***H'* = -ΣN**
1 Pi In Pi
(From species 1 to n; n= total number of species)
Where, **Pi** is the proportion of the individual species in the total population.

3.3.4.3 Aquatic Fauna

Evaluation of Aquatic Fauna

An extensive survey of Rongnichhu on upstream and downstream of diversion site shall be carried out with the intention to examine aquatic animal species such as fishes, insects, arthropods, amphibians, snakes, water-birds, otters etc.

3.3.5 Socio-Economic Study

Secondary information shall be collected from different government and non- government offices. The data proposed to be collected is mainly of secondary nature and involves information regarding access to facilities such as PHC's, schools, bus services, LPG distribution centres, type of roads, livestock information, land utilization, demographic profile of the villages, location and distribution of villages with respect to Project. Public consultation, primarily with stack-holders, shall be conducted.

In order to gather information on public perception of the proposed project the attitude/psychology survey was carried out which depicts the prevailing awareness and acceptance/no-acceptance about the project. Total number of families fully or partially affected by the project, approached for collecting socioeconomic data. All the families present in the villages during the study period were interviewed.

3.3.5.1 Sources of Secondary Data

Table 3.3: Sources of Secondary Data

India Metrological Department	Climatic data
Survey of India	Topo sheet
Botanical Survey of India	Floral characteristics/vegetation of Teesta Valley
Revenue Department	Land data / Circle Rates
Fisheries Department	Fish and Fisheries in area
Forest Department	Forest Working Plan
PHC, Rangpo	Health Status of people of area

3.4 PHYSICO-CHEMICAL ENVIRONMENT

3.4.1 Topography

Thetopography is characterized by high ridges, steep to moderately steep slopes broken by occasionally detached scar faces with falls of 20 to 100 m. The area is drained by the tributaries of Rongni Chhu and Rangpo Chhu, the main drainage system

3.4.2 Geography

Geographically, East Sikkim occupies the south-east corner of the State. It is bounded by North District in the north, China and Bhutan in the East, Darjeeling district of the state of West Bengal in the South and South District in the western side. East District is located at 88°27' to 88°56'E longitude and 27°9' to 27°25' N latitude. The total geographical area of the district is 954 sq. km)

3.4.3 Physiography & Geomorphology

The proposed barrage site on the Rongni Chhu upstream of the confluence of Andheri Khola-Rongni Chhu is located about 2 km downstream of Namli village. The geographical area of the proposed Rongni H.E.P is spread in the Gangtok & Pakyong sub-divisions of East Sikkim. The barrage site of the project is present in the Rongni Chhu and the powerhouse is proposed on the right bank of Rangpo Chhu. The tailrace is proposed to drain into the Rangpo Chhu.

3.4.4 Regional Geology

Because of the tectonic and metamorphic complexity and thick vegetation cover in Sikkim Himalaya the geological classification and stratigraphic position of the rock units in this region are yet to be clearly established and subject to academic debate. Tectono-stratigraphically the rocks have been differentiated into three belts viz. inner belt, axial belt andtrans-axial belt in the northern part of the state. Stratigraphic succession south of the axial belt as established by GSI workers is given in **Table 3.4.**

Table 3.4: Stratigraphic Succession South of Axial Belt

Formation	Age	Litho-Characteristics
Gondwana	Upper Carboniferous to Lower Permian	Sandstone, shale and carbonaceous Shale with occasionally thin beds of Coal and pebbly horizon.
Daling	Upper Proterozoic	Interbedded quartzite and chlorite sericite phyllite / schist.
Chungthang	Proterozoic	Interbedded quartzite and garnetiferous Quartzbiotite schist. calc-silicate rock/ marble
Central crystalline Gneissic Complex	Older Proterozoic	Banded Gneiss with Augen Gneiss and Quartz-biotite gneiss

Within the state of Sikkim the exposed rocks are i) Daling Group: Proterozoic-Precambrian metamorphic rocks of low to medium grade, ii) Darjeeling and Kanchenjunga gneisses: high grade gneisses, iii) Chunthang formation: Quartzite, calc-silicate rocks, marbles, graphite schist and occasionally amphibolites with intrusive granites (Lingtse granite gneiss), and iv) Phanerezoic rocks: includes a) Gondwana Group of Permian age contains sandstone, shale and carbonaceous shale with occasionally thin bands of coal and pebbly shale horizons, b) Paleozoic and Mesozoic Tethyan fossiliferous sequence in the northeastern part of Sikkim.

I)Daling Group: Three distinct formations have been recognized within the Daling group of rocks. These are: Gorubathan Formation – composed of quartz chlorite-sericite schists, phyllites and quartzites, Reyang Formation – composed of quartzites occasionally calcareous, phyllites interbedded with carbonaceous slate and Buxa Formation – composed of dolomite limestone-occasionally interbanded with phyllites.

ii)Darjeeling Group: The Darjeeling Group comprises medium to high grade metamorphic rocks namely migmatized gneisses, kyanite-sillimanite schists and gneisses; kyanite, staurolite gneisses, garnet schists with bands of amphibolite. The staurolite-garnet and garnet schist forms the lower member of the Darjeeling Formation showing effects of shearing and mylonitisation and depicts retrogression and inverted metamorphism.

iii) Chungthang Formation: The Chungtang Formation is highly deformed metamorphic rocks consisting of calc-quartzite, calcsilicate marble, graphite schists, calc granulites and gneisses.

iv) Lingtse Gneiss: A streaky, sheared granite gneiss known as 'Lingtse Gneiss' occurs as a NE-SW trending strip of rocks. It forms a general line of separation between the Daling and the high-grade Darjeeling gneiss. However, some bands of these streaky gneisses are seen within the Darling Formations.

V) Tethyan sequence: The Tethyan sediments are exposed in the north district of Sikkim and are represented by Mount Everest Phyllite series (shale/phyllite), and the Mount Everest limestone series. These are fossiliferous sequences

3.4.5 Regional Structures and Tectonics

The regional geological map with important structures is shown in Figure 3.2. A structural dome enshrines the geology of the Sikkim Himalayas, the genesis of which corresponds to two separate orogenic movements viz. i) an early episode of NS compression led to formation of a regional recumbent fold with EW axis and ii) a latter phase of EW compression that refolded the earlier fold along a N-S axis resulting in a dome-shaped structure.

The planar structural elements include compositional banding and cleavage/ schistosity planes. The S0 planar surface is represented commonly by compositional banding. Quartzite show uniform and persistent compositional banding defined by quartz rich portion with partings and laminae of phyllosilicate. In calcsilicate, the compositional bandings are marked by alternate silica rich and carbonate rich bands. In schists, the compositional banding is marked by quartz rich and muscovite rich bands. The S1 planar surfaces are represented by schistosity planes. The S2 planar surfaces are defined by crenulation cleavage/slip cleavage/fracture cleavage.

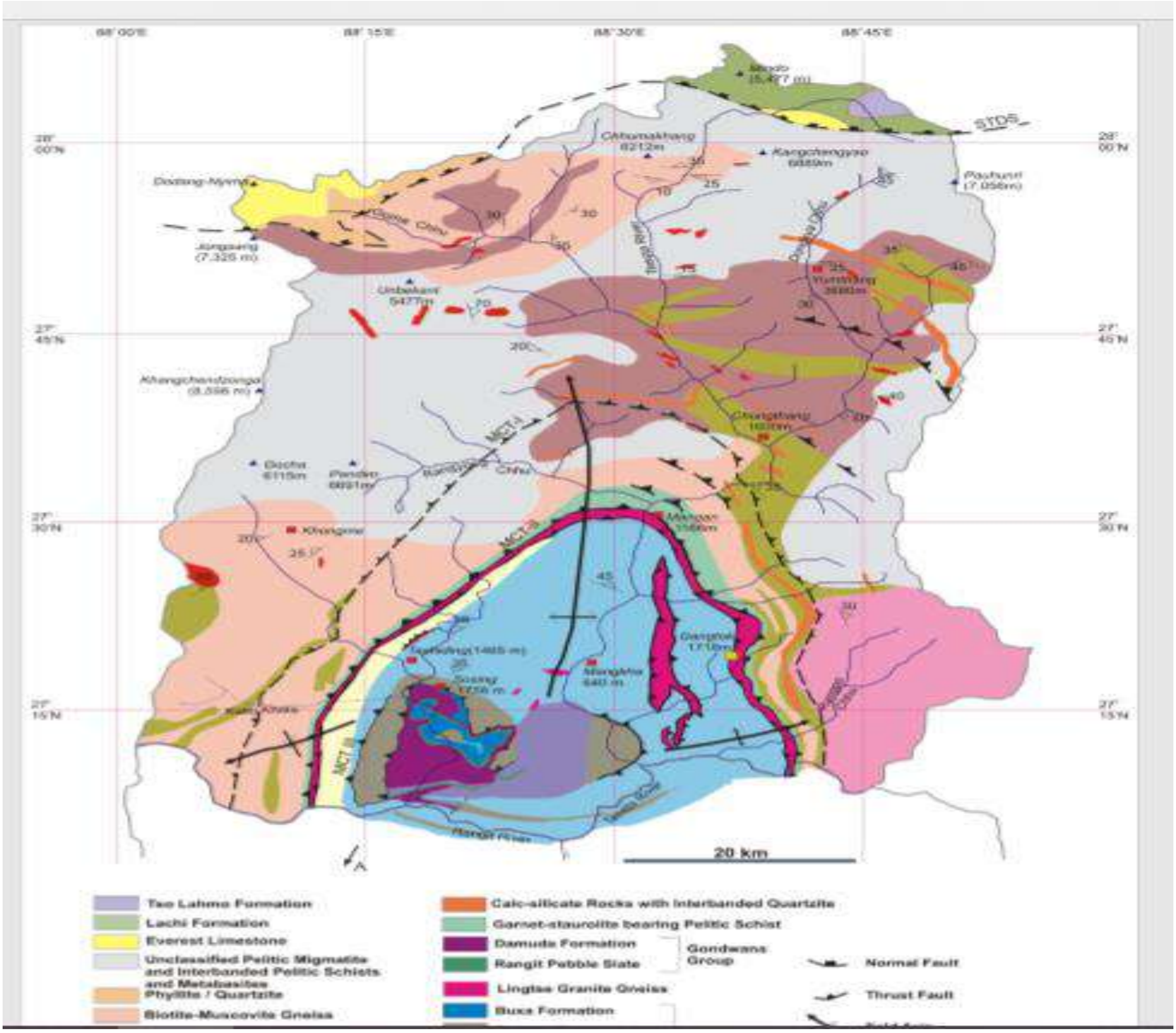


Figure 3.2: Geological Map of Rongnichu HEP

3.4.6 Geology of Project Area

The Rongni H.E.P is located in the Gorubathan Formation of the Daling Group of rocks, which is a monotonous thick assemblage of green slate, bedded and intrusive epidiorites and chlorite feldspathic greywacke at the base of Daling Group. Lingtse granite gneiss is also reported within this group as well as at the contact of this group of rocks with the Central Crystallines exposed north of Gangtok. The topography is characterized by high ridges, steep to moderately steep slopes broken by occasionally detached scar faces with falls of 20 to 100 m. The area isdrained by the tributaries of Rongni Chhu and Rangpo Chhu, the main drainage system.

3.4.6.1 Barrage site

At this site thinly foliated greenish phyllite and quarzitic phyllite with occasional bands of gneiss is exposed on both the abutments. The right bank abutment is a steeply dipping slope from the riverbed up to the elevation of 750 m. Rock outcrop is present up to this level and river borne deposits in the form of a terrace caps this outcrop.In the left abutment the rocks are exposed at the riverbed level and extend up to the top of the ridge under a thin cover of slope wash material. On the left bank at the riverbed level, downstream of the barrage axis, there exists an alluvium deposit (8-10 m wide) comprising rounded to sub-rounded boulders, cobbles and pebbles. The rocks exposed along both the banks at the barrage site belong to Gorubathan Fm of the Daling Group. These include greenish phyllite and quarzitic phyllite with occasional bands of gneiss.

The depth of the river borne material (RBM) near the barrage axis is 20 m. Boulders, pebbles and cobbles of gneiss, quartzite, phyllite, quarzitic phyllite embedded in a sandy and silty matrix constitute the RBM at thebarrage foundation. The bedrock consists of greenish grey colour medium to fine grained phyllite and phyllitic quartzite with occasional bands of gneiss. The rocks are medium to thinly foliated, slightly weathered to fresh and moderately strong.

3.4.6.2 Intake and Feeder Tunnel and Desilting Basin

The intake structure will be founded on bedrock which is exposed right from the river bed level. The feeder tunnel will pass through phyllite and quarzitic phyllite. Good thickness of bedrock (>twice the tunnel diameter) and overburden (<5m) is expected along the feeder tunnel at Andheri Khola. The proposed underground desilting basin will be excavated in moderately foliated phyllite and quarzitic phyllite with sub-ordinate bands of gneiss on the left bank of the Rongni Chhu

3.4.6.3 Head Race Tunnel

The rock class encountered during excavation of HRT is as per **Table 3.5.**

Table 3.5: Rock Class

S. N.	Rock Class	Percentage
1	Class III	30 %
2	Class IV	50%
3	Class V	20%

3.4.6.4 Surge Shaft and Penstock Alignment

The surge shaft area is covered with slope wash material with rock outcrops at some locations. The thickness of the slope wash/ overburden material may vary from 10-15 m as observed at the existing road cuttings. The slope wash material comprises boulders of schist, gneiss and quartzite. The rock housing the surge shaft will be in fair rock (Class-III). The penstock is proposed to be located in a narrow ridge comprising interbeds of phyllite and quarzitic phyllite with subordinate bands of chlorite. The rocks are thinly to very thinly foliated and moderately to highly weathered. The strength of the rock mass is weak to moderately strong.

3.4.6.5 Powerhouse

The surface power station will be located on the right bank of the Rangpo River just upstream of the rocky nose. At the site of the power station the Rangpo River flows nearly in an NE-SW direction. The entire right bank of the Rangpo River in this area is occupied by an approximately 20 m wide, flat, open river terrace occurring between the watercourse and the rising right bank hill slope. The riverbed and the river terrace are covered with thick riverine deposits comprising fine sands with pebbles and large boulders. Above the terrace the terrain consists of a moderately steep to steep rocky slope which will form the back slope of the power station site and route of the penstock.

The power station and surroundings are occupied by metamorphic rocks belonging to the Daling group of rocks of the Lesser Himalayas. Phyllite and quarzitic phyllite with sub-ordinate bands of chlorite schist and partings of quartzite are the main rock types present in the power house area.

3.4.7 Seismicity, Tectonics and Past Earthquake in the Area

3.4.7.1 Seismic Zoning & History

The proposed site lies in seismic zone-IV as per the seismic zoning map of India as incorporated in Indian Standard Criteria for Earthquake Resistant Design of Structures IS:1893-(Part I) 2002: General Provisions and Buildings. According to Seismic Zone Map of India, the state of Sikkim lies in a region with high to highest seismic hazard (**Figure 3.3**).

3.4.7.2 Seismic History

The spatial distribution of seismic activity in the region during the period 1964-1992 suggests that the regional seismicity of Sikkim Himalaya is relatively high to the north of the Main Boundary Thrust (MBT) and the activity decreases progressively southward from the Lesser Himalaya to the foredeep region, under sediment cover (Nath et al., 2000). The central main Himalayan block with considerable seismicity separates the northern Tethyan block and southern foredeep block with subdued seismic activity(Narula et al., 2000). In this area most of the earthquakes are shallow focus (<40 km) and are commonly of 4.5-5.5 magnitude range (**Table 3.6**).

Table 3.6: Earthquakes EventsofMagnitude>4.5Occurred in Sikkim

S.No.	Date	Time	Location	Magnitude (Mb)	Focal Depth (km)
1.	30.8.1964	02h:35m:7.3s	Lat: 27.36 N; Long 88.21 E	5.1	21
2.	21.8.1972	14h: 4m: 33.9s	Lat: 27.33 N; Long: 88.01 E	4.5	33
3.	21.8.1972	18h:55m:07.2s	Lat: 27.23 N; Long: 88.02 E	5.1	33
4.	23.1.1975	01h:37m:42.9s	Lat: 27.44 N; Long: 00.37 E	4.5	32
5.	16.11.1979	19h:17m:27.7s	Lat: 27.90 N; Long: 88.70 E	4.6	39
6.	19.11.1980	19h:00m:45.0s	Lat: 27.40 N; Long: 88.80 E	6.0	47
7.	5.4.1982	02h:19m:41.2s	Lat: 27.38 N; Long: 88.83 E	5.0	09
8.	18.8.1982	18h:01m:07.6s	Lat: 27.04 N; Long: 89.26	4.6	51
9.	25.5.1985	00h:28m:18.7s	Lat: 27.60 N; Long: 88.48 E	4.6	33
10.	7.1.1986	20h: 20m: 00.4s	Lat: 27.40 N; Long: 88.43 E	4.7	41
11.	26.5.1988	16h: 30m: 05.5s	Lat: 27.45 N;Long: 88.61 E	4.6	42

S.No.	Date	Time	Location	Magnitude (Mb)	Focal Depth (km)
12.	27.9.1988	19h: 10m: 10.0	Lat: 27.19 N;Long: 88.37 E	5.0	23

**Source: DPR*

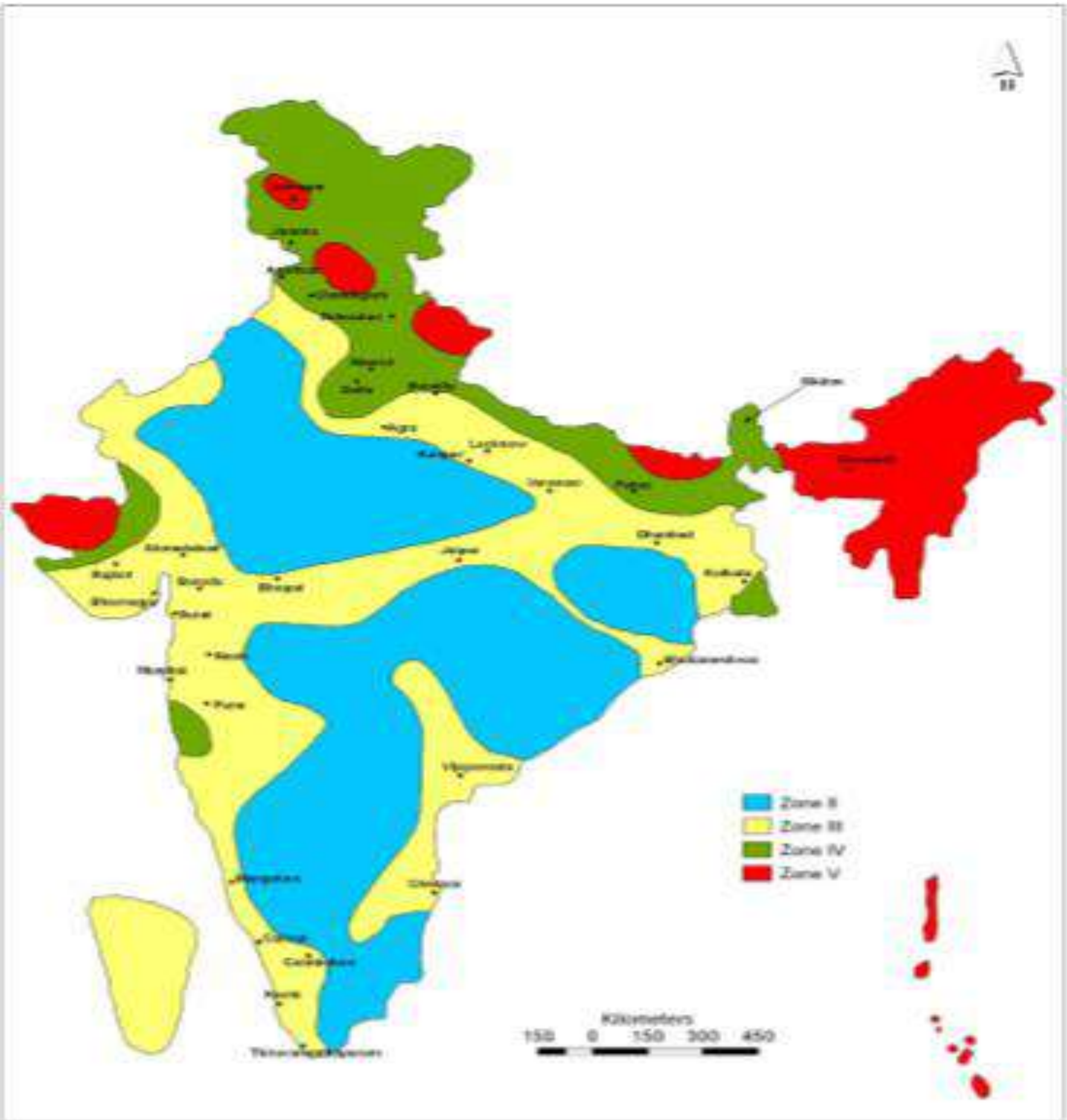


Figure 3.3: Seismic Zonation Map of India

3.4.7.3 Structure and Tectonics

A detailed account on the seismotectonic environment of the Sikkim and its adjoining region is given in the recent syntheses of Narula et al. (2000) and Kayal (2001). Like other parts of the Himalaya, Sikkim Himalaya is also traversed by MCT and MBT **(Fig. 3.4).** The former separates the high grade Central Crystallines from the comparatively lower grade Lesser Himalayan packages, which are separated from the Siwalik belt by the MBT. At places, particularly towards east, several subsidiary thrusts are present between MCT and MBT. Several subsidiary faults, parallel to Teesta fault forming grabens are also reported from Rangpur ridge (Narula et al., 2000). Many northeasterly and northwesterly trending lineaments also cut across the Himalayan belt in this region. Some of them are: i) the Arun Lineament (NE-SW) believed to represent the northern extension of the East Patna Fault, ii) the Kanchendzonga Lineament (NW-SW) extends from the foredeep to well inside the Himalayan belt, iii) the Teesta Lineament (NW-SE), and iv) the Purnia-Everest Lineament (NW-SE).

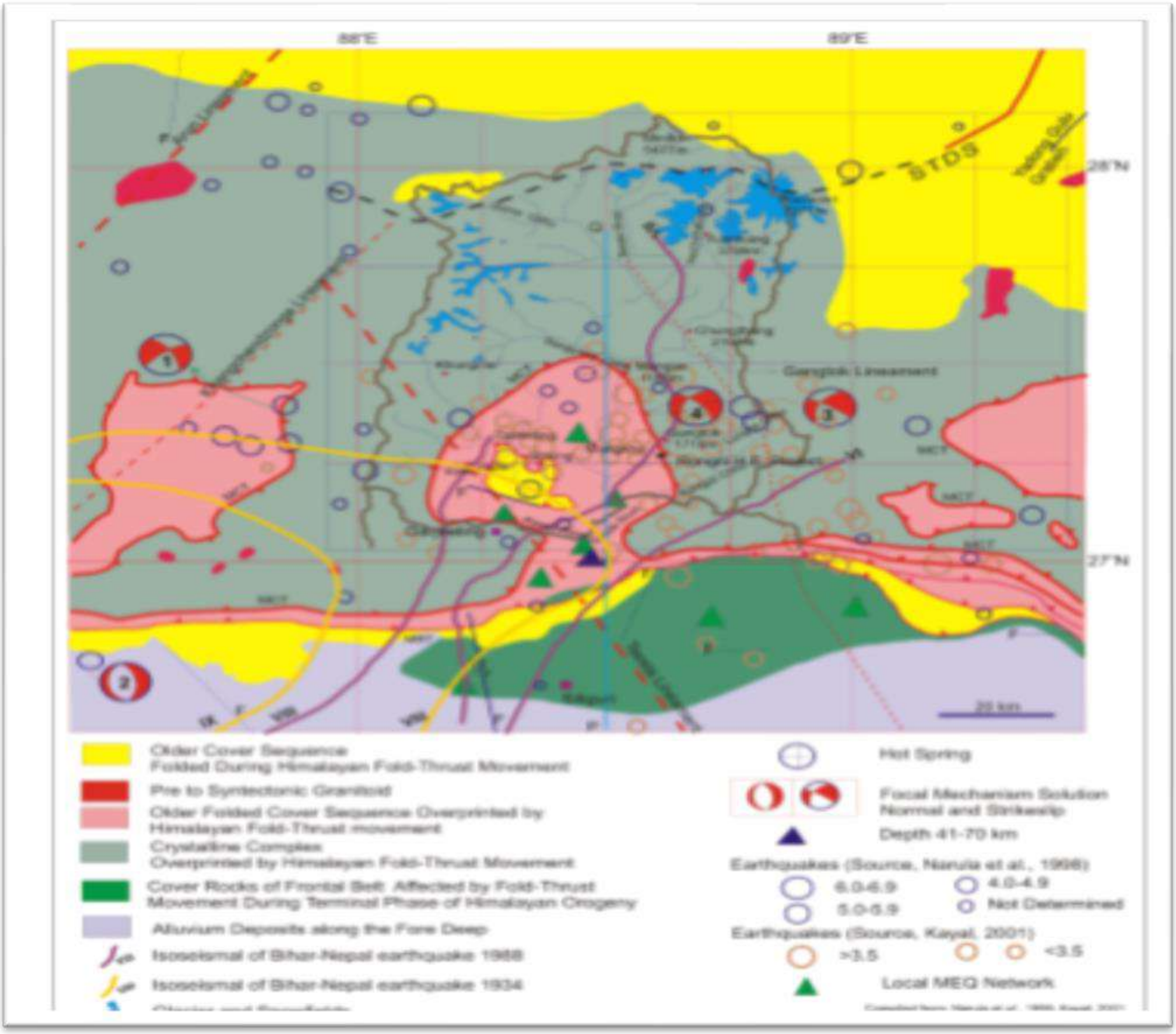


Figure 3.4: Seismotectonic Map of Sikkim and Project Area

3.4.8 Land use and Land Cover of the Study Area

Land use pattern has a significant influence on the quality and quantity of runoff available for a project. It plays an important role in determining the various hydrological phenomena like Infiltration rate, overland flow, evaporation and interception. The existing predominant land use class is dense forest (50.16%),followed by open forest (23.26%),agriculture land (20.29%), settlement(3.91%)andwaterbody (1.42%). The land use pattern of study area is enumerated in **Table 3.7** and shown in **Figure 3.5.**

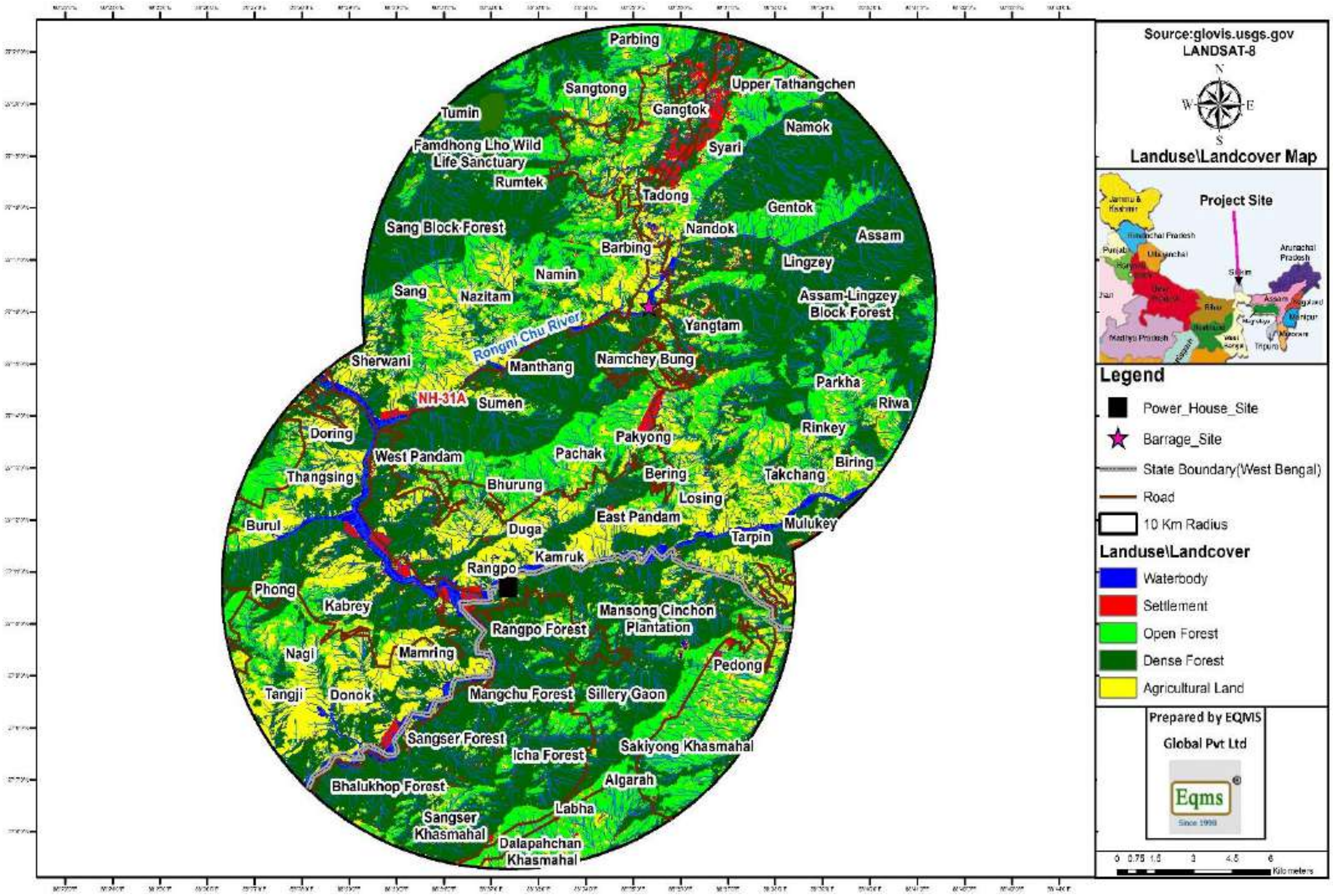


Figure 3.5**: Land use Land Cover of the Study Area**

Table 3.7: Land use & Land cover of Study Area

S. N.	Land use category	Area in sq. km	Area in %
1	Agriculture Land	106.29	20.29
2	Open Forest	121.83	23.26
3	Dense Forest	262.754	50.16
4	Waterbody	12.48	2.38
5	Settlement	20.54	3.91
Total		**523.88**	**100.00**

3.4.9 Slope of Study Area

The study area has hilly and plain topography. The general slope of the study area is from south to north and follows the general trend of drainage. The slope map of the study area is shown in **Figure 3.6** and the 7area under different slope classes is enumerated in **Table 3.8.** Almost 19.93% of the area is covers under very gentle to gentle slope and 80.07% with moderate to steep slope.

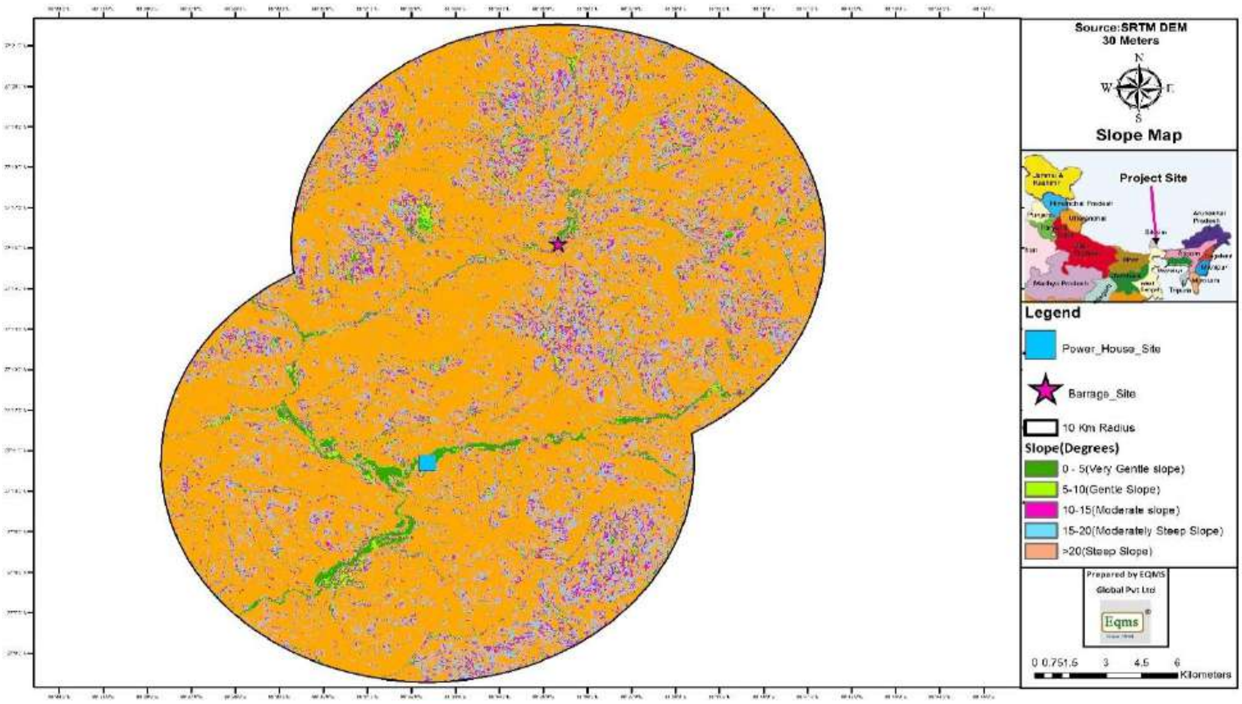


Figure 3.6: Slope Mapof Study Area

Table 3.8: Area under different Slope Class in Study Area

Sr. No	Description	Slope Range (Degrees)	Area under different class (Sq. km)	Area (%)
1	0-5	Very Gentle Slope	47.84	9.13
2	5-10	Gentle Slope	51.36	9.80
3	10-15	Moderate Slope	62.75	11.98
4	15-20	Moderately Steep Slope	77.37	14.77
5	>20	Steep Slope	285.06	54.42
Total			523.88	100.00

3.4.10 Presence of important economic mineral deposit, if any

No major occurrence of economic deposit (major mineral) is expected in the pond area, except materials like boulder, shingle, pebbles and sand that are minor mineral and important as the construction material.

3.4.11 Land Slide Zonation

No active and potential zones were identified.

3.4.12 Land Archaeological/Religious/Historical Monuments.

No archaeological monument of national importance lies in the project area. There is also no structure of national heritage in the area.

3.4.13 Sensitive Areas

Fambonglho Wildlife Sanctuary exists within 3.79 km from the project area but no part of the project falls within the ESZ of WLS as per map authenticated by the Chief Wildlife Warden and Environment, Sikkim,communicated by DFOWildlife East vide letter No. 360/WL/E,dated, 20.12.2019.

3.5 SOIL

3.5.1 Soil Type

A rapid soil survey of low intensity was conducted by the National Bureau of Soil Survey and Land Use Planning, Calcutta Regional Centre, during 1981 has established eight sub-groups and fifteen soil series and is shown in **Table 3.9**.

Table 3.9: Soil Series and Sub-group

Sl. No.	Soil Sub-Group	Soil Series
1.	Typic Haplumbrepts	Markong, Hilley
2.	Lithic Haplumbrepts	Gompa
3.	Typic Dystrochrepts	Lingtse, Losep, Namthang
4.	Litic Dystrochrepts	Machong
5.	Umbric Dystrocbrepts	Thekabong, Chatrikola, Padamchen
6.	Lithic Udorthents	Putuli, Simkara, Nandugaon
7.	Aquic udifluents	Majitar
8.	Ultic Hapludalfs	Tariku

Sikkim being a part of the Himalayas has a varied type of soil. Soils of this State in general, are derived from sedimentary and metamorphic rocks; as a result, they are loose in structure, thin and light in texture. As Sikkim experiences a wide variation of physiographic and vegetation conditions the composition of soil differs from place to place in the region. The texture, thickness and fertility of the soil are influenced by the gradient of soil, climate and vegetal cover. On the whole, the texture of the soil of the region is loamy sand to Silty Clay Loam with varying amount of coarse fractions. On an average the soil depth at hill slopes varies from 60 to 90 cm. Soils in the area are mostly derived from parent rocks such as schist, gneiss and colluvial materials. The characteristics of soil vary from place to place due to topographical variations. The texture of the Soil is loamy sand to Silty clay loam. Soils are generally acidic in nature and Brown Red and Yellow Soils are found in a small area around Rangpo town.The soil map of Sikkim is shown in **(Figure-3.7).**

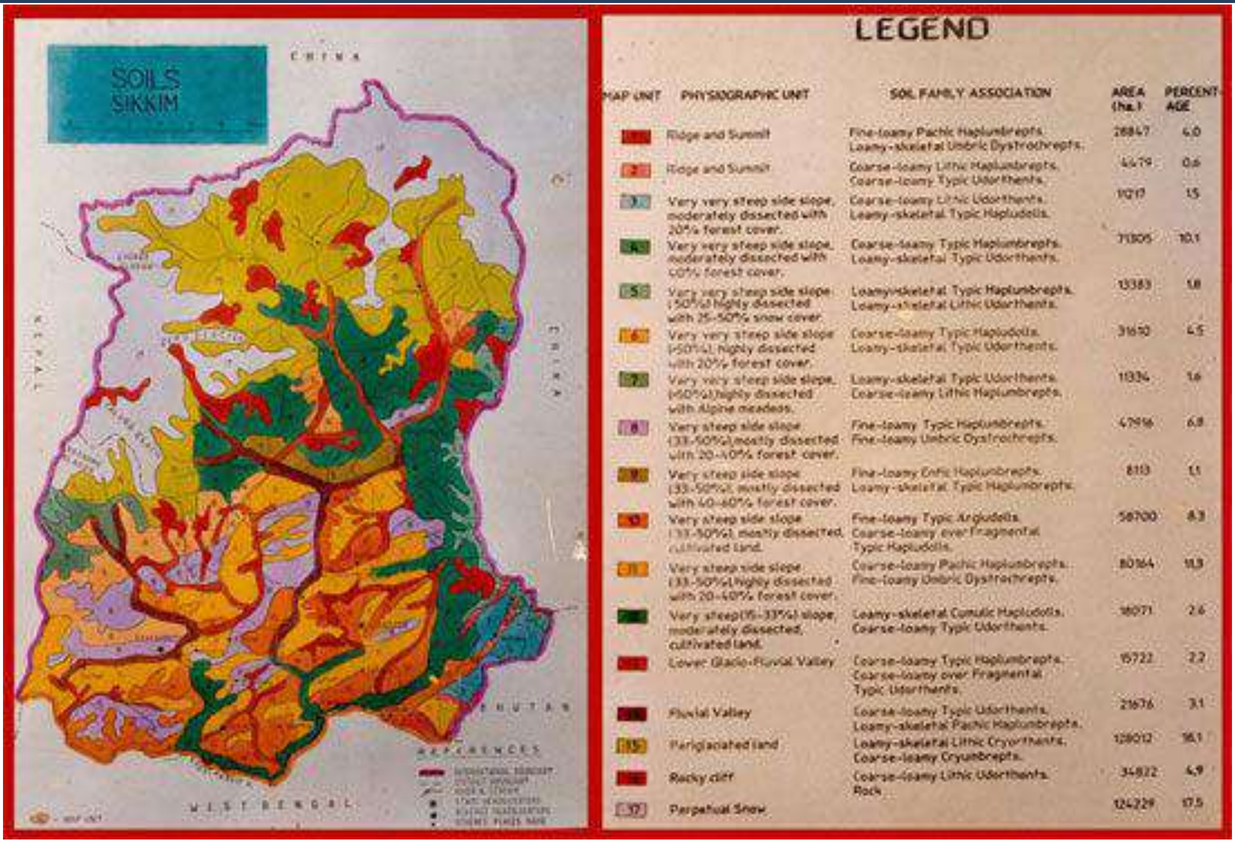


Figure 3.7: Soil Map of Study Area

3.5.2 Protocol for Assessment of Soil physico-chemical Properties

Methods Manual of Soil Testing in India, Department of Agriculture& Cooperation, Ministry of Agriculture, Government of India, New Delhi, shall be followed for collection of soil samples, its preparation for testing and analyzing various physico-chemical properties of soil (**Refer section 3.3.3.3).**

3.5.3 Selection criteria for Soil Sampling Location

For studying soil quality of the study area and with a view to ascertain the impacts due to construction activities on the nearby agriculture land forest land, six sampling locations, representing various land use conditions, were selected to assess the existing soil conditions in and around the project area of impact area. The location of the soil samples is presented in **Table 3.10** and shown in **Figure 3.8.**

Table 3.10: Soil Sampling Location

Station Code	Station Name	Environmental Setting (Forest, Barren, Agriculture Land)
S-1	Namli Village	Agriculture
S-2	Namchebung	Forest
S-3	Naibu	Agriculture
S-4	Nimtar	Agriculture
S-5	Power House	Forest

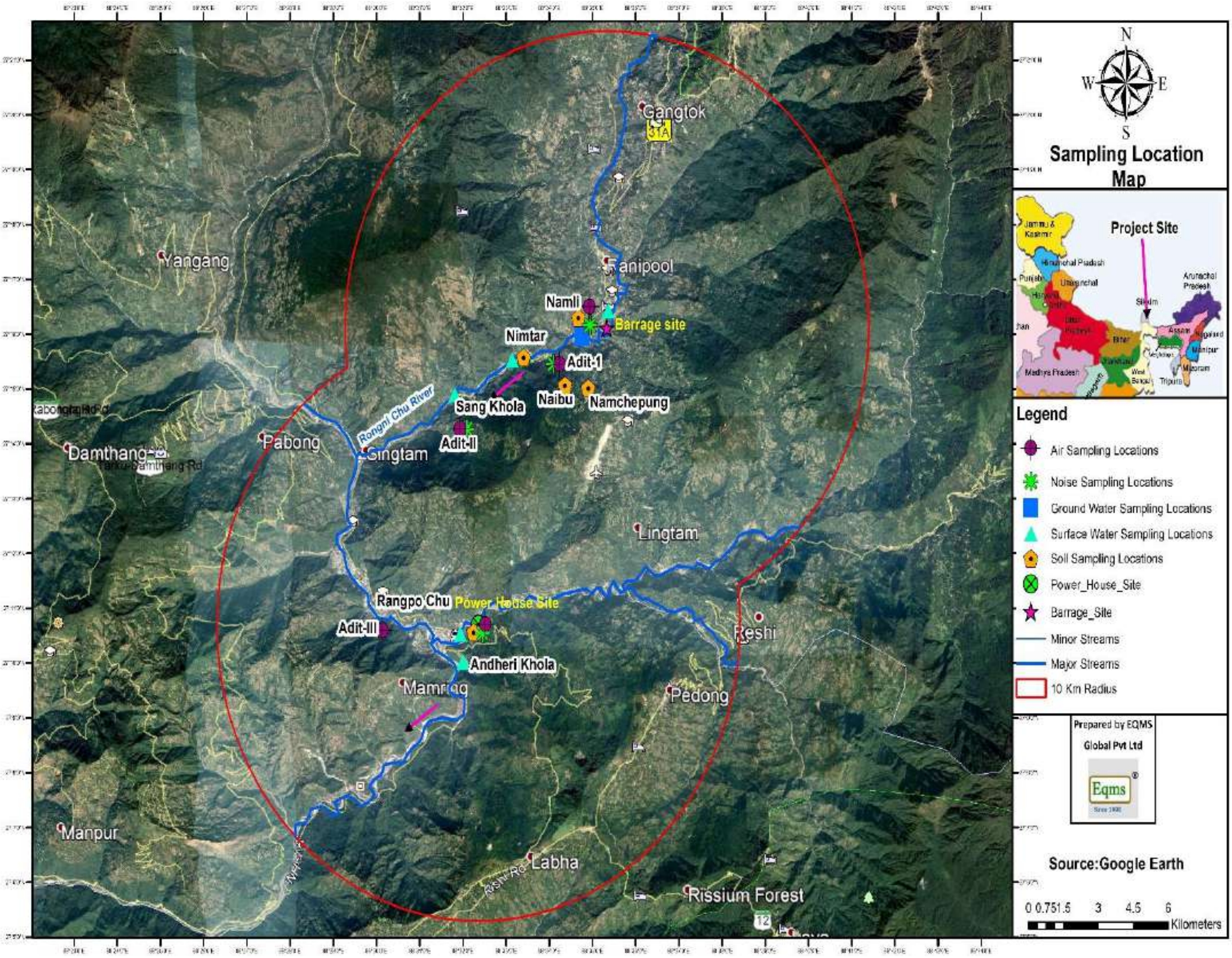


Figure 3.8: Sampling/Monitoring Locations

3.5.4 Soil Quality Analysis

The samples have been collected from the depth of 5cm to 15cm and representative samples prepared by thoroughly mixing. The homogenized samples were analyzed for physico chemical characteristics. The physical and chemical analysis results of the soil samples collected at site during Pre-monsoon, Monsoonand Post-monsoon ,2019 are presented in **Table 3.11** through **Table 3.13.**

Table 3.11: Physico-Chemical Characteristics of Soil (Pre-monsoon,2019)

S. N.	Parameter	Unit	Pre-Monsoon Season, 2019				
			S-1	S-2	S-3	S-4	S-5
Physical Characteristics							
1.	Texture	USDA Sy.	Silty Clay	Silty Clay	Silty Clay	Silty Clay	Silty Clay
2.	Porosity	%	48.0	54.0	53.2	49.8	56.6
3.	Bulk Density	gm/cc	1.38	1.22	1.24	1.33	1.15
4.	WHC	%	29.8	30.6	31.4	28.8	30.9
Chemical Characteristics							
5.	pH (at25°C)	1:2Suspension	6.26	5.85	5.56	6.45	6.41

6.	Conductivity (EC)	µmhos/cm	185.5	175.2	163.8	235.4	208.6
7.	CEC	meq/100 g	25.2	24.6	26.5	30.6	22.8
8.	Organic Carbon	%	0.68	0.72	0.85	0.70	0.66
9.	Calcium as Ca	mg/kg	624.2	645.2	655.8	635.5	652.2
10.	Magnesium as Mg	mg/kg	516.5	534.4	536.5	485.6	544.8
11.	Chloride as Cl	mg/kg	211.5	210.2	226.8	218.5	208.6
12.	Total Alkalinity	mg/kg	10.5	12.6	11.5	14.2	10.8
13.	Sodium as Na	mg/kg	212.5	225.8	246.5	210.2	225.5
14.	Salinity	mg/kg	115.3	119.5	134.5	132.2	125.6
15.	ESP	%	3.7	4.0	4.0	3.0	4.3
16.	**Available Nutrients**						
i).	Nitrogen as N	kg/ha	296.5	278.6	298.8	275.4	305.6
ii).	Phosphorus as P	kg/ha	11.5	10.5	14.6	12.5	11.8
iii).	Potassium as K	kg/ha	174.6	168.5	162.6	158.5	175.8
17.	SAR	-	1.51	1.58	1.72	1.53	1.57

Table 3.12: Physico-Chemical Characteristics of Soil (Monsoon, 2019)

S. N.	Parameter	Unit	Sampling Location				
			S-1	S-2	S-3	S-4	S-5
Physical Characteristics							
1.	Texture	USDA Sy	Silty Clay	Silty Clay	Silty Clay	Silty Clay	Silty Clay
2.	Porosity	%	49.4	55.1	54.0	50.6	56.9
3.	Bulk Density	gm/cc	1.34	1.19	1.22	1.31	1.14
4.	WHC	%	29.6	30.5	30.6	29.7	30.8
Chemical Characteristics							
5.	pH (at25°C)	1:2Suspension	6.06	5.62	5.32	6.42	6.84
6.	Conductivity (EC)	µmhos/cm	188.5	189.2	173.8	205.4	196.5
7.	CEC	meq/100 gm	24.2	22.4	21.6	28.8	23.5
8.	Organic Carbon	%	0.71	0.77	0.86	0.75	0.69
9.	Calcium as Ca	mg/kg	618.2	636.2	641.2	627.5	644.2
10.	Magnesium as Mg	mg/kg	512.5	525.4	520.5	478.6	535.8
11.	Chloride as Cl	mg/kg	205.4	210.8	216.8	214.5	204.6
12.	Total Alkalinity	mg/kg	12.5	14.6	11.8	14.9	12.8
13.	Sodium as Na	mg/kg	205.5	215.4	226.5	212.6	222.5
14.	Salinity	mg/kg	124.3	122.5	136.5	138.2	135.6
15.	ESP	%	3.6	4.2	4.6	3.2	4.1
16.	**Available Nutrients**						
i).	Nitrogen as N	kg/ha	298.5	288.6	302.8	295.4	308.6
ii).	Phosphorus as P	kg/ha	12.5	10.8	13.5	12.9	12.5
iii).	Potassium as K	kg/ha	171.6	166.5	159.6	156.5	172.6
17.	SAR	-	1.48	1.53	1.61	1.55	1.56

Table 3.13: Physico-Chemical Characteristics of Soil (Post-monsoon, 2019)

S. N.	Parameter	Unit	Sampling Location				
			S-1	S-2	S-3	S-4	S-5
Physical Characteristics							
1.	Texture	USDASystem	Silty Clay	Silty Clay	Silty Clay	Silty Clay	Silty Clay
2.	Porosity	%	46.4	51.3	50.2	47.9	52.5

3.	Bulk Density	gm/cc	1.42	1.29	1.32	1.38	1.26
4.	WHC	%	29.6	30.5	30.4	29.8	31.6
	Chemical Characteristics						
5.	pH (at25°C)	1:2Suspension	6.15	5.95	5.86	6.55	6.48
6.	Conductivity (EC)	µmhos/cm	184.2	171.6	165.4	215.8	206.5
7.	CEC	meq/100 gm	25.4	22.5	28.2	31.6	23.8
8.	Organic Carbon	%	0.71	0.76	0.88	0.74	0.68
9.	Calcium as Ca	mg/kg	622.6	641.4	636.5	628.4	627.2
10.	Magnesium as Mg	mg/kg	518.2	535.6	538.4	489.5	546.8
11.	Chloride as Cl	mg/kg	210.5	208.8	224.6	216.2	206.5
12.	Total Alkalinity	mg/kg	11.9	14.5	12.4	15.6	11.6
13.	Sodium as Na	mg/kg	214.5	226.4	248.6	211.4	227.7
14.	Salinity	mg/kg	114.2	118.4	128.5	131.2	120.6
15.	ESP	%	3.6	4.4	3.8	2.9	4.2
16.	**Available Nutrients**						
i).	Nitrogen as N	kg/ha	302.5	298.6	311.8	298.4	315.6
ii).	Phosphorus as P	kg/ha	10.2	9.4	12.5	11.2	10.6
iii).	Potassium as K	kg/ha	178.5	171.4	168.6	159.4	175.4
17.	SAR	-	1.52	1.58	1.74	1.54	1.45

3.5.5 Soil reaction classes, Nutrients Availability and Critical Limits

According to Soil Survey Manual (IARI, 1970), the soils are grouped under different soil reaction classes viz extremely acidic (pH<4.5), very strongly acidic (pH 4.5 – 5.0), strongly acidic (pH 5.1 – 5.5), moderately acidic (pH 5.6-6.0), slightly acidic (pH 6.1-6.5), neutral (pH 6.6- 7.3), slightly alkaline (pH 7.4-7.8), moderately alkaline (pH 7.9-8.4), strongly alkaline (pH 8.5-9.0).The soils are rated as low (below 0.50 %), medium (0.50-0.75 %) and high (above 0.75 %) in case of organic carbon, low (<280 kg ha-1), medium (280 to 560 kg ha-1) and high (>560 kg ha-1) in case of available nitrogen, low (< 10 kg ha-1), medium (10 to 25 kg ha-1) and high (> 25 kg ha-1) for available phosphorus, low (< 108 kg ha-1), medium (108 to 280 kg ha-1) and high (> 280 kg ha-1) for available potassium (Singh et. al. 2004, Mehta et. al.1988). Critical limits of Fe, Mn, Zn, Cu and B, which separate deficient from non-deficient soils followed in India, are 4.5, 2.0, 0.5, 0.2 and 0.5 mg kg-1 respectively. (Follet and Lindsay, 1970 and Berger and Truog, 1940).

3.5.6 Interpretation of Soil Characteristics

Interpretation of Soil Characteristic has been dwelled in following sub-sections:

Soil Texture: The soil textures refer to proportion of mineral composition of soil i.e., sand, clay and silt present in the soil sample. The most commonly observed soil textures are silty clay.

Soil pH: Soil pH is an important soil property, which affects the availability of several plant nutrients. It is a measure of acidity and alkalinity and reflects the status of base saturation. It measures the -ve logarithm of hydrogen ions activity of soil solution and defines the soil acidity and alkanity. The soil pH ranges from 5.32 to 6.84, thereby indicating the soils are strongly acidic toneutral.

Organic Matter: The effect of soil organic matter on soil properties is well recognized. Soil organic matter plays a vital role in supplying plant nutrients, cation exchange capacity, improving soil aggregation and hence water retention and soil biological activity. The organic carbon content of soil varied from 0.66% to 0.88 %, thereby implying that soils are medium to high in organic carbon.

Macronutrients: Nutrients like nitrogen (N), phosphorus (P) and potassium (K) are considered as primary nutrients and sulphur (S) as secondary nutrient. These nutrients help in proper growth, development and yield differentiation of plants and are generally required by plants in large quantity.

Available Nitrogen: Nitrogen is an integral component of many compounds including chlorophyll and enzyme essential for plant growth. It is an essential constituent for amino acids which is building blocks for plant tissue, cell nuclei and protoplasm. It encourages the aboveground vegetative growth and deep green color to leaves. Deficiency of Nitrogen decreasing rate and extent of protein-synthesis and result into stunted growth and develop chlorosis. Available nitrogen content in the surface soils ranges between275.4 to 315.6 kg/hathereby indicating that soils are low to medium in available nitrogen content.

Available Phosphorus: Phosphorus is important component of adenosine di-phosphate (ADP) and adenosine tri-phosphate (ATP), which involves in energy transformation in plant. It is essential component of deoxyribonucleic acid (DNA), the seat of genetic inheritance in plant and animal. Phosphorous take part in important functions like photosynthesis, nitrogen fixation, crop maturation, root development, strengthening straw in cereal crops etc. The availability of phosphorous is restricted under acidic and alkaline soil reaction mainly due to P-fixation. In acidic condition it gets fixed with aluminum and iron and in alkaline condition with calcium. Available phosphorus content ranges between 9.4 to 13.5 kg/hathereby indicating that soils are low tomedium in available phosphorus.

Available Potassium: Potassium is an activator of various enzymes responsible for plant processes like energy metabolism, starch synthesis, nitrate reduction and sugar degradation. It is extremely mobile in plant and help to regulate opening and closing of stomata in the leaves and uptake of water by root cells. It is important in grain formation and tuber development and encourages crop resistance for certain fungal and bacterial diseases. Available potassium content in the soil ranges between 156.5 to178.5kg/ha), thereby indicating mediumin potassium content in the area.

3.5.7 Inference

Soil nutrient status for N.P and K is better explained by working out Nutrient Index Value for each.Parker had classified the nutrient index values less than 1.5 as the indicative of low nutrient status and between 1.5 to 2.5 as medium while higher than 2.5 as high nutrient status.

The following equation is used to calculate Nutrient Index Value

Nutrient Index = {(Nl X 1) + (Nm X 2) + (Nh X 3)} / Nt

Nt = Total number of samples analysed for a nutrient in any given area.

Nl = Number of samples falling in low category of nutrient status.

Nm = Number of samples falling in medium category of nutrient status.

Nh = Number of samples falling in high category of nutrient status

Nutrient Index Value for, N = {(2X1) +(13X2) +(0X3)}/15=1.9 (medium)

Nutrient Index Value for, P = {(1X1) +(14X2) +(0X3)}/15=1.93(medium)

Nutrient Index Value for, K = {(0X1) +(15X2) +(0X3)}/15= 2.0(medium)

Soils have good organic carbon and are capable of supporting agriculture. The soils of study area are neither saline nor sodic as pH value of soils in all analysed samples is less than 8.5 and simultaneously the value of EC is less than 4 dS/m.

3.6 METETROLOGY, AIR AND NOISE

Meteorological factors have a direct bearing on the dispersion and dilution of pollutants/contaminants, discharged into the atmosphere with consequent impact on air Environment. Micro-meteorological properties of the atmosphere govern the concentration of pollutants and its variations with time and location with respect to their sources. Meteorological information is required to understand the climatic profile of the area as well as for devising the baseline ambient air quality monitoring plans. The climatologically summary for nearest IMD station at Gangtok is given in **Table 3.14** and the interpretation of the data is given in sub sections

Table 3.14: Climatological Summary for IMD Station in Gangtok (1981-2009)

Month	Mean max. temp (^{0}C)	Mean min. temp (^{0} C)	Monthly Rainfall (mm)	R.H.at 8:30 (%)	R.H.at 17:30 (%)	Av. Wind Velocity (kmph)
January	12.3	4.7	27.1	83	77	1
February	13.8	6.1	72.2	85	78	1.3
March	17.5	9.2	126.4	80	76	1.8
April	20.5	11.8	296.9	78	78	2.2
May	21.4	14.0	496.4	87	85	1.8
June	22.0	16.4	609.8	93	89	1
July	21.6	17.0	626.3	95	92	0.6
August	22.2	16.9	565.9	94	92	0.7
September	21.4	15.9	438.7	94	90	0.8
October	20.4	12.8	173.4	87	83	1.1
November	17.1	9.1	37.9	82	79	1
December	13.9	6.2	19.5	81	77	0.9
Average Total	**18.7**	**11.7**	**3490.4**	**86**	**83**	**1.2**

**Source: Government of India, India Meteorological Department, Climatologically Tables (1981-2010)*

3.6.1 Temperature

The mean daily maximum temperaturerecorded is 18.7° C while mean daily minimum temperature recorded is 11.7° C. The highest recorded temperature is 29.9 ° C (16.08.1990) while lowest temperature observed to be -2.2° C (10.1.1956

3.6.2 Rainfall

The south west monsoon during the month of June, July, August and September chiefly contributes the rainfall. The total annual rainfall is 3490.40 mm (1981-2010). The maximum total monthly rainfall is 1281.30 mm, which occurred in June ,1997 and minimum monthly rainfall in monsoon is 188 mm which occurred in September,1996. There are about 161 rainy days in a year). The heaviest fall for 24 hours was 470.10 mm (12.08.1984).

3.6.3 Relative Humidity

During the monsoon season, relative humidity generally varies between 87 to 94% in the morning. The air becomes dry after the withdrawal of the north-west monsoon.

3.6.4 Cloudiness and Special Weather Phenomena

The skies are generally moderately to heavily cloud during the monsoon season. The skies are mainly clear or lightly clouded during November to January months. The highest incidences of thunderstorms occur in the period March to May to. Hail, dust storm and squalls are rare in the region. Occasional fog occurs in the winter season.

3.6.5 Wind Pattern

Predominantwind direction is North and south. The average velocity is 1.2 kmph.The wind-rose diagram as sketched from the IMD Station at Gangtok is shown in **Figure 3.9.**

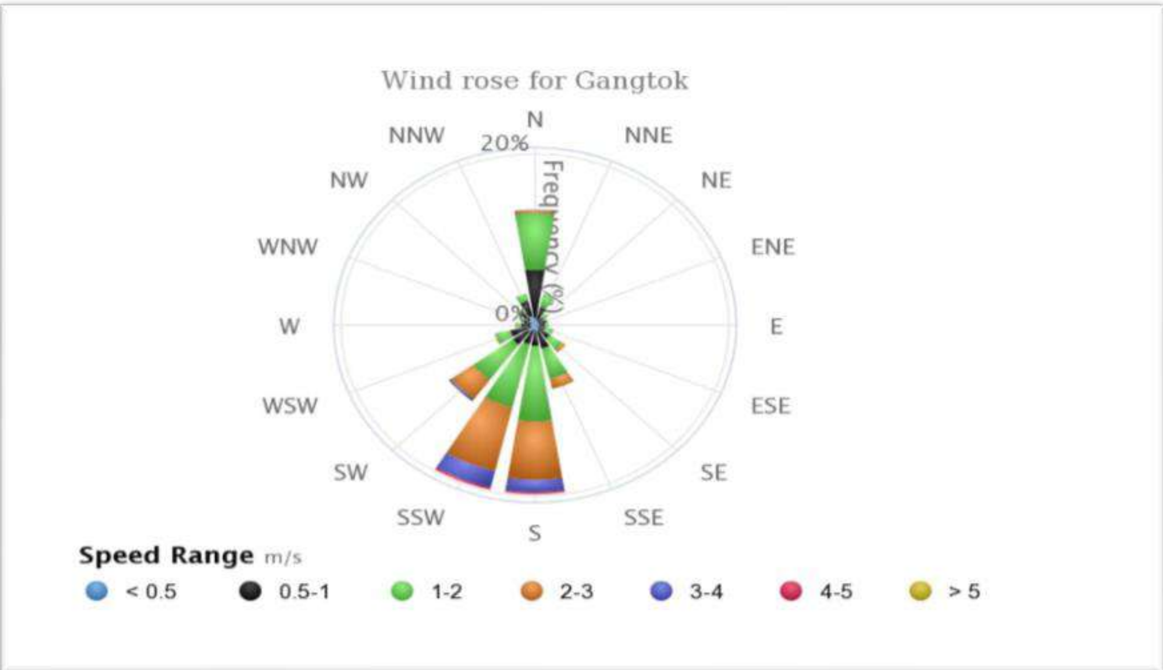


Figure 3.9: Wind-Rose Diagrams

3.6.6 Ambient Air Environment

Air pollution can cause significant effects on the environment and subsequently on human, animals, vegetation and materials. In most cases, air pollution aggravates pre-existing diseases or degrades health status, making people easily susceptible to other infections and development of chronic respiratory and cardiovascular diseases. Further, environmental impacts from air pollution can include acidic deposition and reduction in visibility.

The objective of the study is to analyze the existing ambient air quality within the study area and compare it with the NAAQ standards specified by CPCB to know about the pollution status of air in and around the project area. To quantify the impact of the construction activities on the ambient air quality at the construction site and its surrounding area, it is necessary to evaluate the existing ambient air quality in those areas.

3.6.6.1 Causes Attributing to Air Pollution in and Around Project Area

The existing causes of air pollution in and around project area are due to construction activities i.e. excavation, vehicular movement, dust arising from unpaved village roads and domestic fuel burning and forest fire. At present neither any new road is under construction in study area nor and widening of road is underway. There is no mining activity within the study area except for lifting of boulder and sand from riverbed at some places. The study area also does not house any air pollution intensive industry. The proposed project is hydro-electric project where no air pollution is envisaged during operation phase. During construction phase, minor air pollution may occur due to excavation, quarrying, blasting, drilling, vehicle and D.G set operation.

3.6.6.2 Rationale for Selecting Monitoring Station

Since the proposed site has no pollution intensive activities in its vicinity, five sampling stations located within 10.0 km of the site was considered to provide the surrounding baseline air quality. For the selection of the monitoring locations, long-term meteorological trends were taken into consideration to obtain the predominant wind direction during the sampling period. The monitoring station were selected keeping in view the sites like barrage (AAQ-1) and Adit-I (AAQ-2) where extensive construction activities like excavation, operation of stone crushing plant for production of aggregates and concrete batching plant shall be operative besides to and fro movements of trippers for carrying muck and construction material. The monitoring site at Adit-2 (AAQ-3) and Adit-3 (AAQ-4) and Powerhouse (AAQ-5) were selected due toongoing construction activities of balance work and increase in vehicular movement due to project.The ambient air quality monitoring locations are detailed in **Table 3.15** and shown in **Figure 3.8**.

Table 3.15: Air Monitoring Locations

Station Code	Locations	Approximate Distance (km)/ Direction from Barrage
AAQ-1	Barrage (Namli)	-
AAQ-2	Adit-I	0.6km (SW)
AAQ-3	Adit-II	3km (SW)
AAQ-4	Adit-III	8.0 km (S)
AAQ-5	Power House	12km(S)

3.6.6.3 Protocol for Ambient Level Noise Monitoring

The ambient air quality monitoring for pollutants was done by following Guidelines for Manual Sampling and Analyses (Volume-1) issued by CPCB in May,2011 (Refer section 3.3.3.1 of report)The ambient air quality monitoring during pre-monsoon , monsoon and post-monsoon ,2019 was conducted, on 24-hourly twice a week basis for PM10, SO_2 and NO_x for one month in each season for three seasons, by the EIA consultant through NABL accredited Laboratory. Monitoring was carried out. Summary results of ambient air quality monitoring data are shown in **Table 3.16** through **Table 3.18.**

Table 3.16: Ambient Air Quality Data (μg/m³) DuringPre-monsoon, 2019

St. Code	PM_{10}				NOx				SO_2			
	Min	Max	Mean	98%	Min	Max	Mean	98%	Min	Max	Mean	98%
AAQ-1	39	55	45	54	8.2	13.6	11.1	13.4	6.9	9.1	8.0	9.0
AAQ-2	35	44	40	44	<7	10.5	8.5	10.4	6.4	8.8	7.5	8.7
AAQ-3	35	48	40	47	<7	10.0	8.3	9.9	5.9	8.4	7.1	8.3

AAQ-4	37	58	48	57	7.2	10.4	8.7	10.2	6.7	9.5	8.0	9.4
AAQ-5	45	61	53	61	7.9	15.7	11.3	15.3	7.2	9.2	8.1	9.1
NAAQS for 24 hr	**100**				**80**				**80**			

Table 3.17: Ambient Air Quality Data (µg/m^3) During Monsoon, 2019

St. Code	PM10				NOx				SO2			
	Min	Max	Mean	98%	Min	Max	Mean	98%	Min	Max	Mean	98%
AAQ-1	27	40	32	39	<7	10.2	8.7	10.1	<5	7.5	6.2	7.4
AAQ-2	22	34	27	33	<7	8.5	7.7	8.5	<5	5.9	5.6	5.9
AAQ-3	25	35	29	35	<7	9.0	7.9	8.9	<5	5.8	5.5	5.8
AAQ-4	27	42	35	42	<7	9.4	8.2	9.3	<5	6.4	5.5	6.4
AAQ-5	25	39	32	38	<7	10.7	8.9	10.6	<5	7.3	6.0	7.3
NAAQS for 24 hr	**100**				**80**				**80**			

Table 3.18: Ambient Air Quality Data (µg/m^3) DuringPost -monsoon, 2019

St. Code	**PM_{10}**				**NOx**				**SO_2**			
	Min	**Max**	**Mean**	**98%**	**Min**	**Max**	**Mean**	**98%**	**Min**	**Max**	**Mean**	**98%**
AAQ-1	34	45	39	45	7.5	13.0	10.4	12.9	6.5	9.0	7.7	8.9
AAQ-2	32	39	35	39	<7	9.4	8.2	9.3	6.3	8.4	7.3	8.4
AAQ-3	34	46	40	45	<7	9.7	7.9	9.5	6.9	8.1	7.5	8.1
AAQ-4	36	51	44	51	<7	10.1	8.5	10.0	6.5	8.5	7.4	8.5
AAQ-5	40	54	48	54	7.3	13.8	10.3	13.6	7.6	9.0	8.3	9.0
NAAQS for 24 hr	**100**				**80**				**80**			

3.6.6.1 Interpretation of Results

The monitoring results of ambient air quality were compared with the National Ambient Air Quality Standards (NAAQS) prescribed by MoEFCC; GoI Notification dated 16.11.2009.The maximum concentration of PM_{10}, NO_X and SO_2 was 61µg/m^3, 15.7µg/m^3 and 9.5µg/m^{3}respectively.Thus, it was found that concentration of pollutants was within the limits of standards prescribed by CPCB.

3.6.6.2 inference from results

During monsoon frequent rains wash down the air borne particulates and other pollutants generated and dispersed from the sources in the environment, therefore the period from July to September is cleaner period in the year. The winter months are relatively much calm than other months. The prevailing calm conditions facilitate more stability to atmosphere and consequently slow dispersion of pollutants generated and help in buildup of pollutants in vicinity of the pollutant sources. Lower average mixing height in winter season results in less volume of troposphere available for mixing and hence higher concentrations of pollutants

3.6.7 Ambient Noise Environment

An assessment of baseline noise quality was undertaken to (a) establish the status of exposure of the major sensitive receptors, and (b) to identify the noise pollution levels in and around the site. The noise monitoring was done following CPCB protocol of Noise Monitoring, July 2015.

3.6.7.1 Causes Attributing to Noise Pollution in and Around Project Area

The existing causes of ambient air noise in and around project area are due to community sources, construction activities, vehicular movement and flow of river. At present neither any new road is under construction nor any widening of road, which involve drilling and blasting and running of plant and road construction machinery, is underway in study area. There is no mining activity involving drilling and blasting within the study area. The study area also does not house any noise pollution intensive industry, too. The proposed project is hydro-electric project where noise pollution may occur due to operation of shovels, dozers, rippers etc. for excavation, quarrying, blasting, drilling, vehicle and D.G set operation during construction. During post construction period higher noise levels are expected due to running of turbines and generator inside and near to power house

3.6.7.2 Selection criteria for noise Monitoring Location

The monitoring station were selected keeping in view the sites barrage (N-1)and Adit-I (N-2) where extensive construction activities like excavation, operation of stone crushing plant for production of aggregates and concrete batching plantshall be operative besides to and fro movements of dozer/trippers for carrying muck and construction material. The monitoring site at Adit-2 (N-3) and Adit-3 (N-4) and Powerhouse (N-5) were selected due to ongoing construction activities of balance work and increase in vehicular movement due to project. The monitoring locations are provided in **Table 3.19** and shown in **Figure 3.7.**

Table 3.19: Noise monitoring locations

Station Code	Locations	Approximate Distance (km)/ Direction from Barrage
N-1	Barrage (Namli)	-
N-2	Adit-I	0.6km (SW)
N-3	Adit-II	3km (SW)
N-4	Adit-III	8.0 km (S)
N-5	Power House	12km(S)

3.6.7.3 Protocol for Ambient Level Noise Monitoring

The noise monitoring was done following CPCB protocol of Noise Monitoring, July2015, in so far as site selection criteria, selection of Noise Level Meter, positioning of the instrument, monitoring time and monitoring protocol are concerned. In general monitoring location be selected such that it meets the land use pattern as prescribed in the standard e.g. Industrial, Commercial, Residential & Silence Zone.The station should be located at the ambient level i.e. away from the direct source, away from any vibration and any obstruction.One full day data was collected at each of the locations for each season i.e., during pre-monsoon, monsoonand post-monsoon,2019. The Noise monitoring results have been detailed in **Table 3-20.**

Table 3.20: Leq day and night-time noise levels

St.	Pre-monsoon (2019)	Monsoon (2019)	Post-monsoon (2019)

Code	Leq D	Leq N	Leq DN	Leq D	Leq N	Leq DN	Leq D	Leq N	Leq DN
N-1	49.2	37.4	47.6	50.0	37.9	48.4	47.2	36.1	45.6
N-2	47.9	37.5	46.3	47.1	36.3	45.5	46.9	36.9	45.4
N-3	47.2	36.0	45.6	47.8	36.6	46.2	47.0	36.6	45.4
N-4	48.7	37.6	47.1	48.5	37.1	46.9	48.1	36.4	46.5
N-5	48.7	37.1	47.1	48.0	37	46.4	50.3	41.9	48.8

3.6.7.4 Interpretation of Results

The highest noise levels recorded during daytime at powerhouse site (N5) is 50.3 dB (A) Leq and during nighttime it is 41.9 dB (A) Leq and both are within the CPCB limits. The major source of the noise in the study area is the flow of river, community noise and vehicular movement. The ambient air quality standards in respect of noise are 75, 65, 55 and 50 dB (A) Leq in daytime and 70, 55, 45 and 40 dB (A) Leq during nighttime for industrial, commercial, residential and silence zone respectively. The daytime noise level measured during 6:00 a.m. to 10:00 p.m. and night-time measured from 10:00 p.m. to 6:00 a.m.

3.6.7.5 Inference

Based on observed noise levels for monitoring locations the Noise Pollution Level for Community noise has been determined based on the relation: -

$NPL=L_{90} +(L_{10}-L_{90}) + \{(L_{10}-L_{90})^2\}/60$ dB

Thus, as per the indices the community noise level is the highest in Namli and the least near Adit-II**(Table 3.21).**The noise climate at these locations is shown in **Table 3.22**.

Table 3.21: Noise Pollution Level for Community Noise

Location	Noise Pollution Level for Community Noise		
	Pre-monsoon 2019	Monsoon 2019	Post-monsoon 2019
Barrage (Namli)	56.7	57.0	52.0
Adit-I	53.1	51.8	51.9
Adit-II	53.7	54.1	51.1
Adit-III	54.9	54.6	53.3
Power House	54.5	52.7	54.6

Table 3.22: NoiseClimate

Location	Noise Climate(dB)		
	Pre-monsoon 2019	Monsoon 2019	Post-monsoon 2019
Barrage (Namli)	17.2	17.6	14.5
Adit-I	14	14	13.1
Adit-II	15.3	16.2	13.1
Adit-III	16.1	16.6	15.1
Power House	15.6	14.3	12.8

3.6.8 Traffic Density

The traffic survey is essential to realistically and accurately assess the prevailing traffic volumes and travel characteristics by undertaking classified volume count. The objective of traffic volume count survey is to assess the traffic intensity on the most vulnerable section of the road under question. Traffic volume counts were manually undertaken for 2 days during October 2019 near village Namli on link road from NH-31A for capturing the realistic picture of the current volume and composition of traffic motorized i.e. passenger vehicles (two-wheeler, three-wheeler, bicycle, passenger car); utility vehicles (Jeep, Van, Mini Bus, Standard Bus); Goods vehicles – LCV (Freight), MCV (2 axle rigid chassis), MCV (3 axle rigid chassis), MAV and tractor trailer and non-motorized like animal driven cart.The analysis of traffic counts provides an estimate of average daily traffic (ADT). In order to convert recorded vehicles into a common scale, the passenger car units (PCU) equivalent factor as per IRC:64 -1990 has been adopted. **Table 3.23** reveals that the total ADT at traffic enumeration point on link road were 81 in terms of number which translates into 114 in terms of PCU.

Table 3.23: Traffic Volume Counts on Namli Link Road

S. N.	Nomenclature of Vehicle	PCU factor	No. of Vehicles / day	No. of PCU / day
1	Car / Jeep / Van	1	10	10
2	Two-Wheelers	0.5	20	10
4	Mini- Bus	1.5	0	0
5	Bus	3	0	0
6	Tempo / LCV	1.5	6	9
7	2/3 Axle Truck	3	25	75
8	Tractor	1.5	0	0
9	Cycle	0.5	20	10
Total			**81**	**114**

3.7 WATER QUALITY

Selected water quality parameters of ground water and surface water resources within 10 km radius of the study area has been studied for assessing the water environment and evaluate anticipated impact of the mining activity. Understanding the water quality is essential in preparation of Environmental Impact Assessment and to identify critical issues with a view to suggest appropriate mitigation measures for implementation. The purpose of this study is to:

- Assess the water quality characteristics for critical parameters; and
- Predict the impact of water quality by these mining and related activities.

The information required has been collected through primary surveys and secondary sources. Six groundwater sources and six surface water sources covering upstream & downstream of barrage site in the 10 km radial distance were examined for physico-chemical, heavy metals and bacteriological parameters in order to assess the effect of existing industrial and other activities on water.

For Ground Water sampling, the samples are collected from handpumps, taps and spring water. One of the sources of ground water is spring water since development of ground water is limited due to uncertainty of aquifers formation in hilly and steep terrain. Therefore, most of the water requirement is fulfilled from surface water. Mostly, springs are tapped at the source and water is supplied under Gravity, as hand pumps are available at very few places in the district. The samples were collected and analyzed once each for three seasons during the study period. Water sampling and analysis has been carried out to determine the existing baseline water quality around the project area. Sampling and analysis have been carried out with following standard guidelines for physical, chemical and bacteriological parameters. one ground water and five surface water sampling locations from the study area have been selected which is presented in **Table 3.24 & 3.25.**

Table 3.24: Ground Water Quality Monitoring Locations

S. No.	Station Code	Locations	Source
1	GW1	Namli	Bore well

Table 3.25: Surface Water Quality Monitoring Locations

S. No.	Station Code	Locations	Source
1	SW1	Rongnichu River (u/s barrage site near Namli Village)	River
2	SW2	Rongnichu River (d/sbarrage site near Andheri Khola	River
3	SW3	Martam Khola(near Nimtar village)	Stream
4	SW4	Sang Khola	Stream
5	SW5	Rangpo Chu (near Powerhouse)	River

3.7.1 Ground Water Quality Monitoring Results

Test reports for ground water monitoring during Pre-monsoon, Monsoon and Post-monsoon,2019, are tabulated in **Table 3.26.**

3.7.2 Interpretation of Ground Water Quality Results

Physico-chemical characteristics of ground water samples collected has been compared with the drinking water standard (IS 10500: 2012).

The analysis results indicate that the pH ranged between 7.32 to 7.41, which are well within the specified standard of 6.5 to 8.5 limit. Total hardness was recorded to range from 46 to 52 mg/l, which is more than the permissible limit 600 mg/l at all locations. The Total Dissolved Solids (TDS) concentration recorded ranged between 124 to 135 mg/l and was within the permissible limits (2000 mg/l).

Chlorides at all the locations were within the desirable limits (200 mg/l) as it ranged between 21.2-26 mg/l. Sulphates at all the locations were within the permissible limits (400 mg/l) as it ranged between 7.0- 7.5 mg/l. Fluorides recorded between ranged between 0.09–0.12 mg/l and were within the permissible limit (1.5mg/l). Nitrates were recorded to be ranging in between 0.18 to 0.2 mg/l and are found to be within the desirable limit (45mg/l). Bacteriological studies reveal that no coliform bacterial are present in the samples. The heavy metal contents were observed to be in below detectable limits. All physical and general parameters were observed within the desirable limit at all sampling locations as per IS10500:2012. Concentration of all parameters recorded in the ground water samples for all locations were within the permissible limit. The oil & grease level was below detectable limits in all the samples, which is expected in the project area, as there are no sources of pollution which can lead to increase oil & grease content in surface water. Apart from domestic sources, there are no sources of pollution in the project area. The project has no industries. Likewise, the fertilizer consumption is also low

Thus, it is recommended that water be filtered and disinfected prior to be given to villages for meeting their drinking water requirements.

Table 3.26: Ground Water Quality in the Study Area

S.No	Parameters	Unit	Limits As per IS: 10500:2012		Namli		
			Desirable	Permissible	Pre-monsoon	Monsoon	Post

							Monsoon
1	pH value	-	6.5-8.5	No Relaxation	7.41	7.35	7.32
2	Temperature	^{0}C	-	-	23.8	23.5	23
3	Conductivity	µS/cm	-	-	195	182	188
4	Turbidity	NTU	1	5	<1	<1	<1
5	Total Dissolved Solids	mg/l	500	2000	135	124	129
6	Total Suspended solids	mg/l	-	-	<2	<2	<2
7	Total Hardness (as $CaCO_3$)	mg/l	200	600	52	46	50
8	Chlorides (as Cl)	mg/l	250	1000	26	21.2	23.4
9	Total Alkalinity as $CaCO_3$	mg/l	200	600	32	25	27
10	Sulphate (as SO_4)	mg/l	200	400	7.5	7	7.4
11	Nitrate(as NO_3)	mg/l	45	No Relaxation	0.2	0.18	0.2
12	Fluoride (as F)	mg/l	1	1.5	0.12	0.09	0.1
13	Iron (as Fe)	mg/l	0.3	No Relaxation	0.12	0.1	0.12
14	Zinc (as Zn)	mg/l	5	15	0.65	0.58	0.6
15	Calcium (as Ca)	mg/l	75	200	15.6	10.8	13.5
16	Magnesium (as Mg^{2+})	mg/l	30	100	3.2	4.6	4
17	Sodium (as Na)	mg/l	-	-	6.2	5.5	6.0
18	Potassium (as K)	mg/l	-	-	2.0	1.8	2.0
19	Cadmium (as Cd)	mg/l	0.003	No Relaxation	<0.01	<0.01	<0.01
20	Copper (as Cu)	mg/l	0.05	1.5	<0.01	<0.01	<0.01
21	Nickel (as Ni)	mg/l	0.02	No Relaxation	<0.01	<0.01	<0.01
22	Lead (as Pb)	mg/l	0.01	No Relaxation	<0.01	<0.01	<0.01
23	Mercury (as Hg)	mg/l	0.001	No Relaxation	<0.001	<0.001	<0.001
24	Total Chromium (as Cr)	mg/l	0.05	No Relaxation	<0.05	<0.05	<0.05
25	Total arsenic (as As)	mg/l	0.01	0.05	<0.01	<0.01	<0.01
26	Phenolic Compounds (as C_6H_5OH)	mg/l	0.001	0.002	<0.001	<0.001	<0.001
27	Total Coliform	MPN /100ml	Shall not be detectable		Not detected	Not detected	Not detected

3.7.3 Surface Water Quality Monitoring Results

Table 3.27through **Table 3.29** shows the physico-chemical characteristics of surface water samples collected from upstream and downstream of river, during three seasons.

3.7.4 Interpretation of Surface Water Quality Results

The results were compared with the drinking water quality standard (IS: 2296-1982) reference values and in respect of Classification C for use as drinking water source with conventional treatment. Since the tolerance limits for various parameters for Class C are more stringent and comparison has been made with respect to it. The pH values of all analyzed samples ranged between 6.88 to 7.42 and were within the tolerance limit (6.5-8.5). The TDS levels ranged from 80 to 158 mg/l and werewithin thetolerance limit of 1500 mg/l. The chlorides level in surface water samples ranged from 21.5 to 32.8 mg/l and were below the tolerance limit of 600 mg/l. The sulphates level ranged from 5.2 to 8.5 mg/l and were below the tolerance limit of 400 mg/l. The fluorides level ranged between 0.1 to 0.22 mg/l was lower than the tolerance limit of 1.5 mg/l. The nitrate level ranged between 0.3 to 0.54 mg/l and were within the desirable limit of 50 mg/l. The BOD values exceeded the tolerance limit of 3.0 mg/l in some samples. The concentration of various heavy metals was below the tolerance limits, indicating the suitability of water for meeting domestic requirements. The concentration of cyanides and phenolic compounds were also below the tolerance limits. The Total Coliform level was within the limits specified for Class C water i.e. the water can be suitable for meeting drinking water requirements after conventional treatment and disinfection.

Table 3.27: Surface water quality (Pre-Monsoon, 2019)

S. No	Parameters	Unit	SW-1	SW-2	SW-3	SW-4	SW-5	Test method
1	pH value	-	6.95	6.88	7.28	6.9	7.1	IS :3025(Pt-11)1983RA2017
2	Temperature	^{0}C	17.6	18.2	18.8	17.5	16.9	IS: 3025(Pt-9)
3	Conductivity	mmhos/cm	236	222	240	170	136	IS: 3025(Pt-14)
4	Turbidity	NTU	4	4	5	6	5	IS: 3025(Pt-10)1984RA2017
5	Total Dissolved Solids	mg/l	155	150	158	116	92	IS: 3025(Pt-16)1984 RA 2017
6	Total Suspended solids	mg/l	10	12	8	10	10	IS-3025 (p-17) :1984 RA 2006
7	Total Hardness (as $CaCO_3$)	mg/l	38	40	48	38	46	IS: 3025(Pt-21)2009R2014
8	Chlorides (as Cl)	mg/l	22	22.8	26.8	21.5	25	IS: 3025(Pt-32) 1988R2014
9	Total Alkalinity as $CaCO_3$	mg/l	38	38	29	27	26	IS: 3025(Pt-23) 1986R2014
10	Sulphate (as SO_4)	mg/l	6.5	6.8	7.8	5.6	7.0	IS: 3025(Pt-24) 1986R2014
11	Nitrate (as NO_3)	mg/l	0.46	0.48	0.38	0.45	0.42	IS: 3025(Pt-34) 1988R2014
12	Fluoride (as F)	mg/l	0.12	0.14	0.18	0.16	0.2	APHA 23rd Ed, 4500 F (D)
13	Iron (as Fe)	mg/l	0.2	0.22	0.36	0.35	0.44	APHA 23rd Ed, 3111
14	Zinc (as Zn)	mg/l	0.62	0.56	0.64	0.64	0.58	APHA 23rd Ed, 3111
15	Calcium (as Ca)	mg/l	10.3	10.8	12.4	10	12.0	IS: 3025(Pt-40) 1991R2014
16	Magnesium (as Mg^{2+})	mg/l	3.0	3.2	4.0	3.2	4.0	APHA 23rd Ed, 3500 Mg B
17	Sodium (as Na)	mg/l	6.8	7	7.8	6.6	7.0	APHA 23rd Ed, 3500 Na (B)
18	Potassium (as K)	mg/l	3.0	3.2	3.0	2.8	4.0	APHA 23rd Ed, 3500 K (B)
19	Cadmium (as Cd)	mg/l	<0.01	<0.01	<0.01	<0.01	<0.01	APHA 23rd Ed, 3111
20	Copper (as Cu)	mg/l	<0.01	<0.01	<0.01	<0.01	<0.01	APHA 23rd Ed, 3111
21	Nickel (as Ni)	mg/l	<0.01	<0.01	<0.01	<0.01	<0.01	APHA 23rd Ed, 3111
22	Lead (as Pb)	mg/l	<0.01	<0.01	<0.01	<0.01	<0.01	APHA 23rd Ed, 3111
23	Mercury (as Hg)	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	APHA 23rd Ed, 3112
24	Total Chromium (as Cr)	mg/l	<0.05	<0.05	<0.05	<0.05	<0.05	APHA 23rd Ed, 3111
25	Total arsenic (as As)	mg/l	<0.01	<0.01	<0.01	<0.01	<0.01	APHA 23rd Ed, 3114

26	Phenolic Compounds (as C_6H_5OH)	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	IS: 3025(Pt-43) 1992R2014
27	Oil & Grease	mg/l	<1	<1	<1	<1	<1	IS: 3025(Pt-39) 1991R2014
28	Dissolved Oxygen	mg/l	7.4	7.2	6.5	7.0	7.2	IS: 3025(Pt-38) 1989R2014
29	BOD (for 3 Days 27 ˚C)	mg/l	3.0	3.2	3.0	3.5	3.6	IS: 3025(Pt-58) 2006R2012
30	COD	mg/l	10	12	12	14	14	IS: 3025(Pt-44) 1993R2014
Bacteriological Parameters								
31	Total Coliform	MPN/100ml	<100	<100	<100	<100	<100	IS: 1622-2003 RA - 2009

Table 3.28: Surface water quality (Monsoon, 2019)

S. No	Parameters	Unit	SW-1	SW-2	SW-3	SW-4	SW-5	Test method
1	pH value	-	7.14	7.04	7.42	7.02	7.28	IS :3025(Pt-11)1983RA2017
2	Temperature	^0C	17.0	17.8	17.2	18.1	17.3	IS: 3025(Pt-9)
3	Conductivity	mmhos/cm	210	206	225	155	122	IS: 3025(Pt-14)
4	Turbidity	NTU	<1	<1	<1	<1	<1	IS: 3025(Pt-10)1984RA2017
5	Total Dissolved Solids	mg/l	135	138	148	102	80	IS: 3025(Pt-16)1984 RA 2017
6	Total Suspended solids	mg/l	26	30	22	26	24	IS-3025 (p-17) :1984 RA 2006
7	Total Hardness (as $CaCO_3$)	mg/l	30	34	40	30	35	IS: 3025(Pt-21)2009R2014
8	Chlorides (as Cl)	mg/l	25.4	26	27.5	25	32.8	IS: 3025(Pt-32) 1988R2014
9	Total Alkalinity as $CaCO_3$	mg/l	35	36	28	26	24	IS: 3025(Pt-23) 1986R2014
10	Sulphate (as SO_4)	mg/l	7.2	7	8.5	6.0	7.1	IS: 3025(Pt-24) 1986R2014
11	Nitrate (as NO_3)	mg/l	0.54	0.5	0.46	0.48	0.46	IS: 3025(Pt-34) 1988R2014
12	Fluoride (as F)	mg/l	0.15	0.16	0.2	0.2	0.22	APHA 23rd Ed, 4500 F (D)
13	Iron (as Fe)	mg/l	0.24	0.25	0.4	0.38	0.5	APHA 23rd Ed, 3111
14	Zinc (as Zn)	mg/l	0.7	0.62	0.78	0.72	0.62	APHA 23rd Ed, 3111
15	Calcium (as Ca)	mg/l	7.8	9.6	10.5	8.2	10.2	IS: 3025(Pt-40) 1991R2014
16	Magnesium (as Mg^{2+})	mg/l	2.5	2.5	3.4	2.3	2.3	APHA 23rd Ed, 3500 Mg B
17	Sodium (as Na)	mg/l	6.1	6.2	7.2	5.6	5.8	APHA 23rd Ed, 3500 Na (B)
18	Potassium (as K)	mg/l	2.6	2.8	2.5	2.2	3.2	APHA 23rd Ed, 3500 K (B)

19	Cadmium (as Cd)	mg/l	<0.01	<0.01	<0.01	<0.01	<0.01	APHA 23rd Ed, 3111
20	Copper (as Cu)	mg/l	<0.01	<0.01	<0.01	<0.01	<0.01	APHA 23rd Ed, 3111
21	Nickel (as Ni)	mg/l	<0.01	<0.01	<0.01	<0.01	<0.01	APHA 23rd Ed, 3111
22	Lead (as Pb)	mg/l	<0.01	<0.01	<0.01	<0.01	<0.01	APHA 23rd Ed, 3111
23	Mercury (as Hg)	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	APHA 23rd Ed, 3112
24	Total Chromium (as Cr)	mg/l	<0.05	<0.05	<0.05	<0.05	<0.05	APHA 23rd Ed, 3111
25	Total arsenic (as As)	mg/l	<0.01	<0.01	<0.01	<0.01	<0.01	APHA 23rd Ed, 3114
26	Phenolic Compounds (asC_6H_5OH)	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	IS : 3025(Pt-43) 1992R2014
27	Oil & Grease	mg/l	<1	<1	<1	<1	<1	IS : 3025(Pt-39) 1991R2014
28	Dissolved Oxygen	mg/l	8.0	7.5	6.8	7.5	7.4	IS : 3025(Pt-38) 1989R2014
29	BOD (for 3 Days 27 ˚C)	mg/l	2.5	3	2.4	3.2	3.0	IS : 3025(Pt-58) 2006R2012
30	COD	mg/l	8	10	10	12	12	IS : 3025(Pt-44) 1993R2014
Bacteriological Parameters								
31	Total Coliform	MPN/100ml	<100	<100	<100	<100	<100	IS : 1622-2003 RA - 2009

Table 3.29: Surface water quality (Post-monsoon, 2019)

S. No	Parameters	Unit	SW-1	SW-2	SW-3	SW-4	SW-5	Test method
1	pH value	-	7.06	7.0	7.3	6.94	7.16	IS :3025(Pt-11)1983RA2017
2	Temperature	^0C	12.8	11.4	11.6	12	12	IS: 3025(Pt-9)
3	Conductivity	mmhos/cm	216	212	236	164	130	IS: 3025(Pt-14)
4	Turbidity	NTU	3	2	1	2	2	IS: 3025(Pt-10)1984RA2017
5	Total Dissolved Solids	mg/l	142	144	155	108	84	IS: 3025(Pt-16)1984 RA 2017
6	Total Suspended solids	mg/l	6	4	2	6	4	IS-3025 (p-17) :1984 RA 2006
7	Total Hardness (as $CaCO_3$)	mg/l	34	36	42	36	42	IS: 3025(Pt-21)2009R2014
8	Chlorides (as Cl)	mg/l	23	24.1	27	26.2	29.5	IS: 3025(Pt-32) 1988R2014
9	Total Alkalinity as $CaCO_3$	mg/l	40	42	32	30	29	IS: 3025(Pt-23) 1986R2014
10	Sulphate (as SO_4)	mg/l	6	6.5	7.4	5.2	6.5	IS: 3025(Pt-24) 1986R2014
11	Nitrate (as NO_3)	mg/l	0.4	0.45	0.3	0.4	0.38	IS: 3025(Pt-34) 1988R2014
12	Fluoride (as F)	mg/l	0.11	0.1	0.16	0.15	0.18	APHA 23rd Ed, 4500 F (D)

13	Iron (as Fe)	mg/l	0.2	0.2	0.3	0.32	0.4	APHA 23rd Ed, 3111
14	Zinc (as Zn)	mg/l	0.55	0.54	0.85	0.6	0.56	APHA 23rd Ed, 3111
15	Calcium (as Ca)	mg/l	9.8	9.8	11.0	9.6	11.2	IS: 3025(Pt-40) 1991R2014
16	Magnesium (as Mg^{2+})	mg/l	2.4	2.8	3.6	2.9	3.5	APHA 23rd Ed, 3500 Mg B
17	Sodium (as Na)	mg/l	6.4	6.5	7.5	6.2	6.6	APHA 23rd Ed, 3500 Na (B)
18	Potassium (as K)	mg/l	2.8	3.1	2.6	2.4	3.4	APHA 23rd Ed, 3500 K (B)
19	Cadmium (as Cd)	mg/l	<0.01	<0.01	<0.01	<0.01	<0.01	APHA 23rd Ed, 3111
20	Copper (as Cu)	mg/l	<0.01	<0.01	<0.01	<0.01	<0.01	APHA 23rd Ed, 3111
21	Nickel (as Ni)	mg/l	<0.01	<0.01	<0.01	<0.01	<0.01	APHA 23rd Ed, 3111
22	Lead (as Pb)	mg/l	<0.01	<0.01	<0.01	<0.01	<0.01	APHA 23rd Ed, 3111
23	Mercury (as Hg)	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	APHA 23rd Ed, 3112
24	Total Chromium (as Cr)	mg/l	<0.05	<0.05	<0.05	<0.05	<0.05	APHA 23rd Ed, 3111
25	Total arsenic (as As)	mg/l	<0.01	<0.01	<0.01	<0.01	<0.01	APHA 23rd Ed, 3114
26	Phenolic Compounds (as C_6H_5OH)	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	IS: 3025(Pt-43) 1992R2014
27	Oil & Grease	mg/l	<1	<1	<1	<1	<1	IS: 3025(Pt-39) 1991R2014
28	Dissolved Oxygen	mg/l	8.2	8.0	7.0	7.8	7.8	IS: 3025(Pt-38) 1989R2014
29	BOD (for 3 Days 27 °C)	mg/l	2.4	2.8	2.4	3.1	2.8	IS: 3025(Pt-58) 2006R2012
30	Chemical Oxygen Demand	mg/l	8	9.0	10.0	12.0	10.0	IS: 3025(Pt-44) 1993R2014
Bacteriological Parameters								
31	Total Coliform	MPN/100ml	<100	<100	<100	<100	<100	IS: 1622-2003 RA - 2009

3.8 WATER ENVIRONMENT AND HYDROLOGY

In order to conduct EIA studies baseline data pertaining to water environment of the project within the study area has been collected. The baseline data was studied for evaluating the basin characteristics, drainage pattern, hydrology, ground water regime and downstream water use.

3.8.1 Basin Characteristics

Rongni Chhu basin is a canoe shaped basin. The streams of this basin are rainfed as well as spring fed. The important left bank tributaries of RongniChhu are YaliChhu, ReshuChhu, Lakh Khola, TaksomChhu,AhoKhola, Andheri Khola and Rondu Khoa. The right bank tributaries are Rang Chhu, Chhuba Khola, Pagla Khola, Martam Khola and Sang Khola.

3.8.2 Drainage Pattern

Drainage is the single most entity, which defines the network antecedent river. The drainage pattern of the study area exhibits dendritic pattern. The majority of the area possesses a dendritic to sub-dendritic drainage containing irregular branching of the smaller tributaries. The closeness of these small branches is depending on the permeability of the underlying rocks and the amount and nature of precipitation. It is the most common drainage pattern of hillside slopes of the study area. The sub-parallel drainage pattern comprises a series of streams which run approximately parallel to each other. They are evolved in areas of uniformly dipping rocks

3.8.2.1 Gross Trellis

The trellis drainage pattern is normally developed in the hillside slopes and usually aligned along the strike of the rock formation. The softer rocks like phyllitic slates exhibit such drainage. The trellis drainage pattern is well developed in the terraces and lower most reaches of the valley. The majority of the area possesses a dendritic to sub-dendritic drainage containing irregular branching of the smaller tributaries. The closeness of these small branches is depending on the permeability of the underlying rocks and the amount and nature of precipitation. It is the most common drainage pattern of hill side slopes of the study area.

3.8.2.2 Gross Radial, Local Annular

The radial drainage pattern is a characteristic feature of the high altitudinal zone specially the summit surfaces. Litho logically, these areas are constituted by the resistant and impervious rocks with steep slopes. The sub-parallel drainage pattern comprises a series of streams which run approximately parallel to each other. They are evolved in areas of uniformly dipping rocks.

3.8.2.3 Gross Sub-Parallel, Local Sub-Rectangular

The major river in the study area is antecedent in nature. The sinuosity, braiding and meandering in the river course is generally noticed, although at some places, they are straight and narrow. Due to the increase of the drainage area and the discharge, the river valley becomes wider in downstream with flattened gradient.

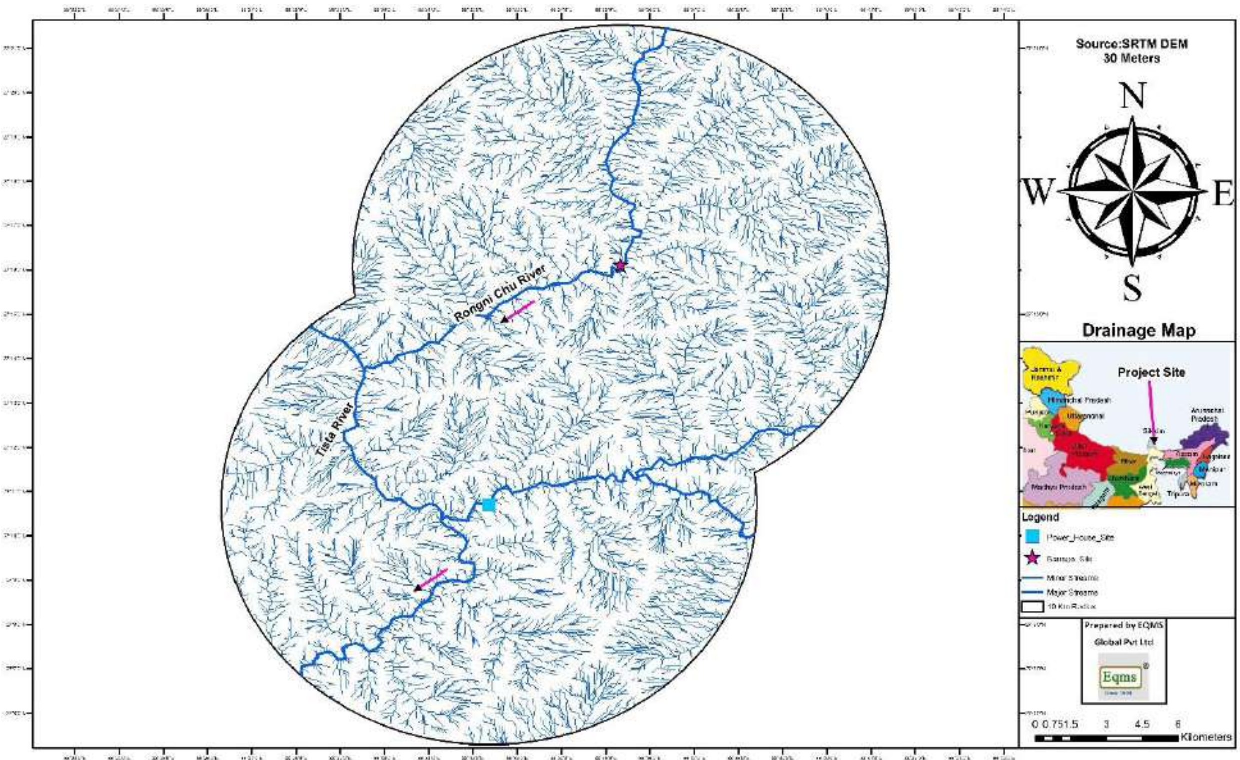


Figure 3.10: Drainage Map of Study Area

3.8.3 Hydro-meteorological Data

For a hydro-electric project the important hydrological parameters which have a bearing on the project and its design are the water availability, occurrence of storms in and around the basin, the design flood and diversion flood estimation and the sediment inflow rate entering into the reservoir. Detailed hydrological studies have already been conducted in respect of 10-daily water availability series, probable maximum design flood and silt rate at the barrage site.

3.8.3.1 Rain fall Data Availability

Thereare five rain gauge stations in around the project region viz.,Sankalang,Dikchu,Gangtok,Tadong and Kalimpong of which Gangtok and Tadong cover catchment of Rognichhu. Monthly and annual normal based on these stations are given in **Table 3.30.**

Table 3.30: Annual Rainfall(mm)at Different Rain Gauge Stations

Month	Sankalang (1992-98)	Dikchhu (1975-2006)	Gangtok (1959-80)	Tadong 1959-80)	Kalimpong (1959-80)
January	82	29.2	40	22	17
February	165	68.5	50	60	10
March	241	131.3	127	106	34
April	200	239.6	271	261	66
May	372	425.2	535	450	124
June	578	523.6	650	537	402
July	499	490.1	666	537	665
August	370	419.3	578	495	505

September	354	396.5	429	412	336
October	199	169.5	180	148	113
November	35	44.5	36	30	8
December	34	22.1	17	18	2
Total	**3129**	**2959.4**	**3581**	**3076**	**2281**

3.8.3.2 Discharge Data Availability

The stream flow records of 10-daily of the Rongni Chhu at the Singtam gauge site (Catchment area = 246 km2) are available for past 6 years (May 1994-Apr 2003). Records are also available for the neighboring streams viz. i) Rangpo Chhu at Rangpo Bridge (catchment area 626 km2) for 13 years (May 1972-Apr 1985) and 5 years (May 1990- Apr 1995), ii) Rangit river at Stage-III dam site (catchment area 962 km2, 262 km2 snowfed, 700 km2 rainfed) for 27 years (May 1975-Apr 2000). The discharge data availability with period at different G&D sites is shown in **Table 3.31.**

Table 3.31: Discharge Data Availability Period at Different G&D Sites

River	Gauging Station	Catchment Area(s.km)	Period of Record
Rongni Chhu	Singtam	246	May 1994- April 2003
RangpoChhu	Rangpo bridge	626	May1972- April 1985
Rangit River	Stage-III dam site	962	May 1975- April 2000

3.8.4 Water Availability

Based on the above discharge data sets, after eliminating the inconsistencies, a long-term stream runoff series (31 years; from 1972-73 to 2007-08) at the Rongni barrage site was obtained.The observed stream flow series at Singtam (1994-95 to 2002-03) with an annual runoff of 3145.3mm is scaled to 3166mm. The average annual runoff of 3166mm is considered as a "reasonable looking" assessment.

3.8.4.1 Flow series at barrage Site for period 1972-73 to 2007-08.

The Assuming that the stream flow is proportional to the catchment area, streamflow series at Rongni chhu barrage site has been developed based on 10 daily stream flow series of 31 years as per the pattern of the data at source viz.,Rongni chhu, Rangpo chhuand Rangit riverfrom where the data are transferred to the project barrage site. The approved 10-daily discharge series at the project site so derived by above method for the period 1972-73 to 2007-08 is enclosed in **Table 3.32.**

Table 3.32: Ten Daily Flow Series at Barrage Site (cumec)

Month	10-daily	72-73	73-74	74-75	75-76	76-77	77-78	78-79	79-80	80-81
June	1 to10	24.97	15.54	15.80	10.96	21.93	45.57	29.50	6.80	25.84
	11 to 20	27.52	34.74	13.32	16.36	17.55	22.31	56.03	14.21	48.14
	21 to 30	30.49	33.30	19.38	30.38	20.81	31.03	47.10	18.83	36.41
July	1 to 10	50.17	27.69	29.77	56.26	48.81	37.99	40.44	18.94	56.59
	11 to 20	37.97	22.23	42.96	40.37	51.50	52.71	50.36	34.83	68.53

	21 to 30	59.00	37.07	103.63	36.47	37.61	39.64	63.02	66.11	48.95
Aug	1 to 10	71.46	59.99	70.20	17.18	46.59	65.69	60.78	57.51	50.20
	11 to 20	65.92	73.50	29.17	14.33	66.05	33.29	40.58	27.54	45.51
	21 to 30	55.97	47.23	35.88	16.78	32.77	31.71	22.49	40.69	41.32
Sep	1 to 10	65.97	40.18	28.92	39.24	30.87	30.21	27.64	53.10	40.90
	11 to 20	48.27	38.17	33.28	42.84	26.60	25.96	40.25	36.81	29.84
	21 to 30	56.77	29.75	23.59	34.49	19.09	17.69	30.26	20.76	29.78
Oct	1 to 10	25.52	39.74	19.20	34.40	16.32	25.86	22.25	22.17	29.15
	11 to 20	19.56	77.13	15.54	23.55	10.73	19.91	16.06	25.52	18.65
	21 to 30	16.01	30.18	10.57	14.48	8.05	15.27	11.66	13.96	16.05
Nov	1 to 10	11.98	24.59	8.32	11.70	7.77	13.89	12.90	14.70	15.77
	11 to 20	9.71	8.00	5.72	10.52	6.14	10.28	12.62	12.53	13.96
	21 to 30	7.37	9.77	4.74	10.27	5.15	8.17	15.12	11.69	12.14
Dec	1 to 10	6.67	6.17	3.73	7.81	4.19	6.58	12.83	15.16	10.35
	11 to 20	5.15	5.51	3.76	7.02	4.59	6.24	11.04	10.17	8.95
	21 to 30	4.69	3.73	3.18	5.14	4.06	5.42	10.09	8.91	8.15
Jan	1 to 10	4.09	3.91	3.25	4.90	3.49	5.56	8.91	8.07	8.56
	11 to 20	2.96	3.10	5.53	4.65	2.96	4.42	6.43	6.25	7.69
	21 to 30	2.60	3.28	7.15	4.74	2.53	4.74	3.92	6.26	7.08
Feb	1 to 10	2.32	3.91	8.68	4.60	1.89	4.96	3.80	6.22	6.05
	11 to 20	2.16	3.10	5.26	4.54	1.74	5.44	4.24	6.08	5.51
	21 to 28	4.10	3.28	5.18	5.00	1.87	4.28	5.76	5.78	4.48
March	1 to 10	4.13	3.91	3.27	5.60	1.73	3.41	4.55	5.76	4.28
	11 to 20	4.27	3.10	3.39	4.58	2.53	4.64	4.30	7.07	5.33
	21 to 30	4.44	3.28	2.19	4.62	2.66	4.09	3.99	7.38	5.74
April	1 to 10	6.38	3.91	3.13	3.87	9.09	4.24	4.25	9.65	7.97
	11 to 20	4.80	3.10	2.05	4.76	11.95	9.02	50.06	13.39	8.68
	21 to 30	7.79	3.28	4.09	7.68	9.57	12.54	5.29	17.49	15.14

May	1 to 10	12.42	5.69	8.57	23.55	8.34	12.79	8.75	9.27	12.80
	11 to 20	21.01	7.55	5.83	4.42	13.41	18.44	35.57	13.48	24.01
	21 to 30	12.13	12.15	12.63	9.32	34.48	45.35	7.55	25.68	15.25

Month	10-daily	81-82	82-83	83-84	84-85	85-86	86-87	87-88	88-89	89-90
June	1 to10	20.43	15.98	30.59	22.72	24.91	15.36	10.58	10.58	27.77
	11 to 20	19.91	21.52	23.65	23.44	29.95	24.61	17.24	17.24	56.23
	21 to 30	31.09	26.41	49.11	25.19	28.51	24.00	36.37	36.37	44.60
July	1 to 10	46.48	24.88	54.76	27.51	32.18	33.09	42.22	38.28	48.44
	11 to 20	25.39	33.30	44.57	30.48	34.16	32.72	33.58	34.53	49.05
	21 to 30	33.54	37.89	37.33	34.63	42.32	29.71	31.45	40.14	42.98
Aug	1 to 10	30.34	83.17	26.21	32.84	31.45	27.16	46.24	46.36	30.47
	11 to 20	29.47	83.12	22.08	27.06	31.45	20.47	48.04	46.07	30.61
	21 to 30	33.47	83.06	25.51	41.13	23.32	26.06	27.63	36.66	30.22
Sep	1 to 10	44.18	42.16	39.52	69.14	30.39	22.92	44.79	40.83	27.50
	11 to 20	38.73	38.85	39.38	55.25	29.07	25.74	27.72	29.61	26.74
	21 to 30	17.03	28.87	30.57	32.44	26.92	24.61	31.47	24.91	26.55
Oct	1 to 10	11.70	18.98	20.32	24.56	19.67	22.65	20.55	15.97	33.06
	11 to 20	7.42	12.23	20.18	24.36	49.89	19.10	12.02	14.87	24.64
	21 to 30	5.87	22.36	15.73	17.95	15.87	13.30	9.33	12.86	18.69
Nov	1 to 10	6.11	11.76	8.33	14.83	5.89	7.07	6.75	9.56	12.96
	11 to 20	5.57	9.89	6.78	12.52	5.39	5.65	5.33	8.35	11.32
	21 to 30	4.41	8.32	5.59	11.10	4.74	5.59	5.27	8.39	10.29
Dec	1 to 10	3.76	7.66	4.56	11.22	3.63	8.37	5.17	8.35	9.03
	11 to 20	3.39	6.68	3.74	11.60	2.90	8.14	5.12	7.80	7.84
	21 to 30	2.23	5.83	3.40	10.04	2.92	7.58	4.50	7.70	7.31
Jan	1 to 10	2.10	5.08	2.56	5.24	2.92	6.46	4.31	5.45	7.25
	11 to 20									

		1.87	4.55	2.67	4.70	2.86	5.35	4.35	7.07	6.40
	21 to 30	1.69	4.43	2.65	4.58	2.86	4.80	4.33	6.79	5.57
Feb	1 to 10	1.75	4.25	2.64	4.36	2.84	4.64	3.99	6.83	6.02
	11 to 20	1.72	3.98	2.50	4.07	3.00	4.42	3.87	6.40	6.14
	21 to 28	1.68	4.12	1.96	4.23	2.94	4.31	3.41	6.60	6.79
March	1 to 10	1.66	3.84	2.85	3.95	2.94	4.31	2.80	6.91	7.09
	11 to 20	1.65	3.97	2.79	4.09	2.94	4.31	6.48	7.68	7.31
	21 to 30	2.23	3.95	3.01	4.08	2.94	4.58	6.68	7.72	7.21
April	1 to 10	5.39	5.49	3.68	5.49	2.92	6.99	6.68	7.39	7.11
	11 to 20	4.98	6.49	4.89	6.49	2.90	6.85	6.54	7.52	9.60
	21 to 30	5.50	8.18	8.74	8.18	3.32	7.03	6.99	7.72	9.72
May	1 to 10	8.46	10.29	12.13	7.37	7.81	10.04	9.65	10.29	10.29
	11 to 20	8.87	13.49	19.72	7.62	8.13	11.05	10.65	9.18	9.85
	21 to 30	9.27	15.83	21.96	16.58	10.87	11.61	11.22	32.79	11.00

Month	10-daily	90-91	91.92	92-93	93-94	94-95	95-96	96-97	97-98	98-99
June	1 to10	36.13	23.96	17.18	37.47	25.24	27.83	19.62	42.93	74.18
	11 to 20	31.44	26.11	10.81	24.74	30.41	31.87	14.84	56.02	86.86
	21 to 30	68.29	32.94	10.82	40.43	29.74	37.16	22.40	43.79	44.22
July	1 to 10	93.56	30.60	74.43	44.10	26.21	53.45	25.40	44.80	47.07
	11 to 20	104.27	38.15	65.99	25.16	22.03	53.22	36.83	44.10	41.37
	21 to 30	92.55	37.05	24.28	54.30	28.36	42.51	35.26	31.46	47.02
Aug	1 to 10	79.73	44.35	68.03	96.47	28.88	41.67	32.84	53.06	30.82
	11 to 20	80.33	50.14	68.15	85.54	42.85	45.79	42.62	48.13	37.78
	21 to 30	56.30	49.40	76.82	85.70	43.93	47.36	34.83	33.98	33.04
Sep	1 to 10	17.43	57.60	43.74	28.57	35.54	46.63	29.20	32.58	25.49
	11 to 20	18.77	38.53	42.99	32.24	32.38	36.73	25.07	32.63	11.06
	21 to 30	19.96	17.27	31.76	48.98	25.29	38.18	26.13	36.09	38.04

Oct	1 to 10	15.70	11.79	29.80	22.97	34.25	26.16	38.94	20.53	18.45
	11 to 20	14.91	12.01	28.74	21.66	22.64	21.44	19.81	14.78	24.76
	21 to 30	8.00	10.25	28.90	15.33	22.90	14.57	14.31	12.43	31.27
Nov	1 to 10	5.88	10.36	12.31	18.12	23.67	20.94	9.89	9.83	4.83
	11 to 20	5.11	9.34	9.71	16.71	18.02	20.87	7.85	8.46	3.98
	21 to 30	4.52	8.65	8.95	16.20	17.12	15.73	4.62	7.37	3.69
Dec	1 to 10	4.07	8.07	7.66	9.79	13.81	11.47	4.59	6.85	2.97
	11 to 20	3.67	7.55	6.68	7.83	13.43	8.82	5.43	7.08	2.73
	21 to 30	3.67	7.61	5.83	7.20	8.90	6.62	5.89	7.41	2.39
Jan	1 to 10	3.40	7.30	6.77	5.93	5.14	5.90	3.91	5.92	2.24
	11 to 20	3.25	6.62	7.34	4.86	4.25	6.13	2.98	5.19	2.03
	21 to 30	2.89	6.83	8.19	4.31	3.96	5.55	4.62	4.82	1.94
Feb	1 to 10	2.74	6.52	5.44	4.07	3.32	5.41	5.65	4.45	1.86
	11 to 20	2.70	6.48	5.72	4.00	3.27	4.97	4.52	5.20	1.79
	21 to 28	2.70	5.33	6.07	3.80	3.05	4.38	4.71	4.82	1.80
March	1 to 10	2.58	5.93	5.41	4.35	3.04	4.93	5.25	5.21	1.74
	11 to 20	2.69	5.69	5.07	4.43	3.00	6.22	5.22	4.84	1.68
	21 to 30	2.69	5.67	5.01	4.25	3.63	4.59	4.31	7.26	1.72
April	1 to 10	3.29	6.40	5.12	5.97	4.19	4.44	6.91	6.33	2.34
	11 to 20	3.85	7.22	5.05	8.54	4.07	5.48	9.24	6.68	3.14
	21 to 30	3.99	7.42	5.08	9.11	8.14	7.34	8.29	7.50	11.07
May	1 to 10	4.09	7.44	6.02	11.86	4.85	21.26	9.30	24.76	13.44
	11 to 20	5.92	9.78	6.69	10.96	15.66	25.54	10.60	17.72	8.03
	21 to 30	7.57	11.2	8.29	15.63	24.76	19.75	12.90	18.09	12.32

Month	10-daily	99-2000	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08

June	1 to10	10.76	8.84	18.32	48.94	4.22	30.28	44.09	23.42	20.89
	11 to 20	22.15	117.01	23.76	35.25	5.50	39.40	57.38	30.48	27.18
	21 to 30	43.66	27.07	36.10	32.96	5.72	41.01	59.72	31.73	28.29
July	1 to 10	83.76	31.25	26.64	43.80	46.50	42.51	63.34	37.01	65.93
	11 to 20	44.94	37.07	30.06	40.66	45.24	41.35	61.62	36.97	64.14
	21 to 30	47.94	39.61	28.84	37.61	52.25	47.76	71.17	42.70	74.08
Aug	1 to 10	40.85	38.85	25.23	48.50	35.41	38.94	47.24	40.39	62.67
	11 to 20	46.96	41.34	37.78	49.44	33.74	37.10	45.01	38.49	59.72
	21 to 30	54.85	41.75	42.55	50.15	34.26	37.67	45.70	39.08	60.64
Sep	1 to 10	48.33	43.71	34.78	30.40	37.75	29.31	44.17	38.90	68.94
	11 to 20	44.25	29.06	38.34	33.52	33.20	25.78	38.85	34.21	60.63
	21 to 30	37.59	20.69	26.37	26.81	28.45	22.09	33.29	29.32	51.95
Oct	1 to 10	36.86	13.56	41.47	24.17	24.84	13.92	12.30	22.10	40.68
	11 to 20	27.50	9.79	32.90	21.87	22.46	12.59	11.12	19.98	36.78
	21 to 30	22.22	7.13	19.70	15.94	17.73	9.94	8.78	15.78	29.05
Nov	1 to 10	13.18	6.79	9.50	13.21	1.65	2.60	1.87	13.39	25.83
	11 to 20	9.72	7.67	5.51	11.53	1.34	2.11	1.52	10.87	20.96
	21 to 30	6.98	6.24	5.48	9.41	1.19	1.88	1.36	9.70	18.70
Dec	1 to 10	5.40	4.23	5.26	6.82	5.38	0.11	0.05	8.97	16.44
	11 to 20	4.43	3.82	4.83	6.32	4.81	0.10	0.04	8.02	14.70
	21 to 30	4.45	5.26	3.96	5.61	4.70	0.10	0.04	7.83	14.36
Jan	1 to 10	4.12	4.95	3.16	4.42	1.92	2.15	6.93	6.24	9.43
	11 to 20	3.25	4.17	2.26	3.78	1.73	1.94	6.24	5.63	8.50
	21 to 30	3.21	3.79	2.35	3.78	1.85	2.07	6.68	6.03	9.10
Feb	1 to 10	3.19	3.55	3.38	3.85	7.35	5.75	5.86	6.09	8.91
	11 to 20	2.34	3.95	4.90	3.87	7.06	5.52	5.62	5.85	8.56
	21 to 28	1.67	5.99	4.50	3.96	5.83	4.56	4.64	4.83	7.06
	1 to 10	2.75	5.31	4.79	4.13	10.22	10.19	4.84	3.63	7.11

March	11 to 20	3.21	4.83	6.55	4.44	11.01	10.97	5.21	3.91	7.66
	21 to 30	2.82	5.42	8.60	4.79	12.39	12.35	5.87	4.41	8.62
April	1 to 10	4.00	5.31	8.29	5.23	35.69	23.05	4.84	4.23	8.31
	11 to 20	3.31	7.97	12.04	6.49	42.08	27.18	5.71	4.99	9.80
	21 to 30	10.36	11.85	9.92	9.31	53.63	34.64	7.27	6.36	12.49
May	1 to 10	6.16	10.59	23.21	10.69	38.75	35.13	9.77	5.66	9.73
	11 to 20	5.23	10.59	19.20	12.53	45.42	41.17	11.46	6.63	11.41
	21 to 30	13.70	19.12	22.63	16.18	64.52	58.48	16.27	9.42	16.20

3.8.4.2 Runoff and Discharge Pattern

The runoff and discharge pattern in Rongni Chhu adopted for the Rongni H.E. project is similar to that of any other Himalayan river where the lean period is during the winter and peak discharge is during the monsoon months.The discharge gradually increases from May to July and declines between August and November for the 90% dependable year **(Figure 3.11).**

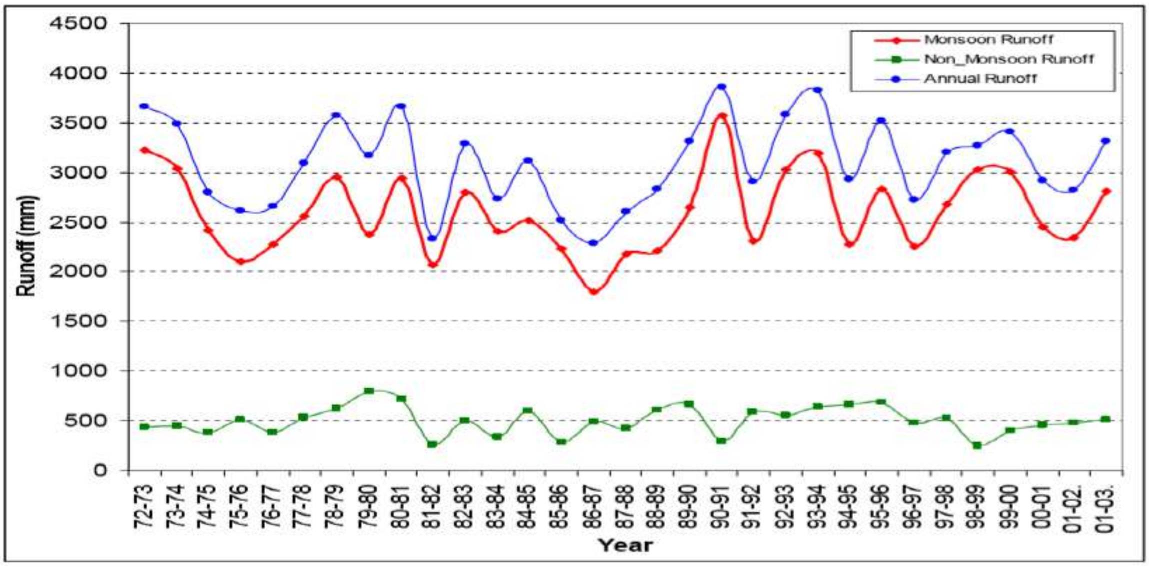


Figure 3.11: Runoff Patternat Barrage Site for31 years

3.8.4.3 Determination of 90 %, 75% and 50 % Dependable Flow for Power Study

The annual yield data observed has been arranged in descending order to arrive at 90% and 50% dependable year based on Weibull's formulae. The computation of dependable year is shown in **Table 3.32**.

Table 3.33: Computation of 90% and 50% Dependable Year

S.N.	Hydro- Year	Annual Energy (MU)	Hydro- Year	Annual Energy in Descending Order (MU)	Rank Number (N)	Exceedance Probability N*100/(M+1) (%)
1	1972-73	702.76	2007-08	887.72	1	2.70
2	1973-74	643.54	1993-94	743.95	2	5.41
3	1974-75	534.24	1990-91	723.59	3	8.11
4	1975-76	507.02	1972-73	702.76	4	10.81
5	1976-77	525.59	1980-81	698.41	5	13.51
6	1977-78	608.33	2003-04	695.09	6	16.22
7	1978-79	654.70	1995-96	687.52	7	18.92
8	1979-80	**600.79**	1992-93	675.58	8	21.62
9	1980-81	698.41	2005-06	667.09	9	24.32
10	1981-82	422.35	2004-05	664.00	10	27.03
11	1982-83	638.23	1978-79	654.70	11	29.73
12	1983-84	534.36	1973-74	653.54	12	32.43
13	1984-85	573.77	1999-00	641.27	13	35.14
14	1985-86	473.59	1982-83	638.23	14	37.84
15	1986-87	440.84	1997-98	634.97	15	40.54
16	1987-88	495.55	1989-90	609.64	16	43.24
17	1988-89	557.99	2002-03	608.41	17	45.95
18	1989-90	609.64	1977-78	608.33	18	48.65
19	1990-91	723.59	1979-80	600.79	19	51.35
20	1991-92	562.51	1998-99	598.88	20	54.05
21	1992-93	675.48	1984-85	573.77	21	56.76
22	1993-94	743.95	2000-01	569.15	22	59.46
23	1994-95	564.84	1994-95	564.84	23	62.16
24	1995-96	687.52	1991-92	562.51	24	64.86
25	1996-97	**488.88**	2001-02	558.05	25	67.57
26	1997-98	634.97	1988-89	557.99	26	70.27
27	1998-99	598.88	2006-07	550.24	27	72.97
28	1999-00	641.27	1983-84	534.36	28	75.68
29	2000-01	569.15	1974-75	534.24	29	78.38
30	2001-02	558.05	1976-77	525.59	30	81.08
31	2002-03	608.41	1975-76	507.02	31	83.78
32	2003-04	695.09	1987-88	495.55	32	86.49
33	2004-05	664.00	1996-97	488.88	33	89.19
34	2005-06	667.09	1985-86	473.59	34	91.89
35	2006-07	**550.24**	1986-87	440.84	35	94.59
36	2007-08	887.72	1981-82	422.35	36	97.30

Energy in 50% dependable year (1979-80) =600.79 MU

Energy in 75% dependable year (2006-07) =550.24 MU

Energy in 90% dependable year (1996-97) =488.88 MU

3.8.4.4 Flow Pattern in50 %, 90%

The discharge gradually increases from May to July and declines between August and November for the 90% dependable yearin the project area, adopted average of monthly 10 daily average water discharge varies from 10.71 cumec in February to 226.86 cumec in October for the 90% dependable year 1985-1986. The adopted monsoon runoff is 2235 mm for the 90% dependable year and that of non-monsoon period is 278 mm. The discharge during the monsoon varies from 7.37 to 42.32 cumec during the monsoon period and from 2.9 to 5.83 cumec for the 90% dependable year(**Figure 3.13**). The highest discharge was 49.89 cumec corresponding to highest runoff 226.86 mm in the mid of October. The adopted average of monthly 10 daily average water discharge varies from 15.38 cumec in February to 314.42 cumec in September for the 50% dependable year 1984-1985. The adopted monsoon runoff is 3119 mm for the 50% dependable year and that of non-monsoon period is 599 mm **(Figure 3.12).** The discharge during the monsoon varies from 18 to 69 cumec during the monsoon period and from 3 to 14 cumec for the 50% dependable year. The highest discharge was 69 cumec corresponding to highest runoff 314 mm at the beginning of September

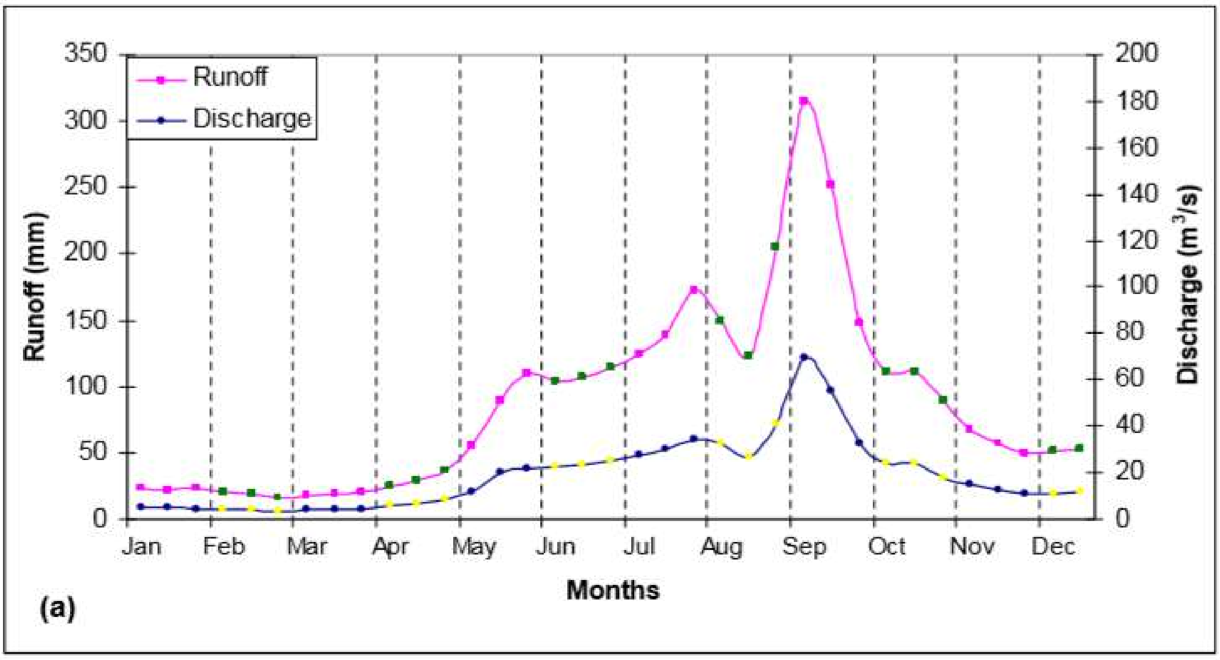


Figure 3.12: Runoff and Discharge Pattern at Barrage Site in 50% Dependable Year

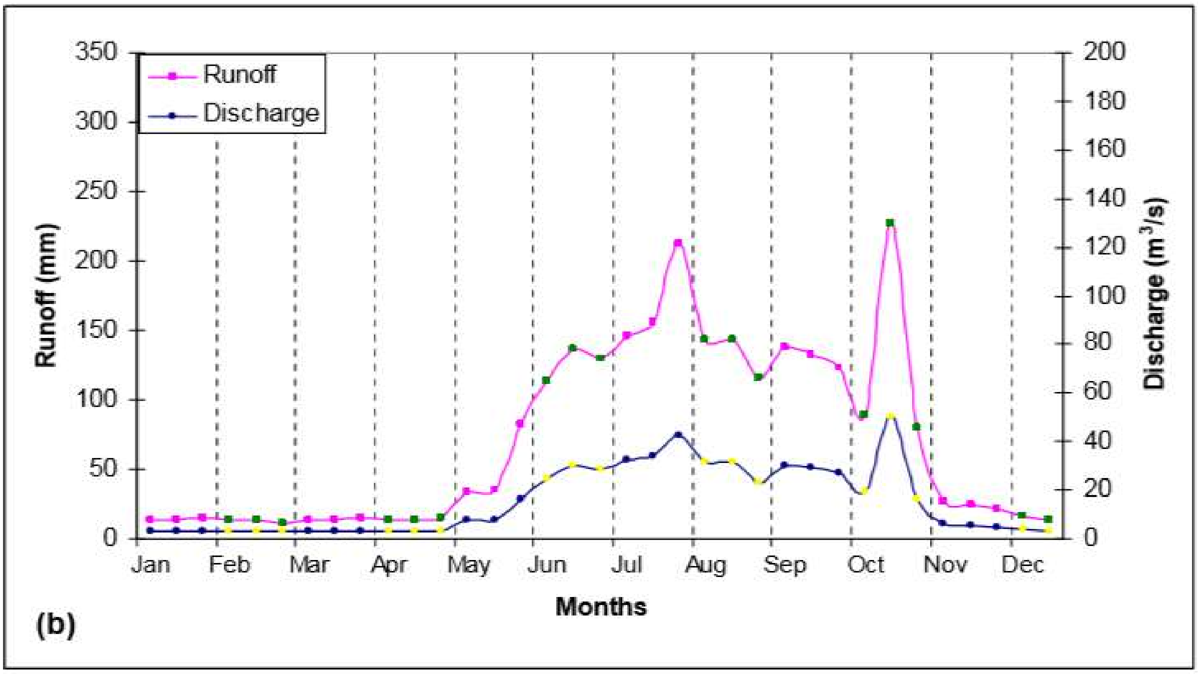


Figure 3.13: Runoff andDischarge Patternat Barrage Site in 90% Dependable Year

3.8.4.5 Dependable Flow (50%, 75 and 90%)

The details of 10-daily flow in 50%, 75% and 90% dependable year are given in **Table 3.34.**

Table 3.34: 10-Daily Flow In 50% and 90% Dependable Year (cumec)

Month	Period	50% Dep. Year (1979-80)	75% Dep. Year (2006-07)	90% Dep. Year (1996-97)
Jun	I	6.80	23.42	19.62
	II	14.21	30.48	14.84
	III	18.83	31.73	22.40
Jul	I	18.94	37.01	25.40
	II	34.83	36.97	36.83
	III	66.11	42.70	35.26
Aug	I	57.51	40.39	32.84
	II	27.54	38.49	42.62
	III	40.69	39.08	34.83
Sep	I	53.10	38.90	29.20
	II	36.81	34.21	25.07
	III	20.76	29.32	26.13
Oct	I	22.17	22.10	38.94
	II	25.52	19.98	19.81
	III	13.96	15.78	14.31
Nov	I	14.70	13.39	9.89
	II	12.53	10.87	7.85

	III	11.69	9.70	4.62
Dec	I	15.16	8.97	4.59
	II	10.17	8.02	5.43
	III	8.91	7.83	5.89
Jan	I	8.07	6.24	3.91
	II	6.25	5.63	2.98
	III	6.26	6.03	4.62
Feb	I	6.22	6.09	5.65
	II	6.08	5.85	4.52
	III	5.78	4.83	4.71
Mar	I	5.76	3.63	5.25
	II	7.07	3.91	5.22
	III	7.38	4.41	4.31
Apr	I	9.65	4.23	6.91
	II	13.39	4.99	9.24
	III	17.49	6.36	8.29
May	I	9.27	5.66	9.30
	II	13.48	6.63	10.60
	III	25.68	9.42	12.90

3.8.5 Sedimentation

As the project is run of the river (Barrage), reservoir sedimentation studies are neither warranted nor carried out. However, the annual suspended silt load of Teesta river at Chungthang site and Dickhut site was observed to be 79.137 ham/yr. and 498.087ham/yr. Month wisevariation of suspended load is shown in **Figure 3.14.**

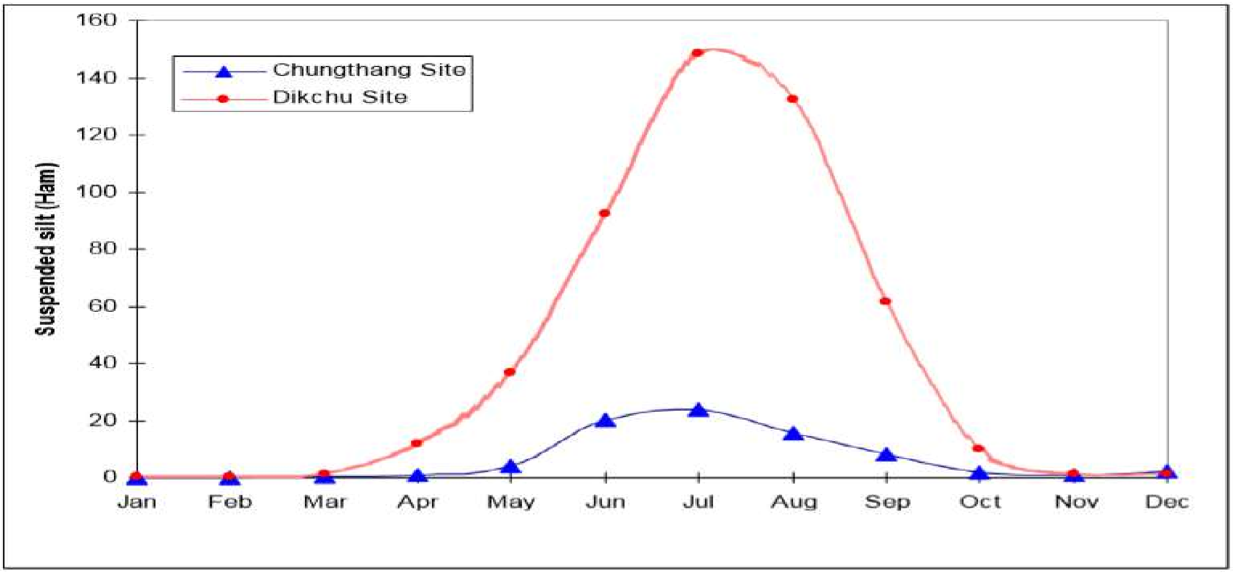


Figure 3.14: Month wise Variation of Suspended Silt Load

3.8.6 Design Flood

3.8.6.1 Design Flood for Spillway

The design flood peak for different flood frequency, SPF and PMF is tabulated in **Table-3.35.** Based on these the spillway has been designed for passing SPF (920 cumecs); whereas free board has been based on PMF.

Table 3.35: Design Flood

S.N.	Particular	Discharge (cumecs)
1	25-year flood peak	640
2	50-year flood peak	705
3	100-year flood peak	775
4	SPF	920
5	PMF	1195

3.8.6.2 Diversion Flood

The work in river section shall not be carried out from June to September due to high stage of river and threat of flash floods. The maximum observed 10-daily discharge for months other than monsoon months (October to April) has been observed as 54 cumecs in December.1973. Therefore, diversion discharge of 100 cumecs has been adopted.

3.8.7 Hydrogeology

The ground water occurs in largely disconnected localized bodies under favorable geological structures, such as joints, fractured zones in various lithological units, weathered zones in the phyllite, schist, gneisses and quartzite. The ground water is available from source perennial springs from nallas present in all geological formations in the area. Due to higher relief and steep gradient of the area, the subsurface flow of ground water is intercepted with manifest as seepages and springs. The area is characterized by high rainfall which is primary source of ground water. The springs are not deep seated. Direct infiltration and rainfall through joints, fracture, weathered zones of the rocks and through soil covers is the principal mode of recharge of the springs. Due to steep slope most of the precipitation in the area is lost as surface run off through streams, kholas and intermittent springs which are tapped through pipe lines and distributed by gravity method for domestic use. Precipitation is the main source of recharge of ground water but glacier melt water is also recharging the ground water considerably. Discharge of the springs occurring in different types of rock formations in the area varies from 0.25 to 1.8 lps though the discharge decreases generally from December-January to May and maximum discharge is recorded during post monsoon period i.e., September to November.

3.8.8 Catastrophic Events Like Cloud Burst and Flash Floods

Neither anycloud burst nor flash flood events in Rongni Chhu catchment area have been reported.

3.8.9 Competitive Water Use

At present on main Rongni Chhu there does not exist any river valley project neither on upstream of proposed Rongnichhu HEP nor on downstream. Namchebung, Pekyong, Phekchu, Sumin, Namnang, Burung and Rapdong are situated downstream of the barrage site up to the confluence of Rongni

Chhu with Teesta river. These villages are lying well above the Rongni Chhu river bed. The villagers are dependent upon the water from small streams joining Rongni Chhu on either side. The paucity of water flow in this stretch of Rongni Chhu, therefore, would have little effect on the human population in this region. In the study area, irrigation canal / gules off-take from local nalas to meet the water requirement of crops being raised in nearby villages. The irrigated area is very insignificant as always is the case in the hill and the irrigation water requirement is very little due to low evapo-transpiration rates and the variety of the crops raised.

3.8.10 Contribution of Kholas d/s of Barrage

D/s of Barrage up to confluence of Rongnichu with the Teesta in about 13.25 km stretch, there are 12 Khola/Nallas (**Table3.36**) which contribute substantial amount of discharge.

Table 3.36: Distance of Confluence Point of Kholas D/S Of Barrage

S. N.	Khola/Nala	Distance(m)from d/s of Barrage
1	Andheri Khola	155
2	Budhunay Khola	670
3	Chuba Khola	1518
4	Kazi Khola	2635
5	Pagla Khola	3038
6	Martam Khola	5148
7	Nim Khola	5344
8	Rabring Khola	6646
9	Pekchu Khola	7745
10	Sang Khola	9481
11	Rathong Nala	10312
12	Topakhani Nala	10804

The prominent Khola/Nala which contribute discharge to Rongnichu from left bank up to 3 km d/s of barrage are Andheri Khola and Kazi Khola, while from right bank are Chuba Khola and Pagla Khola. Theten-daily discharge of these Kholas on catchment proportion basis is given in **Table 3.37** and the catchmentarea of these Kholas is shown in **Figure 3.15.**

Table 3.37: Ten daily Discharge of Kholas up to 3 km d/s of Barrage

Month	10 - Daily	Andheri khad at 0.16 km d/s (CA=9.5sq km)	Chhuba khad at1.5 km d/s (CA=2.85sq km)	Kazi khad at 2.6 km d/s (CA=6.4 sq. km)	Pagla khad at 3.0 km d/s (CA=6.13 sq. km)
Jun	I	0.98	0.29	0.66	0.63
	II	0.74	0.22	0.50	0.48
	III	1.12	0.34	0.75	0.72
Jul	I	1.27	0.38	0.86	0.82
	II	1.84	0.55	1.24	1.19
	III	1.76	0.53	1.19	1.14
Aug	I	1.64	0.49	1.11	1.06
	II	2.13	0.64	1.44	1.38

	III	1.74	0.52	1.17	1.12
Sep	I	1.46	0.44	0.98	0.94
	II	1.25	0.38	0.84	0.81
	III	1.31	0.39	0.88	0.84
Oct	I	1.95	0.58	1.31	1.26
	II	0.99	0.30	0.67	0.64
	III	0.72	0.21	0.48	0.46
Nov	I	0.49	0.15	0.33	0.32
	II	0.39	0.12	0.26	0.25
	III	0.23	0.07	0.16	0.15
Dec	I	0.23	0.07	0.15	0.15
	II	0.27	0.08	0.18	0.18
	III	0.29	0.09	0.20	0.19
Jan	I	0.20	0.06	0.13	0.13
	II	0.15	0.04	0.10	0.10
	III	0.23	0.07	0.16	0.15
Feb	I	0.28	0.08	0.19	0.18
	II	0.23	0.07	0.15	0.15
	III	0.24	0.07	0.16	0.15
Mar	I	0.26	0.08	0.18	0.17
	II	0.26	0.08	0.18	0.17
	III	0.22	0.06	0.15	0.14
Apr	I	0.35	0.10	0.23	0.22
	II	0.46	0.14	0.31	0.30
	III	0.41	0.12	0.28	0.27
May	I	0.47	0.14	0.31	0.30
	II	0.53	0.16	0.36	0.34
	III	0.65	0.19	0.43	0.42

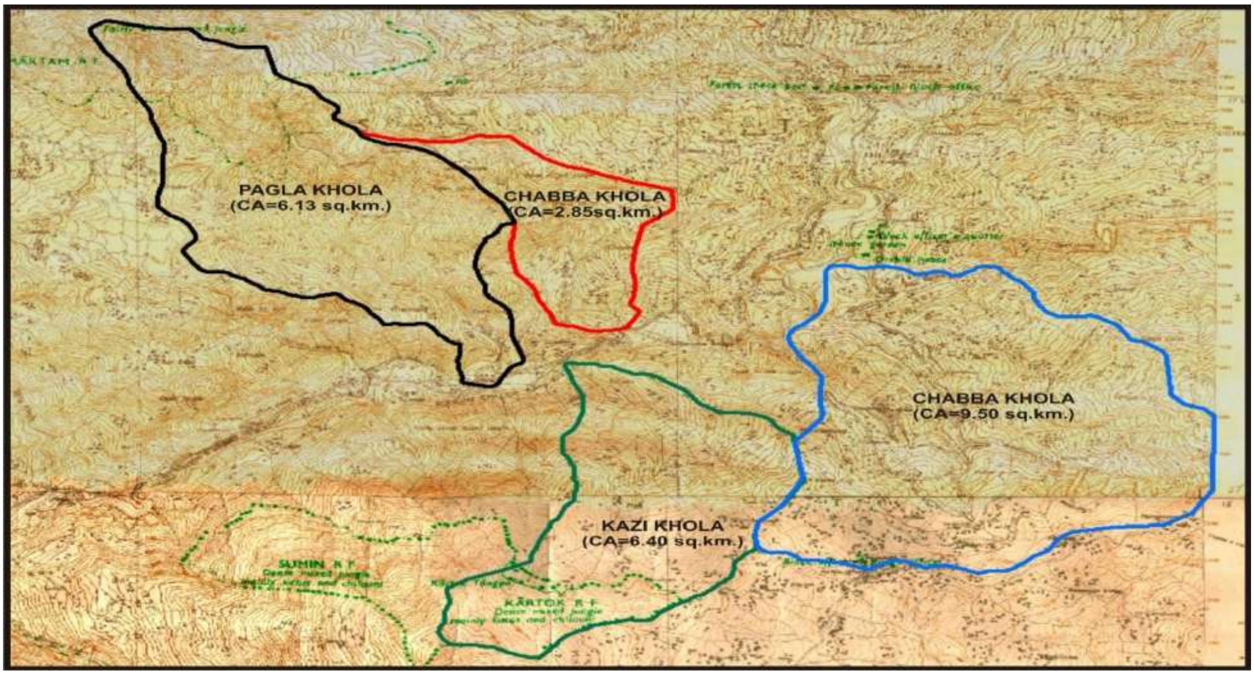


Figure 3.15: Catchment Area of Prominent Khola up to 3 KN D/s of Barrage

3.8.11 Environmental Flow Requirement

Environmental flow is the bare minimum flow, which need to be maintained in river all the time throughout the year, for sustenance of the aquatic and ecological life. No conditions were imposed for release of e-flow in the EC letter. However, in the original DPR 'Sacrificial Discharge' of 0.3 cumec (environmental flow) during non-monsoon months (October to May) was taken into account for Power Studies. For monsoon months no sacrificial discharge was considered as spills were expected, in 10-dailys when discharge was higher than rated discharge. The Principal Bench of NGT in Judgment dated 09.08.2017, has stipulated maintenance of a minimum @ 15% to 20% of the average lean season flow in all rivers in the country. The three regime environmental flows are shown in **Table 3.38.**

Table 3.38: Three Regime Environmental Flows

S. N.	Season	Months	E-Flow	
			%age	Cumec
1	Monsoon	June, July, Aug and Sept	15	4.31
2	Lean Season	Dec, Jan, Feb and March	15	0.71
3(i)	Non- Monsoon, Non -Lean	Oct and Nov	15	2.39
3(ii)	Non- Monsoon, Non -Lean	April and May	15	1.43

Based on the aspect of three regime environmental flows and considering contribution of Kholas upto 3km d/s, the percentage of inflow available upto 3 km d/s is given in **Table3.39.** It is evident from Table that the average percentage of inflow available upto 3 km d/s in monsoon, lean season and Non-monsoon and non-lean season is 31%,28.5% and 36% respectively.

Table 3.39: Percentage Environmental Inflows Available at 3 km d/s

Month	10 - Daily	Inflow at Barrage (Cumec)	E-flow (Cumec)	Flushing discharge (Cumec)	Inflow available for generation (Cumec)	Discharge available after flushing point	Andheri khad at 0.16 km d/s (CA=9.5sq km)	Chhuba khad at1.5 km d/s (CA=2.85sq km)	Kazi khad at 2.6 km d/s (CA=6.4 sq. km)	Pagla khad at 3.0 km d/s (CA=6.13 sq. km)	Discharge available at 3 km d/S	% of inflow available at 3 km d/s
Jun	I	19.62	4.31	-	15.31	4.31	0.98	0.29	0.66	0.63	6.88	35.06
	II	14.84	4.31	-	10.53	4.31	0.74	0.22	0.50	0.48	6.25	42.14
	III	22.4	4.31	-	18.09	4.31	1.12	0.34	0.75	0.72	7.24	32.34
Jul	I	25.4	4.31	-	21.09	4.31	1.27	0.38	0.86	0.82	7.64	30.06
	II	36.83	4.31	0.96	31.56	5.27	1.84	0.55	1.24	1.19	10.09	27.40
	III	35.26	4.31	-	30.95	4.31	1.76	0.53	1.19	1.14	8.93	25.32
Aug	I	32.84	4.31	-	28.53	4.31	1.64	0.49	1.11	1.06	8.61	26.22
	II	42.62	4.31	6.75	31.56	11.06	2.13	0.64	1.44	1.38	16.64	39.04
	III	34.83	4.31	-	30.52	4.31	1.74	0.52	1.17	1.12	8.87	25.47
Sep	I	29.2	4.31	-	24.89	4.31	1.46	0.44	0.98	0.94	8.13	27.86

	II	25.07	4.31	-	20.76	4.31	1.25	0.38	0.84	0.81	7.59	30.29
	III	26.13	4.31	-	21.82	4.31	1.31	0.39	0.88	0.84	7.73	29.59
Oct	I	38.94	2.39	4.86	31.69	7.25	1.95	0.58	1.31	1.26	12.35	31.71
	II	19.81	2.39	-	17.42	2.39	0.99	0.30	0.67	0.64	4.98	25.16
	III	14.31	2.39	-	11.92	2.39	0.72	0.21	0.48	0.46	4.26	29.80
Nov	I	9.89	2.39	-	7.5	2.39	0.49	0.15	0.33	0.32	3.69	37.26
	II	7.85	2.39	-	5.46	2.39	0.39	0.12	0.26	0.25	3.42	43.54
	III	4.62	2.39	-	2.23	2.39	0.23	0.07	0.16	0.15	2.99	64.83
Dec	I	4.59	0.71	-	3.88	0.71	0.23	0.07	0.15	0.15	1.31	28.56
	II	5.43	0.71	-	4.72	0.71	0.27	0.08	0.18	0.18	1.42	26.17
	III	5.89	0.71	-	5.18	0.71	0.29	0.09	0.20	0.19	1.48	25.15
Jan	I	3.91	0.71	-	3.2	0.71	0.20	0.06	0.13	0.13	1.22	31.25
	II	2.98	0.71	-	2.27	0.71	0.15	0.04	0.10	0.10	1.10	36.92
	III	4.62	0.71	-	3.91	0.71	0.23	0.07	0.16	0.15	1.31	28.46
Feb	I	5.65	0.71	-	4.94	0.71	0.28	0.08	0.19	0.18	1.45	25.66
	II	4.52	0.71	-	3.81	0.71	0.23	0.07	0.15	0.15	1.30	28.80
	III	4.71	0.71	-	4	0.71	0.24	0.07	0.16	0.15	1.33	28.17
Mar	I	5.25	0.71	-	4.54	0.71	0.26	0.08	0.18	0.17	1.40	26.62
	II	5.22	0.71	-	4.51	0.71	0.26	0.08	0.18	0.17	1.39	26.70
	III	4.31	0.71	-	3.6	0.71	0.22	0.06	0.15	0.14	1.27	29.57
Apr	I	6.91	1.43	-	5.48	1.43	0.35	0.10	0.23	0.22	2.33	33.79
	II	9.24	1.43	-	7.81	1.43	0.46	0.14	0.31	0.30	2.64	28.57
	III	8.29	1.43	-	6.86	1.43	0.41	0.12	0.28	0.27	2.52	30.34
May	I	9.3	1.43	-	7.87	1.43	0.47	0.14	0.31	0.30	2.65	28.47
	II	10.6	1.43	-	9.17	1.43	0.53	0.16	0.36	0.34	2.82	26.59
	III	12.9	1.43	-	11.47	1.43	0.65	0.19	0.43	0.42	3.12	24.18

3.9 BIOLOGICAL ENVIRONMENT

The baseline study for existing ecological environment was carried out during monsoon season. A phased and consultative approach was followed to carry out ecological assessment. Successive phases of the assessment include:

- Secondary data collection through desktop review of available literature
- Onsite data collection for determining vegetation and wildlife in the study area
- Reconnaissance survey
-

Secondary Data Collection

An extensive desktop review of available published literature (books, websites, scientific papers, articles etc.) was conducted. The State Forest/ Working Plan was also referred for secondary information. Additional information was sourced from the project proponent, governmental institutions and local residents of the survey-area. The secondary data was appropriately supplemented by a field survey for primary data collection

3.9.1 Forest Cover

Proposed site is located in East Sikkim. Sikkim is a small state of India in Eastern Himalaya with steep mountains and deep valleys, located between 27 00’46” to 28 07’48” N latitude and 88 00’58” to 88 55’25” E longitude. It is surrounded by international boundary from three sides. In the west, it is separated from Nepal by Singalila range, in the east lies Bhutan and is bounded by Tibet in the north. In the south it shares its Indian border with the state of West Bengal. Total geographical area of the Sikkim State (**Figure 3.16**) is 7096 Sq. Km. As per the State Forest Report 2015 the total recorded Forest area of Sikkim is about 47.31% of the total geographical area. As the proposed site is located in East Sikkim and about 73% of total geographical area is under forest in East Sikkim. District wise forest cover of Sikkim is presented in **Table 3.40.**

Table 3.40: District Wise Distribution of Forest Area of Sikkim

District	Geographical area	Very Dense Forest	Mod. dense Forest	Open Forest	Total	Percent of GA
East Sikkim	954	162	411	126	699	73.27
West Sikkim	1166	110	489	173	772	66.21
North Sikkim	4226	135	889	291	1315	31.12
South Sikkim	750	93	371	107	571	76.13
Total	7096	500	2,160	687	3357	47.31

Source: State Forest Report 2015

As per Champion & Seth (1968) Classification, Sikkim has 10 forest types excluding the plantation which belong to forest type groups, viz. East Himalayan Moist mixed Deciduous, Rhododendron Scrub, East Himalayan mixed Coniferous Tropical and East Himalayan Sub-Alpine Birch/ Fir Forest. %age-wise distribution of forest covers in different forest type groups found in the state on the basis of the forest cover assessment is provided in **Table 3.41.**

Table 3.41: Percentage Wise Distribution of Forest Cover of Sikkim

S. N.	Forest Type	Area (%)
1	3C/C1a (i) East Himalayan Sal	1.11
2	3C/C3b East Himalayan Moist Mixed Deciduous Forest	4.04
3	8B/C1 East Himalayan Subtropical Wet Hill Forest	25.15
4	11B/C1 Bulk Oak Forest	24.78
5	12/C3a East Himalayan mixed Coniferous Forest	6.42
6	12/DS1 Montane Bamboo Brakes	0.03
7	14/C2 East Himalayan Sub-Alpine Birch/ Fir Forest	27.0
8	15/C1 Birch/ Rhododendron Scrub	3.85
9	15/E1 Dwarf/ Rhododendron Scrub	1.53
10	15/E1 Dwarf/ Rhododendron Scrub	4.11
11	Plantation/TDF	1.98
Total		**100.00**

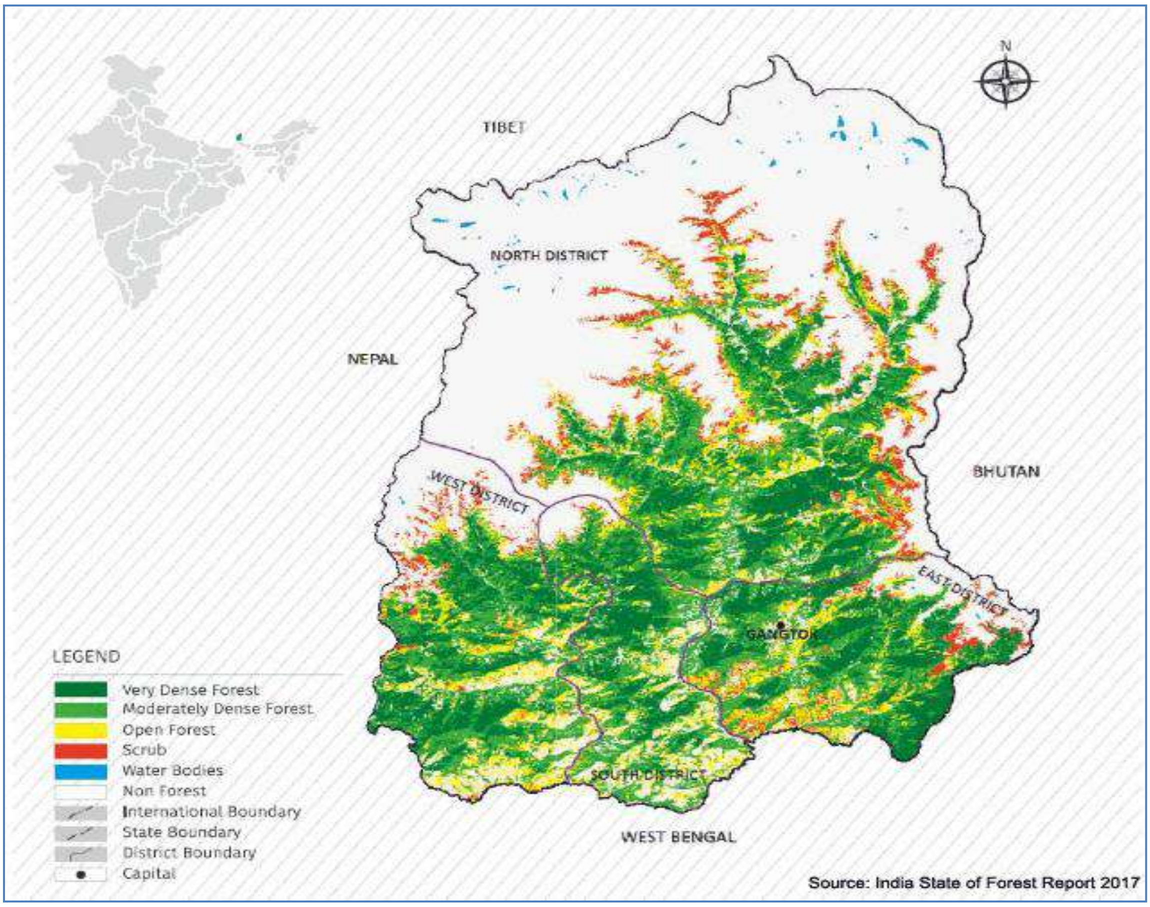


Figure 3.16: Forest Cover Map of Sikkim

3.9.2 Forest Types in East Sikkim

The proposed Rongni H.E. project on Rongni Chhu is located in Pakyong sub-division of East Sikkim. The proposed barrage site is located near Namli village approximate 400 m upstream of the confluence of Andheri Khola and Rongni Chhu. The power generating units would be located in a surface power house about 2 km upstream of Rangpo village on the right bank of Rangpo Chhu.

Based on the altitude, the forests of the East Sikkim district can broadly be identified as (i)Lower hill forest, (ii)Middle hill forests and (iii)Upper hill forests

Lower hill forests: The proposed Power house site as well as barrage site falls in lower hill forest. The vegetation of this zone confined to an altitude between 300-900 m consists of mainly tropical dry deciduous to semi-evergreen species with sal as a dominant species. Because, the spectral signature of sal is significantly distinguishable from those of the mixed species, the predominant areas of the former are labeled as sal forests and those of the latter as mixed forests. Some of the common tree species are Terminalia myriocarpa, Albizzia lucida, Callicarpa arborea, Dalbergia sissoo, Anogeissus latifolia, Adina cordifolia and certain' bamboo species as undergrowth.

Middle hill forests: The tall evergreen species of Alnus nepalensis, Prunus cerasoides, Shima wallichii, Englehardtia spicata and associated with other species of Castonopsis Macaranga, Eugenia, Sapium etc. are seen in the altitude zone between 900 and 1800 m. No single spectral signature could be demarcated, probably because of heterogeneous floristic composition and absence of any predominant species. In the present investigation, single season (November) datum has been used due to non-availability of cloud free data for other seasons making it rather. difficult to delineate dominant species composition, hence classified under mixed subtropical broad-leaved forest.

Upper hill forests: Further, the upper hills can broadly be distinguished into four strata based on altitude and also general species composition as:

- **Zone 1. (1800-2400 m):** This zone, is a transitional zone between subtropical mixed broad leaved to sub-temperate zone with species ranging from *Alnus, Michilus, Quercus and Sympocos sp.* The evergreen tree species dominates the region and the undergrowth is mainly of dwarf species of bamboos.
- **Zone 2. (2400-3000 m):** The typical temperate forests consist of species of Pinus and Abies mixed with Picea, Tsuga and Juniperus covering extensive areas intermixed with species of Oak, Rhododendron, Betula and Michilus sp. *Pinus roxburghii* is mostly confined to Rangit valley in East District. (Abies, Larix, Tsuga are dominant in North district).
- **Zone 3. (2700-3700 m):** The zone mainly consists of Rhododendron species intermixing _with temperate to evergreen species. The vegetation becomes spares as altitude increases and often restricted to grooves of the hills.
- **Zone 4. (3700-4500 m):**This zone harbours scarcely any vegetative cover because of the adverse conditions of less soil cover and high wind coupled with frost. However, bushy vegetation with xerophytic characteristic species is common. Some of the species are Juniperous, Salix, Barberis. This zone is called as Alpine but the presence of scrub or without any bush or with grasses makes the terrain look different. Based on the presence or absence of vegetative cover

3.9.2.1 Forest Type within Study Area (10 Km Area of the Project)

The study area 10 km area of the proposed site falls mainly in Lower and middle hill forest only. The forests present in the Rongni Chhu and adjoining Rora chhu, have been grouped into different forest types following the classification of Champion & Seth (1968), Hajra & Das (1982), Negi, (1989, 1996), Hajra & Verma (1996), Srivastva (1998). As the 10 km study area of the proposed barrage as well as powerhouse site falls within the altitude of 2500m hence the major forest types found in this catchment are discussed below.

A Tropical Moist Deciduous Forests:

This type of forest is a common feature of the study area as this type of forest is found near the powerhouse site (Rangpo) and the barrage site (Namli). These low hill forests occur from 230 m up to 900 m. The important species of the forest are *Adina cordifolia, Aglaia lawii, Altsonia neriifolia, A. scholaris, Artocarpus integrifolia, Bombax ceiba, Canarium strictum, Duabanga grandiflora, Erythrina arborescens, Ficus semicordata, F. racemosa, Mangifera sylvatica, Shorea robusta, Terminalia myriocarpa, Tetrameles nudiflora, etc.* The shrubs are *Boehmeria pendulifera, B. platyphylla, Callicarpa arborea, Clerodendrum japonicum, Dendrocalamus sikkimensis, Eupatorium odoratum, Lantana camara, Phyllostachys bambusoides, Saurauia roxburghii, Leea aequatica, L. indica and Ziziphus mauritiana. Among twiners are Bauhinia vahlii, Celastrus paniculatus, Cryptolepis buchananii, Entada phaseoloides, Stephania glabra, etc.* There are some riverine semi-evergreen types of elements such as *Albiziachinensis, Bischofiajavanica, Oroxylumindicum, Pandanus nepalensis*, Rhuschinensis, etc. found along the river bank. The other riverine elements are tall grasses like *Imperata cylindrica, Neyraudia arundinacea, Pennisetum orientale, P. purpureum, Saccharum spontaneum* and *Thysanolaena latifolia.*

B. Sub-tropical Forests: These forests are found upstream of the proposed barrage site between elevations of 750 and 1,600 m and are dominated by mainly evergreen tree species.

- **Middle Hill Forest (Sub-tropical wet hill forests**

Middle hill forests and extend up to 1,600 m elevation. Many of the tropical genera like *Bischofia*, *Duabanga, Pterospermum, Tetrameles,* etc. are absent and more temperate genera *viz*. *Alnus, Lithocarpus, Lyonia* and *Quercus* are found. This type of forest is found in Ranipul, Rumtek and Tadong areas of East Sikkim. Some broad leaved trees like *Castanopsisindica, Duabanga grandiflora, Engelhardtia spicata, Erythrina arborescens, Semingtoniapopulnea, Schimawallichii, Toonaciliata,* etc occur in lower warmer areas. In upper elevations and cooler areas *Alnus nepalensis, Juglans regia, Lyonia ovalifolia, Macaranga denticulata, Prunus cerasoides*, *Quercus glauca,* etc occur. Understorey is fairly dense mixed and formed of many shrubs and climbers. Predominant shrubs of these forests are *Brassiopsis mitis, Dendrocalamushamiltonii, Euryaacuminata, Maesachisia, Mussaendaroxburghii, Oxysporapaniculata, Rhamnusnepalensis, Rubusellipticus*and *Vitex negundo*. Climbers are many and represented by species of *Clematis*, *Cissus, Cassia, Cryptolepis, Dioscorea, Piper, Rubus, Stephania, Tetrastigma*, etc. Some exotic weeds which have established in area are *Argemone mexicana, Eupatorium adenophorum, E. odoratum, Lantana camara*and *Partheniumhysterophorus*.

- **Sub-tropical pine forests (*Pinus roxburghii*):**

These forests are found in dry localities and represenrted by a few scattered trees of pine (*Pinus roxburghii*). At some places trees of *Cryptomeria japonica, Pinus kesiya*and *Thujaorientalis*are seen planted. The other associates of *forest are Albiziachinensis, Alnusnepalensis, Berberis aristata, Boehmeriaplatyphylla, Prunus cerasoides, Quercus glauca, Rhododendron sp., Rhuschinensis, etc.* The herbaceous flora and grasses on the mountain slopes is comprised of *Arundinellanepalensis, Chrysopogonaciculatus, Cymbopogon pendulus, Digitariaciliaris, Imperatacylindrica, Oplismenuscompositus, Pennisetumorientale, Pogonatherumpaniceum, Saccharum spontaneum* and *Themedaarundinacea* are common grasses in the forest.

C. Temperate Forest: These forests are found between 1,600 and 3,000 m elevation and are further divided into two sub-types: a) Broad leaved temperate wet forests, and b) Mixed coniferous forests

- **Temperate wet broad leafforest**

These forests are found between elevations of 1,600 and 2,600 m. There are a number of deciduous tree species but oaks and laurels are dominant. The tree canopy in the first storey comprised of *Acer campbellii, Albiziachinensis, Alnusnepalensis, Castanopsistribuloides, Elaeocarpus sikkimensis, Erythrina arborescens, Engelhardtia spicata, Juglans regia, Litsea sericea, L. elongata, Lithocarpuspachyphylla, Lyonia ovalifolia, Macaranga denticulata, Persearoxburghii, Pinus roburghii, Prunus cerasoides, Quercus lamellosa, Q. lineata, Schimawallichii,* etc. In addition to these trees, a number of exotic tree species like *Cryptomeria japonica, Cupressus corneyana, Eucalyptus globulus* and *Grevillea robusta* have beenintroducedfortheireconomicutilityinthecapitalareaofGangtok.

The ground flora is very thin and vary from place to place. *Berberis aristata, Coriarianepalensis, Cotoneaster microphylla, Daphne bholua, Dichroafebrifuga, Edgeworthiagardneri, Leucosceptrumcanum, Mahonia nepaulensis, Mussaendaroxburghii, Oxysporapaniculata, Rubusellipticus, Viburnum erubescens,* etc. are common shrubs in the understorey. The common climbers are *Cissusrepens, Clematis montana, Dioscoreabulbifera, Hedyotis scandens, Hodgsoniamacrocarpa, Porana grandiflora, Rubuspaniculatus, Rubiasikkimensis, Smilax aspericaulis, Trichosantheslepiniana,* etc. Epiphytic plants are many such as *Aeschynanthushookeri, Dendrobium chrysanthum, Hedychium gracile, H. acuminatum, Peperomia* spp., *Polypodium* spp., *Raphidophora glauca* and *Vittaria*spp. In addition to these, there are some parasitic plants like *Cuscutareflexa, Loranthusodoratus*and *Viscum nepalense*found twining on trees. Common herbaceous species are *Acorus calamus, Anaphaliscontorta, Arisaema speciosum, Begonia* spp., *Carex*spp., *Cautleyagracilis, Didymocarpus pulchra, Drymarriacordata, Eupatorium adenophorum, Girardiniadiversifolia,* *Houttuynia cordata, Impatiens* spp., *Persicariaperfoliata, Pileascripta, Polygonum plebium, Poaannua, Thyasnolaenalatifolia*and *Urticadioica*. There are many ferns and fern- alies in the area of catchment.

The common ferns are *Adiantum caudatum, Cheilanthesfarinosa, Dicranopterislineris, Gleichenia glauca, Loxogrammeinvoluta, Lygodiumflexuosum, Microsorummembranaceum, Onchyumjaponicum, Polypodium*spp., *Pteris* spp., *Pyrrosia*spp. and *Vittariasikkimensis.* Some of the common liverworts are *Antheceroshimalayensis, Marchantiapaleacea, M.papulosa, Riccia* sp. and *Funaria indica*. In addition to these plants there are some other interesting group of plants like lichens which generally found on the bark of trees and the stones. Most common ones are species of Parelia, Peltigera, Ramalina, Usnea, etc.

- **Mixed coniferous forests**

The forests of this zone are dense evergreen and fir (*Abiesdensa*) is characterstic of the highest forest ridges especially above Karponang (2,938 m). Besides *Abiesdensa*, some oak and deciduous tree species such as *Acer, Betula, Rhododendron,* etc. are found on moist and damp places. There is also patchy vegetation of many evergreen shrubs in the understorey. Among shrubs are species of *Berberis, Cotoneaster, Rhododendron, Thamnocalamus*and *Viburnum.* Most of these shrubs are loaded with many epiphytic mosses and lichens. Important mosses of the catchment are *Anomodon minor, Calliergonnubigenum, Funaria indica, Rhynchostegiellaherbacea,*etc.

3.9.2.2 Vegetation Composition in Study Area

A. SubmergenceArea: The submergence site is located in upstream of confluence of RongniChhu and Andheri Khloa near Namli village in the East Sikkim. The area in the vicinity of proposed project comprised of degraded Mixed broad-leaf tropical deciduous forest with few Semi-evergreen riverine tree species**(Figure3.17).**

On left bank of Rongni Chhu the tree canopy is comprised of *Albiziachinensis, Bischofiajavanica, Duabanga grandiflora, Engelhardtia spicata, Erythrina arborescens, Ficus reticulata, F. religiosa, Gynocardiaodorata, Schimawallichii*and *Tetradiumfraxinifolium.* Second storey is also very thin and composed of some small trees and tall spreading weeds. *Boehmeriaplatyphylla, Caesalpiniadecapetala, Euonymus pendulus, Eupatorium odoratum, Holmskioldiasanguinea, Lantana camara*, *Rhamnusnepalensis*, etc. are found in the understorey. Climbers and epiphytes are often seen on the forest floor. *Cissusdiscor, Cuscutareflexa, Jasminum humile, Lygodium japonicum, Piper sylvaticum, Stephania glabra, Todaliaasiatica,* etc. are important trailing species. Herbaceous flora was represented by some pteridophytic plants, grasses and weeds. The pteridophytes are represented by species of *Adiantum, Coniograme, Lygodium, Selaginella*, etc. on this bank. Among the herbs and grasses are *Ageratum conyzoides, Artemisia nilagirica, Arundinellanepalensis, Arthraxonhispidus, Capillipediumassimile, Commelinabenghalensis, Eupatorium adenophorum, Imperatacylindrica, Lespedeza gerardiana, Oxalis corniculata, Pileascripta, Pogonatherumpaniceum, Saccharum spontaneum* and *Thysanolaenalatifolia.*

Species composition of right bank is more or less similar to the left bank but *Alnus nepalensis* was found as a dominant tree species with other tree associates. Important tree associates were *Albiziachinensis, Bischofiajavanica, Bombax ceiba, Duabanga grandiflora, Erythrina arborescens, Oroxylumindicum, Pandanus nepalensis, Schimawallichii,* etc. Second storey was very open and occupied by few trailing and spreading shrubby species. *Dendrocalmushamiltonii, Eupatorium odoratum, Mimosa himalayana, Lantana camara,* etc. were in the under storey. Climbers and epiphytes were rare. Herbs were represented by few non vascular pteridophytic plants, weeds and few grasses.

Figure 3.17: Vegetation at Barrage Site and Submergence Area

B. Powerhouse Site: A surface powerhouse has been proposed on the right bank of Rangpo Chhu just 2.5 km upstream of the confluence of Rangpo Chhu and Teesta river at Rangpo town. Fairly dense mixed tropical moist deciduous forest is found in the vicinity of project. Important tree associates in the canopy include *Albiziachinensis, A. odoratissima, Boehmerialongifolia, Bombax ceiba, Callicarpa arborea, Duabanga grandiflora, Lagerstroemia lanceolata, Malotusphilippensis, Rhuschinensis, Shorearobusta, Terminalia bellerica,* etc. Second storey is very open and represented by many invasive and fast growing species like *Boehmeriaplatyphylla, Clerodendrum japonicum, Eupatorium odoratum, Lantana camara,Leeaaequata, Woodfordiafruticosa*, etc. Climbers and epiphytes were also very few at this bank. *Cissusrepens, Cissampelospariera, Mimosa himalayana, Pueraria tuberosa, Stephania glabra, Vigna retusa*, etc. were found trailing in the forest. Epiphytes were represented by *Dendrobium aduncum*, *Pepromia*spp., *Polypodium* sp., *Vittaria*sp., etc. Among herbs were *Ageratum conyzoides, Arthraxonhispidus, Desmodiumrenifolium, Dichanthiumannulatum, Eupatorium adenophorum, Flemingiafruticosa, Neyraudiaarundinacea, Oplismenuscompositus, Parthenium hysterophorus, Pogonatherumpaniceum, Saccharum spontaneum*and *Thysanolaenalatifolia.*

The species composition of the vegetation on the left bank is also more or less similar, however, with the presence of more semi evergreen and rivierine plant species. The tree canopy is comprised of *Adina cordifolia, Albiziachinensis, Altsoniascholaris, Anthocephaluscadamba, Bischofiajavanica, Bombax ceiba, Callicarpa arborea, Duabanga grandiflora, Oroxylumindicum, Rhuschinensis*and *Terminalia myriocarpa*. Second storey is comprised of *Brassiopsis mitis, Clerodendrumbracteatum, Debregeasiasalicifolia, Eupatorium odoratum, Leeaaequata, Saurauiaroxburghii, Vitex nigundo*, etc. Herbaceous flora was represented by some tall grasses and many small herbs. Among tall grasses were *Arundinellanepalensis, Arthraxonhispidus, Imperata cylindrica, Saccharum spontaneum, Thysanolaena latifolia*,etc.

C. 10 Km Study Area: The 10 km area around the Barrage and powerhouse site comrises of Lower hill forests and Middle hill forest including the agaian ecosystem.The vegetation is constituted mostly by the tropical moist deciduous and riverine semi-evergreen plant species in the lower altitudes of the catchment. In the mid hills mixed sub-tropical hill forest are prevalent while towards higher elevations dense mixed temperate broad-leaf, mixed coniferous and open scrub forest occur.

Some of the common tree species are *Tectonagrandis, Shorearobusta, Terminalia myriocarpa, Albizzia lucida, Callicarpa arborea, Dalbergia sissoo, Anogeissus latifolia, Adina cordifolia, Adina cordifolia, Alnusnepalensis, Prunus cerasoides, Shimawallichii, Englehardtia spicata, Albiziachinensis, A. odoratissima, Boehmerialongifolia, Bombax ceiba, Callicarpa arborea, Duabanga grandiflora, Lagerstroemia lanceolata, Malotusphilippensis, Rhuschinensis, Terminalia bellerica,* etc. Second storey is very open and represented by many invasive and fast growing species like *Boehmeriaplatyphylla, Clerodendrum japonicum, Eupatorium odoratum, Lantana camara,Leeaaequata, Woodfordiafruticosa, Brassiopsis mitis, Dendrocalamushamiltonii, Euryaacuminata, Maesachisia, Mussaendaroxburghii, Oxysporapaniculata, Rhamnusnepalensis, Rubusellipticus*and *Vitex negundo*. Climbers are many and represented by species of *Clematis*, *Cissus, Cassia, Cryptolepis, Dioscorea, Piper, Rubus, Stephania, Tetrastigma*, etc. Some exotic weeds which have established in area are *Argemone mexicana, Eupatorium adenophorum, E. odoratum, Lantana camara*and *Partheniumhysterophorus*.

3.9.3 Floristic Composition

During primary and secondary study carried out under present project, 82 tree species, 11 shrub species and 28 herbs/grasses/climbers were recorded from the study area. The comprehensive list of the plant species for command as well as 10 km study area (tree, shrubs, herbs, climbers etc.) observed in the study area is given **Table 3.42.**

Table 3.42: Tree species Reported in the Study Area

S.N.	Common name	Scientific name	Family
		Trees	
1.	Gobra salla	*Abis densa*	Coniferae
2.	Kapas	*Acer cambellii*	Aceracceae
3.	Putli	*Acer laevigatum*	Butulaceae
4.	Firfirry	*Acer oblongum*	Aceraceae
5.	Lal kapas	*Acer pectinatum*	Butulaceae
6.	Angari	*Adromedia villosa*	Ericaceae
7.	Sato siris	*Albbiza procera*	Leguminosae
8.	Siris	*Albizza lebbeck*	Leguminosae
9.	Gokul	*Alianthus grandis*	Simarubaceae
10.	Uttis	*Alnus nepalensis*	Betulaceae
11.	Malango	*Arundinaria pantingia*	Gramineae
12.	Nagbeli	*Bauhinia anguina*	Caesalpinioideae
13.	Taaki	Bauhinia purpurea	Caesalpinioideae
14.	Koiralo	*Bauhinia veriegata*	Caesalpinoideae
15.	Saur	*Betula alnoides*	Butulaceae
16.	Saur	*Betula cylindrostachy*	Butulaceae
17.	Bhugpath	*Betula utilis*	Butulaceae
18.	Kaijal	*Bischofia javanica*	Euphorbiaceae
19.	Simal	*Bombax malabaricum*	Bombaceae
20.	-	*Canarium sikkimensis*	Burseraceae
21.	Katus	*Castranopsis hystrix*	Facaceae
22.	Dalneykutus	*Castranopsis indica*	Facaceae
23.	Tati Ningalo	*Cephalostachyum intermedia*	Gramineae
24.	Dhuphi	*Cryptomeria japonica*	Dandanceae
25.	Argali	*Daphne sureil*	Thymeleaceae

26.	Tusaro	*Debregeasia velutina*	Urticaceae
27.	Goyalo	*Dysoxylum procerum*	Meliaceae
28.	Bhadrasey	*Elaeocarpus sikkimensis*	Elaeocarpaceae
29.	Mauha	*Engelhardtia spicata*	Juglandaceae
30.	Phaleydo	*Erythrina stricta*	Leguminosae
31.	Barar	*Ficus bengalensis*	Moraceae
32.	Rai Khanew	*Ficus benjamina*	Moraceae
33.	LuteyKhanew	*Ficus cunia*	Moraceae
34.	Nebaro	*Ficus hookeri*	Moraceae
35.	Kabra	*Ficus infectoria*	Moraceae
36.	Dudilo	*Ficus nemoralis*	Moraceae
37.	Gantey	*Gynocardia odorata*	Flacourtiaceae
38.	Umbaka	*Jambosa Formosa*	Myrtaceae
39.	Okhar	*Juglans regia*	Juglandaceae
40.	Sukphadhup	*Juniperus pseudosabina*	Cupressaceae
41.	Sukpabhup	*Juniperus recurva*	Cupressaceae
42.	Lak Arupatha	*Laurocerasus undulates*	Rosaceae
43.	Siltimbur	*Litsaea citrate*	Lauraceae
44.	Kutmero	*Litsaea polyantha*	Lauraceae
45.	Malata	*Macaranga denticulate*	Lauraceae
46.	Lapchakaiolo	*Machilus edulis*	Magnoliaceae
47.	Ghoga chap	*Magnolia cambelli*	Magnoliaceae
48.	Kakrei Chap	*Magnolia globosa*	Magnoliaceae
49.	Rani Chap	*Michelia excelsa*	Magnoliaceae
50.	Sato Chap	*Michelia punduana*	Magnoliaceae
51.	Kimboo	*Morus laevigata*	Moraceae
52.	Totala	*Oroxylum indicum*	Bignonaceae
53.	Bepari	*Ostodes paniculatus*	Euphorbiaceae
54.	Tarika	*Pandanus frucatus*	Myrtaceae
55.	Dhup	*Pinus excelsa*	Coniferae
56.	Dhup	*Pinus longifolia*	Coniferae
57.	Dhangresalla	*Pinus wallichiana*	Coniferae
58.	MarchaJara	*Polygala arillata*	Polycalaceae
59.	Paiyun	*Prunus cerasoides*	Rosaceae
60.	Payu	*Prunus cerasoides*	Rosaceae
61.	Pathleykatus	*Quercus lanceaefolius*	Fagaceae
62.	SungureKatus	*Quercus pachyphylla*	Fagaceae
63.	Sunpathi	*Rhododendron anthopogon*	Ericaceae
64.	Chimal	*Rhododendron aeruginosum*	Ericaceae
65.	LaliGuras	*Rhododendron arboreum*	Ericaceae
66.	Chimal	*Rhododendron argentums*	Ericaceae
67.	Sato Chimal	*Rhododendron aucklandia*	Ericaceae
68.	Lal Chimal	*Rhododendron barbatum*	Ericaceae
69.	SanuChimal	*Rhododendron cinnabarium*	Ericaceae
70.	Lahara Chimal	*Rhododendron dalhousiae*	Ericaceae
71.	Kolargo	*Rhododendron falconeri*	Ericaceae
72.	Bhikimloo	*Rhus semialata*	Anacardiaceae
73.	Bhalayo	*Rhus succedanea*	Anacardiaceae

74.	Ritha	*Sapindusdetergens*	Lauraceae
75.	Ritha	*Sapindus detergens*	Sapindaceae
76.	Googon	*Sauraiua fasciculate*	Saurauiaceae
77.	Chilouney	*Schima wallichii*	Theaceae
78.	Sakhua	*Shorea robusta*	Dipterocarpaceae
79.	Lapsi	*Spondias axillaris*	Anacardiaceae
80.	Sagun	*Tectona grandis*	Lauraceae
81.	Panisaj	*Terminalia myriocarpa*	Combretaceae
82.	Lak Asara	*Viburum grandiflorum*	Caesalpinoideae
Shrubs			
83.	Amliso	*Thysanolaena maxima*	Poaceae
84.	Kamla	*Boehmeria macrophylla*	Urticaceae
85.	Lantina weed	*Lantana camara*	Compositeae
86.	Ban Cara	*Musa thomsoni*	Musaceae
87.	Ghungring	*Neyraridia madagascariensis*	Poaceae
88.	Titaypati	*Artimesia vulgaris*	Compositeae
89.	Dhokrey	*Datura surveolens*	Solanaceae
90.	Kalijahr	*Eupatorium adenophorum*	Compositeae
91.	Ulaybanmara	*Eupatorium odoratum*	compositeae
92.	Aisilo	*Rubus calycinus*	Compositeae
93.	Kalobiluney	*Antidesma acuminattum*	Euphorbiaceae
Herbs			
94.	Banso	*Digitaria sanguinalis*	Poaceae
95.	Duboo	*Cynodon dactylon*	Poaceae
96.	Abizalo	*Drymaria cordata*	Caryophyllaceae
97.	Gogleyto	*Elastostema platyphylla*	urticaceae
98.	Siru	*Imperata cylindrical*	Poaceae
99.	Salima	*Chrysopogon gryllus*	Poaceae
100.	Chipay	*Pauzolzia viminea*	Urticacceae
101.	Simrai	*Nasturtium officinale*	Tropaeslaceae
102.	Gariasisnu	*Urtica dioica*	Urticaceae
103.	Boksi Kara	*Solanum khasianum*	Solanaceae
104.	Elamey	*Ageratum conyzoides*	Compositeae
105.	Ratnowlo	*Persicaria capitata*	Polygonaceae
106.	Batupatey	*Cissampelos panira*	Polygonaceae
107.	Dhotisara	*Setaria palmifolia*	
108.	Udasay	*Gallinsopogon parviflora*	composateae
109.	Wildstrawberry	*Fragaria vasca*	Poaceae
110.	Chitrobonso	*Axonopu s compressus*	Orchidaceae
111.	Sunakhari	*Dendrobium nobile*	Orchidaceae
112.	Epiphytic orchid	*Coelogyne cristata*	Orchidaceae
Bamboos			
113.	Mali Bans	*Bumbosa nutans*	Gramineae
114.	Choya Bans	*Dendrocalamus hamimltonii*	Gramineae
115.	Bhalu Bans	*Dandrocalamus sikkimensis*	Gramineae
116.	Pareng	*Arundinaria hookeriana*	Gramineae
117.	Khatha Bans	*Phyllostanchy edulis*	Gramineae

Climbers			
118.	Bantarul	*Dioscorea dioica*	-
119.	Indreni	*Trichosanthes bracteata*	-
120.	Jungali pan	*Piper retrofractum*	-
121.	Dudaylara	*Euphorbia hitra*	-

3.9.3.1 Rare Threatened and Endangered Species

Recorded floral species from the study area were assessed for their conservation status by cross-checking with red data book of Indian plants (Nayar&Sastri, 1987-90) and none of the plant taxa were found under RET category

3.9.3.2 Critical Environmental Resources in Project Study Area

No critical Environmental Resources (CERs) namely Biosphere Reserves, Wildlife Sanctuaries, National Parks, Tiger Reserves, are present within the 10 km study area of the proposed project site except Fambong Lho Wildlife Sanctuary which is located about 3.79 km NW of the proposed Barrage site as per map authenticated by the Chief wildlife Warden and Environment, Government of Sikkim, communicated by DFO,Wildlife East vide letter No. 360/WL/E,dated, 20.12.2019.

Some of the upper reaches of the catchment area of the proposed project falls under Fambong Lho Wildlife Sanctuary. It is found further west of Rumtek Reserve Forest area. Approximately 17.63 sq km of the sanctuary area falls in the Rongni Chhu catchment. The sanctuary covers total of about 51 sq km in the tract to the north- west of Gangtok. It is located about 20 km from Gangtok and above the road between Singtam and Dikchu. Important forest types found in this sanctuary are: Moist mixed deciduous forest, Mixed coniferous and Wet temperate forest. The sanctuary is famous for for its avifauana which include species like the hill partridge, satyr tragopan, fire-tailed myzornis, bar-throated minla, red-tailed minla, black-eared shrike babbler, scaly laughingthrush, streak-breasted scimitar babbler, rusty-fronted barwing, yellow-browed tit, red-headed bullfinch, crimson-browed finch, chestnut-crowned warbler etc. Among the Mammalian fauna which are regularly sighted in this sanctuary are barking deer, yellow-throated marten, Himalayan brown bear and red panda. Beside these, Clouded leopard, takin, red fox and musk deer are also present at higher altitudes.

3.9.3.3 Medicinal Plants

The conservation of medicinal plants means every species of plants in its natural habitat should be protected and preserved. Conservation of invaluable biodiversity is a national and international agenda. Because of continuous exploitation of medicinal plants from their natural habitats, it is required to replant and regenerate them in other areas having similar habitat or environment. Due to over exploitation of natural resources many plant species have become extinct from the world. Sikkim Himalaya, particularly the East and North districts are exceptionally rich in medicinal plants and herbs. Some of the plants like *Achyranthes aspera, Acorus calamus, Artemisia nilagirica, Bergenia ciliata, Cissampelospariera, Cyperusrotundus, Hedychium spicatum, Houttuynia cordata, Oroxylumindicum, Rubiasikkimensis, Viola betonicifolia,* etc are quite common in tropical and sub-tropical parts of proposed project. *Nardostachys grandiflora, Picrorhizakurrooa, Podophyllum hexandrum*and *Rheum acuminatum*are important medicinal plants of high altitude zones. These plants are used internally for treating stomachic diarrhoea, dysentery, cough, cold, fever and asthma and externally for rheumatism, skin diseases, cuts, boils andinjuries.

The hills of Sikkim are inhabited by different ethnic groups with their different systems of practice. The practice of using herbs here is broadly of two types i.e. the Nepalese and Tibetan system. However, many of the wild plant species used locally for medicinal purposes are depleting from the area due to many anthropogenic activities. The names economically important recorded during the survey have been listed in **Table 3.43.**

Table 3.43:Economocally ImportantTree species

S.N.	Botanical Name	Local Name	Altitude (m)	Parts used
1	*Achyranthes aspera*	Chir-chita	Up to 2400	Whole plant
2	*Acorus calamus*	Bojho	1000-2000	Rhizome
3	*Ageratum conyzoides*	Osari	Up to 2600	Leaves
4	*Alnus nepalensis*	Utis	1000-2600	Bark
5	*Bauhinia variegata*	Kachnar	Up to 1500	Flower
6	*Bergenia ciliata*	Pakhanbhed	1500-3000	Rhizome
7	*Callicarpa arborea*	Sumalis	Up to 1600	Bark
8	*Centella asiatica*	Bhrami	600-2300	Whole plant
9	*Cinnamomum tamala*	Tejpat	Up to 1500	Bark
10	*Cissampelos pariera*	Akanadu	Up to 1000	Leaf
11	*Costus speciosus*	Keu	Up to 1500	Stem
12	*Datura stramonium*	Dhatura	Up to 1500	Seed
13	*Engelthardtia spicata*	Silapoma	500-2100	Bark
14	*Evodia fraxinifolia*	Khanakpa	1000-1400	Fruits
15	*Ficus relegiosa*	Peepal	Up to 1200	Whole plant
16	*Girardinia diversifolia*	Awa	Up to 2600	Leaf
17	*Gynocardia odorata*	Ghaley	Up to 1200	Seed
18	*Houttuynia cordata*	Nombaring	1000-2400	Leaves
19	*Lyonia ovalifolia*	Anyar	1000-3000	Leaf
20	*Mallotus philippensis*	Ruina	Up to 1200	Fruit
21	*Oroxylum indicum*	Paksam	250-900	Seeds
22	*Schima wallichii*	Chilaune	300-2000	Stem
23	*Thysanolaena latifolia*	Amliso	Up to 1800	Roots
24	*Zingiber officinale*	Adrak	Up to 1200	Rhizome

3.9.3.4 Other EconomicallyImportant Plants

The wood used in lower areas for timber include *Bischofiajavanica, Castanopsisindica,* Canarium *strictum, Garugapinnata, Fraxinus floribunda, Schimawallichii, Shorearobusta, Terminalia myriocarpa*and *Toonaciliata*. In addition to these trees, some tall and woody bamboos like *Bambusatulda*, *Dendrocalamushamiltonii, D. sikkimensis,* etc. are also used for these purposes. At higher altitudes various oak and coniferous species were used as timber trees and fuel wood. Important timber yielding trees of upper catchment areas include *Abiesdensa, Juglans regia, Lithocarpuspachyphylla, Quercus lamellosa*and *Tsuga dumosa*. Some of the other plant species in the study area are used by the local inhabitants for various purposes. A list of some commonly occurring plant species and their miscellaneous uses are given in **Table 3.44**.

Table 3.44: Common Useful Plant Species

S. N.	Palnt name	Uses
1	*Artemisia nilagirica*	Leaves and flowering tops used for flavouringalcoholic drinks
2	*Acorus calamus*	Rhizomes are used as an insecticides in storage ofcereals
3	*Arisaema tortuosum*	Tubers are used for insecticidalpurposes
4	*Cardamine corymbosa*	Leaves are eaten asvegetables
5	*Dendrocalamu shamiltonii*	Culms used for matwork andbaskets
6	*Echinochloa frumentacea*	Seeds are good source of potentbeer
7	*Geranium wallichii*	Flowers used for ornamentalpurposes
8	*Rhododendron arboreum*	Flowers used for squacepreparation
9	*Terminalia myriocarpa*	It is planted for landscaping
10	*Thysanolaena latifolia*	Plants used for broom preparation

3.9.4 Phytosociological Analysis for Community Structure

It is veryy essential to understand the community structre in the study area. In order to understand the community structure, vegetation sampling was done at different locations in the project area.Co-existence and competition amongst various species are affected directly by the number of individuals in the community. Therefore, knowing the quantitative structure of the community becomes essential. Various diversity indices including Simpson's Diversity Index give a comparative and quantitative picture of the community existing in the study area. To characterize vegetation in the study area, the primary data was collected and analyzed for describing the characteristics of vegetation with reference to species composition and structural attributes. The diversity measurements reflect as to how many diverse species are present, while the density measurements indicate number of individuals of a species in the study area. Species diversity is the best measure of community structure and it is sensitive to various environmental stresses. Smaller value of Simpson's Diversity Index shows healthy ecosystem and the higher value shows that an ecosystem is under environmental stress. The vegetation (trees, Shrubs and Herbs) sampling was carried out at Six different sampling locations near Barrage site, Power house site and near dumping zones. Details of the sampling locations present in **Table 3.45.**

Table 3.45: Sampling Location for Vegetation Survey

Location Code	Location Name	Type of vegetation
V-1	Powerhouse site(Right bank of Rangpo Chhu)	Tropical mixeddeciduous
V-2	Adit-III and Dumping site(Left bank of Rongni Chhu)	Tropical mixeddeciduous
V-3	Adit-II and Dumping site(Left bank of Rongni Chhu)	Tropical mixedbroadleaf
V-4	Adit-I and Dumping site (Left bank of Barrage site)	Tropical mixed broadleaf
V-5	Left bank of Barrage site(Left bank of Rongni Chhu)	Tropical mixed broadleaf
V-6	Right bank of Barrage site (Right bank of Rongni Chhu)	Tropical mixed broadleaf

3.9.4.1 V-1 Powerhouse site (Right bank of Rangpo Chhu)

A total of 12 tree species has been recorded at powerhouse site. The vegetation is dominated by *Shorea robusta*. The associated species in the tree canopy were *Malotus*philippensis, *Callicarpa arborea, Boehmerialongifolia, Rhuschinensis, Schimawallichii, Lagerstroemia lanceolata*and *Schimawallichii.Eupatorium odoratum*is the dominent species among the shrubs associtedspecis are*Woodfordiafruticosa, Clerodendrum japonicum, Cassia mimosoides and Buddlejaasiatica etc.*

Phytosociological characterstics of Tree and shrub species recorded at Power house site is presented in **Table 3.46 and 3.47.**

Table 3.46:Phytosociological characterstics of Tree species recorded around V-1 Site

S. N.	Species Name	Density/ ha	Relative Density (%)	Frequency %	RF %	Dominance	RD (%)	IVI
1	Shorea robusta	770.00	66.38	60.00	20.00	0.43	43.43	129.81
2	*Malotus philippensis*	120.00	10.34	50.00	16.67	0.25	24.76	51.77
3	*Dysoxylum excelsum*	30.00	2.59	30.00	10.00	0.04	4.38	16.97
4	*Schima wallichii*	50.00	4.31	30.00	10.00	0.02	1.62	15.93
5	*Callicarpa arborea*	40.00	3.45	20.00	6.67	0.05	4.98	15.09
6	*Toona ciliata*	10.00	0.86	10.00	3.33	0.03	2.84	7.03
7	*Albizia chinensis*	10.00	0.86	10.00	3.33	0.03	2.69	6.88
8	*Albizia odoratissima*	10.00	0.86	10.00	3.33	0.04	4.38	8.57
9	*Boehmeria longifolia*	30.00	2.59	20.00	6.67	0.02	1.62	10.87
10	*Bombax ceiba*	20.00	1.72	20.00	6.67	0.05	4.98	13.37
11	*Lagerstroemia lanceolata*	50.00	4.31	20.00	6.67	0.03	2.69	13.66
12	*Rhus chinensis*	20.00	1.72	20.00	6.67	0.02	1.64	10.03
SDI		0.58						

Table 3.47:Phytosociological characterstics ofShrub species recorded around V-1 Site

S. N.	Species Name	Sympson Index (SDI)	Frequency (%)	Density (Per /4m^2)	Dominance
1	*Buddleja asiatica*	0.625	30	0.5	1.67
2	*Eupatorium odoratum*		90	3.6	4.00
3	*Clerodendrum japonicum*		20	0.4	2.00
4	*Boehmeria platyphylla*		10	0.3	3.00
5	*Lee aaequata*		10	0.2	2.00
6	*Woodfordia fruticosa*		40	0.7	1.75
7	*Cassia mimosoides*		30	0.7	2.33

3.9.4.2 V-2 Adit-III (left bank of Rongni Chhu)

On the Adit-III (left bank of Rongni Chhu,) tree and sapling strata were dominated by*Albiziachinensis followed by Schimawallichii. The associated species of the tree layer were Bombax ceiba, Shorearobusta, Engelhardtia spicata, Rhuschinensis, Malotusphilippensis*etc.*Eupatorium odoratum*is the dominent species among the shrubs associtedspecis are*Oxysporapaniculata, Leeaaequata, Cassia mimosoides, Costusspeciosus and Dendrocalamushamiltonii etc.* Phytosociological characterstics of Tree and shrub species recorded around Adit-III is presented in **Table 3.48** and**Table 3.49.**

Table 3.48:Phytosociological characterstics of Tree species recorded around V-2 Site

Sl. No.	Species Name	Density/ ha	Relative Density (%)	Frequency %	RF %	Dominance	RD (%)	IVI
1	*Schima wallichii*	50.00	8.20	30.00	9.38	0.08	7.87	25.44
2	*Callicarpa arborea*	20.00	3.28	20.00	6.25	0.06	6.33	15.86
3	*Albizia odoratissima*	40.00	6.56	20.00	6.25	0.05	5.32	18.12
4	*Bombax ceiba*	100.00	16.39	50.00	15.63	0.08	7.86	39.88
5	*Ficus oblonga*	40.00	6.56	20.00	6.25	0.12	12.08	24.89
6	*Malotus philippensis*	70.00	11.48	30.00	9.38	0.12	12.06	32.91
7	*Albizia chinensis*	130.00	21.31	50.00	15.63	0.21	21.20	58.13
8	*Ficus semicordata*	50.00	8.20	20.00	6.25	0.07	6.64	21.09
9	*Bridelia retusa*	10.00	1.64	20.00	6.25	0.01	0.79	8.68
10	*Ficus auriculata*	30.00	4.92	10.00	3.13	0.09	9.06	17.11
11	*Engelhardtia spicata*	50.00	8.20	20.00	6.25	0.08	8.15	22.60
12	*Rhus chinensis*	20.00	3.28	30.00	9.38	0.03	2.66	15.31
SDI		0.64						

Table 3.49: Phytosociological characterstics of Shrub species recorded around V-2 Site

S. N.	Species Name	Sympson Index (SDI)	Frequency (%)	Density (Per /4m^2)	Dominance
1	*Oxyspora paniculata*	0.687	20	0.5	2.50
2	*Eupatorium odoratum*		80	3.5	4.38
3	*Leea aequata*		20	0.5	2.50
4	*Cassia mimosoides*		20	0.7	7.00
5	*Boehmeria platyphylla*		30	0.8	2.67
6	*Costus speciosus*		10	0.2	2.00
7	*Dendrocalamus hamiltonii*		20	0.4	2.00

3.9.4.3 V-3 Adit-III (left bank of Rongni Chhu)

On the Adit-II (*left* bank of Rongni Chhu), again tree and sapling strata were dominated by *Schimawallichii followed by Gynocardiaodorata, Engelhardtiaspicata,*. The other associated species of the tree layer were *Albiziaodoratissima,Macaranga denticulata ,Cyathea spinulosa,* and *Duabanga grandiflora etc*. The shrub vegetation is much diverse at this site. though *Neiliathrysifolia* is the dominent species among the shrubs associated species are *Eupatorium odoratum, Boehmeriaplatyphylla, Oxysporapaniculata etc.* Phytosociological characterstics of Tree and shrub species recorded around Adit-II is presented in **Table 3.50 and 3.51**.

Table 3.50:Phytosociological characterstics of Tree species recorded around V-3 Site

S. N.	Species Name	Density/ ha	Relative Density (%)	Fre. %	RF %	Dominance	RD (%)	IVI
1	*Albizia odoratissima*	30.00	4.48	10.00	3.85	0.04	4.48	12.80
2	*Macaranga denticulata*	90.00	13.43	40.00	15.38	0.13	13.43	42.25

3	*Schima wallichii*	130.00	19.40	40.00	15.38	0.19	19.40	54.19
4	*Ostodes paniculata*	50.00	7.46	10.00	3.85	0.07	7.46	18.77
5	*Oroxylum indicum*	60.00	8.96	20.00	7.69	0.09	8.95	25.60
6	*Engelhardtia spicata*	40.00	5.97	20.00	7.69	0.06	5.97	19.63
7	*Gynocardia odorata*	100.00	14.93	50.00	19.23	0.15	14.92	49.08
8	*Cyathea spinulosa*	120.00	17.91	30.00	11.54	0.18	17.91	47.36
9	*Duabanga grandiflora*	10.00	1.49	10.00	3.85	0.01	1.49	6.83
10	*Alnus nepalensis*	20.00	2.99	10.00	3.85	0.03	2.98	9.82
11	*Alangium salviifolium*	10.00	1.49	10.00	3.85	0.01	1.49	6.83
12	*Pandanus nepalensis*	10.00	1.49	10.00	3.85	0.01	1.49	6.83
SDI		*0.60*						

Table 3.51: Phytosociological characterstics of Shrub species recorded around V-3 Site

S. N.	Species Name	Sympson Index (SDI)	Frequency (%)	Density (Per /4m^2)	Dominance
1	*Eupatorium odoratum*	0.823	40	0.8	2.00
2	*Boehmeria platyphylla*		30	0.7	2.33
3	*Neilia thrysifolia*		60	2.3	3.83
4	*Oxyspora paniculata*		10	0.3	3.00
5	*Clerodendrum japonicum*		20	0.4	2.00
6	*Manihot esculenta*		10	0.2	2.00
7	*Rhamnus nepalensis*		20	1.1	5.50
8	*Abroma angustifolia*		10	0.2	2.00
9	*Trema orientalis*		10	0.3	3.00
10	*Leea aequata*		20	0.2	1.00

3.9.4.4 V-4 Adit-I (left bank of Rongni Chhu)

A total of 13 tree species has been recorded at Adit-I and dumping site. The vegetation is dominated by *Schimawallichii followed by Cyatheaspinulosa.*.The other associated species of the tree layer were *Macaranga denticulata, OroxylumindicumAlbiziaodoratissima, Duabanga grandiflora etc.*The shrub vegetation is much diverse at this site. though *Brassiopsis mitis* and *Mussaendaroxburghii* are the dominent species among the shrubs associted species are*Leeaaequata, Boehmeriaplatyphylla, RhamnusnepalensisOxysporapaniculata etc.* Phytosociological characterstics of Tree and shrub species recorded around Adit-I is presented in **Table 3.52** and **Table3.53.**

Table 3.52:Phytosociological characterstics of Tree species recorded around V-4 Site

S. N.	Species Name	Density/ ha	Relative Density (%)	Fre. %	RF %	Dominance	RD (%)	IVI
1	*Albizia odoratissima*	40.00	6.06	20.00	7.14	0.06	6.06	19.26

2	*Macaranga denticulata*	70.00	10.61	30.00	10.71	0.11	10.60	31.92
3	*Schima wallichii*	140.00	21.21	50.00	17.86	0.21	21.21	60.28
4	*Ostodes paniculata*	50.00	7.58	10.00	3.57	0.08	7.57	18.72
5	*Oroxylum indicum*	60.00	9.09	20.00	7.14	0.09	9.09	25.32
6	*Engelhardtia spicata*	40.00	6.06	20.00	7.14	0.06	6.06	19.26
7	*Gynocardia odorata*	70.00	10.61	50.00	17.86	0.11	10.60	39.07
8	*Cyathea spinulosa*	120.00	18.18	30.00	10.71	0.18	18.18	47.07
9	*Duabanga grandiflora*	10.00	1.52	10.00	3.57	0.02	1.51	6.60
10	*Alnus nepalensis*	20.00	3.03	10.00	3.57	0.03	3.03	9.63
11	*Alangium salviifolium*	10.00	1.52	10.00	3.57	0.02	1.51	6.60
12	*Rhus chinensis*	20.00	3.03	10.00	3.57	0.03	3.03	9.63
13	*Pandanus nepalensis*	10.00	1.52	10.00	3.57	0.02	1.51	6.60
SDI		0.70						

Table 3.53: Phytosociological characterstics of Shrub species recorded around V-4 Site

S. N.	Species Name	Sympson Index (SDI)	Frequency (%)	Density (Per /4m^2)	Dominance
1	*Clerodendrum japonicum*	0.80	20	0.4	2.00
2	*Datura stramonium*		30	0.5	1.67
3	*Neiliathrysiflora*		10	0.3	0.50
4	*Leeaaequata*		10	0.3	3.00
5	*Brassiopsis mitis*		50	1.7	3.40
6	*Mussaendar oxburghii*		50	1.6	3.20
7	*Oxyspora paniculata*		10	0.3	3.00
8	*Rhamnus nepalensis*		20	0.4	2.00
9	*Boehmeria pendulifera*		20	0.4	2.00
10	*Dendrocalamus hamiltonii*		20	0.2	1.00

3.9.4.5 V-5 Barrage site (Left bank of Rongni Chhu).

A total of 8 tree species has been recorded at Left bank of Barrage site (Left bank of Rongni Chhu). The vegetation is mainly dominated by *Schimawallichii and Engelhardtia spicata.* The other associated species of the tree layer were *Albiziachinensis, GynocardiaodorataTetradiumfraxinifolium and Ficussps. etc*The shrub vegetation is much diverse at this site. though *Eupatorium odoratum followed by Ficusoligodon, Caesalpiniadecapetala, Rhamnusnepalensis* are the dominent species among the shrubs associted species are*Rhamnusnepalensis, Boehmeriaplatyphylla, Toddaliaasiatica etc.* Phytosociological characterstics of Tree and shrub species recorded around Barrage site (Left Bank) is presented in **Table 3.54** and **Table 3.55**.

Table 3.54:Phytosociological characterstics of Tree species recorded around V-5 Site

Sl. No.	Species Name	Density / ha	Relative ensity (%)	Frequency %	RF %	Dominance	RD (%)	IVI
1	*Schima wallichii*	180.00	28.13	90.00	29.03	0.28	28.12	85.28

2	*Albizia chinensis*	70.00	10.94	40.00	12.90	0.11	10.94	34.78
3	*Gynocardia odorata*	20.00	3.13	10.00	3.23	0.03	3.12	9.48
4	*Daphniphyllum chartaceum*	60.00	9.38	30.00	9.68	0.09	9.37	28.43
5	*Tetradium fraxinifolium*	30.00	4.69	20.00	6.45	0.05	4.69	15.83
6	*Ficus glomerata*	60.00	9.38	30.00	9.68	0.09	9.37	28.43
7	*Engelhardtia spicata*	200.00	31.25	80.00	25.81	0.31	31.25	88.30
8	*Bischofia javanica*	20.00	3.13	10.00	3.23	0.03	3.12	9.48
SDI		0.48						

Table 3.55: Phytosociological characterstics of Shrub species recorded around V-5 Site

S. N.	Species Name	Sympson Index (SDI)	Frequency (%)	Density (Per /4m^2)	Dominance
1	*Ficus oligodon*	0.790	20	0.7	3.50
2	*Holmskioldia sanguinea*		10	0.2	2.00
3	*Eupatorium odoratum*		90	3.2	3.56
4	*Caesalpinia decapetala*		10	0.3	3.00
5	*Eurya acuminata*		10	0.3	3.00
6	*Rhamnus nepalensis*		40	1.1	2.75
7	*Boehmeria platyphylla*		40	1.1	2.75
8	*Toddalia asiatica*		10	0.2	2.00
9	*Euonymous pendulus*		10	0.3	3.00
10	*Lantana camara*		30	0.6	2.00

3.9.4.6 V-6 Barrage site (Right bank of Rongni Chhu).

A total of 8 tree species has been recorded at Right bank of Barrage site (Right bank of Rongni Chhu). The vegetation is mainly dominated by *Engelhardtia spicata and Schima wallichii.* The other associated species of the tree layer were *Albiziachinensis, GynocardiaodorataTetradiumfraxinifolium and Ficussps. etc.*
Among the shrubs at Barrage site Lantana camara is the dominent species among the shrubs associted species are *Eupatorium odoratum, Boehmeriaplatyphylla, Dendrocalamushamiltonii and Rhamnusnepalensis.* Phytosociological characterstics of Tree and shrub species recorded around Barrage site (Right Bank) is presented in **Table 3.56** and **Table 3.57.**

Table 3.56:Phytosociological characterstics of Tree species recorded around V-6 Site

S. N.	Species Name	Density / ha	Relative ensity (%)	Frequency %	RF %	Dominance	RD (%)	IVI
1	*Schima wallichii*	170.00	28.81	80.00	27.59	0.29	28.82	85.22
2	*Albizia chinensis*	70.00	11.86	40.00	13.79	0.12	11.87	37.52
3	*Gynocardia odorata*	20.00	3.39	10.00	3.45	0.03	3.39	10.23
4	*Daphniphyllum chartaceum*	60.00	10.17	30.00	10.34	0.10	10.17	30.69
5	*Tetradium fraxinifolium*	10.00	1.69	10.00	3.45	0.02	1.70	6.84
6	*Ficus glomerata*	40.00	6.78	20.00	6.90	0.07	6.78	20.46
7	*Engelhardtia spicata*	190.00	32.20	80.00	27.59	0.32	32.21	92.00
8	*Bischofia javanica*	30.00	5.08	20.00	6.90	0.05	5.09	17.07

SDI	0.52

Table 3.57: Phytosociological characterstics of Shrub species recorded around V-6 Site

S. N.	Species Name	Sympson Index (SDI)	Frequency (%)	Density (Per /4m^2)	Dominance
1	*Lantana camara*	0.72	70	2.7	3.86
2	*Eupatorium odoratum*		30	1	3.33
3	*Boehmeria platyphylla*		50	1.7	1.89
4	*Rhamnus nepalensis*		10	0.3	3.00
5	*Dendrocalamus hamiltonii*		20	0.6	2.00
6	*Mimosa himalayana*		20	1	2.50

Observation: Adit I, II, III are the more diverse site than Barrage and Powerhouse site.More than 13 nos, of tree species has been recorded in all quadrates sampled in above six locations. *Shorea robusta* is frequent at Powerhouse site and *Schimawallichii* and *Engelhardtia spicata* is more dominent at barrage site location. the vegetation is more diverse at Adit I, II, III site and vegetation is dominated with *Schimawallichii followed by Gynocardiaodorata, Engelhardtiaspicata,*. Maximum value of IVI was observed at Power house site for Shorearobuta with IVI 129.81 followed by *Engelhardtia spicata* having IVI of 92.0 and .*Schimawallichii* 85.28 at other locations.

Among the shrub species *Eupatorium odoratum*is the dominent species at Power house site. While *at Barrage site Lantana camara, Eupatorium odoratum* are the Frequent pecies among the shrubs associted species. The shrub vegetation is much diverse at Adit I, II, III site. *Neiliathrysifolia, Brassiopsis mitis* and *Mussaendaroxburghii* are the dominent species.

Simpson diversity index-

Tree vegetation:The Simpson diversity index in the above sites selected for the study ranges from 0.48 to 0.70 in the study area. The number of species per sample is a measure of richness. The more species present in a sample, the 'richer' the sample. It indicates that the submergence area is less richer in compression of other sites.

Shrub Vegetation: The Simpson diversity index in the above sites selected for the study ranges from 0.625 to 0.80 in the study area. The number of species per sample is a measure of richness. The more species present in a sample, the 'richer' the sample. It indicates that the powerhouse site area is less richer in compression of other sites.

3.9.5 Faunal Diversity

Since observations of fauna and wildlife take long time, primary surveys were limited to field visits and direct and indirect sightings of animals. The presence of wildlife was also confirmed from the local inhabitants depending on the animal sightings and the frequency of their visits in the area. In addition to these, secondary sources were referred for the preparation of a checklist and other analysis in the study of animals and wildlife in the region. Though faunal surveys were carried out for the species of Mammals, Birds, Herpetofauna butterfles and Insects and the study of mammals and birds were studied by placing systematic transects at different sampling locations in the study area **(Table 3.58).**

Table 3.58: Sampling Transects for Faunal Surveys

Sampling Transects	Length of Transect Covered (Km)
Submergence, Near Barrage Site	2.0
Upstream/right bank, near Power house site	3.2
Command area	3.0

3.9.5.1 Mammals

The study has wide range of faunal diversity. Commonly found mammals reported in Brrage and powerhouse site. The project area is densely populated with high intensity of agricultural activities. The anthropogenic activities are predominant around the river and project area. The largest town of Sikkim (Gangtok) is located in the vicinity. The high anthropogenic activities, high vehicular density and dense human population acts as a deterrent for the wildlife in the project site hence the no major wildlife is reported in project area and wildlife is very restricted to Forest area and snactuary area present within the study area. There are about 43 species of mammals repoted in the study area. out of the reported mammals Red Panda and Clouded leopard are the Schedule-I species as per the wildlife Act 1972. Rest of the species falls in schedule II, II, IV and V of WLA 1972. The schedule-I species are mainly found in Fambong Lho Wildlife Sanctuary area which is located about 3.6 km in northwest direction. As per the Local people the Scheduled -I fauna is rarely sited in study area. Direct sighting and people consultation confirmed the presence of mongoose, Jungle cat Rhesus macaque, Porcupine, Wild Boar, Squirrel etc, in the study area. Species recorded during this survey are listed in **Table 3.59.**

Table 3.59: List of Mammalian species observed in the Study Area

S. N.	Common name	Scientific name	Schedule as per WPA (1972)	IUCN Status
1	Goral	*Naemorhedus goral*	III	-
2	Barking Deer	*Muntiacus muntjak*	III	-
3	Indian wild boar	*Sus scrofa*	III	-
4	Red Panda	*Ailurus fulgens*	I	EN
5	Jackal	*Canis aureus*	II	-
6	Tibetian fox	*Vulpes montanus*	II	-
7	Clouded leopard	*Neofelis nebulosa*	I	EN
8	Jungle cat	*Felis chaus*	II	-
9	Common mongoose	*Herpestes edwardsii*	IV	-
10	Common otter	*Lutra lutra*	II	-
11	Himalayan marten	*Martes flavigula*	II	-
12	Yellow-bellied weasel	*Mustela kathiah*	II	-
13	Himalayan weasel	*Mustela sibirica*	II	-
14	Striped-backed weasel	*Mustela strigidorsa*	II	-
15	Small-toothed palm civet	*Arctogalidia trivirgata*	-	-
16	Himalayan palm civet	*Paguma larvata*	II	-
17	Naked-rumped tomb bat	*Taphozous nudiventris*	-	-
18	Great Himalayan bat	*Hipposideros armiger*	V	-

19	Fulvous leaf-nosed bat	*Hipposideros fulvus*	V	-
20	European free-tailed bat	*Tadarida teniotis*	V	-
21	Indian flying fox	*Pteropus giganteus*	V	-
22	Fulvous fruit bat	*Rousettus leschenaultia*	V	-
23	Mountain fruit bat	*Sphaerias blanfordi*	V	-
24	Greater horseshoe bat	*Rhinolophus ferrumequinum*	V	-
26	Shrew species	*Sori culuscaudatus*	-	-
27	Blacknaped hare	*Lepus nigricollis*	IV	-
28	Assamese macaque	*Macaca assamensis*	II	-
28	Rhesus macaque	*Macaca mulatta*	II	-
29	Indian porcupine	*Hystrix indica*	III	-
30	Wood mouse	*Apodemus sylvaticus*	V	-
31	Indian mole rat	*Bandicota bengalensis*	V	-
32	Sikkim Vole	*Microtus sikkimensis*	V	-
33	Indian field mouse	*Mus booduga*	V	-
34	House mouse	*Mus musculus*	V	-
35	Sikkim mouse	*Mus pahari*	V	-
36	Himalayan rat	*Rattus nitidus*	V	-
37	Brown rat	*Rattus norvegicus*	V	-
38	Common house rat	*Rattus rattus*	V	-
39	Sikkim rat	*Rattus sikkimensis*	V	-
40	Woolly flying squirrel	*Eupetaurus cinereus*	V	-
41	Hairy-footed flying squir.	*Belomys pearsonii*	III	-
42	Hoary-bellied Hima.squi.	*Callosciurus pygerythrus*	II	-
43	Five-striped palm squirrel	*Funambulus pennantzi*	-	-

**Sighted during field investigation*

IUCN- International Union for Conservation of Nature; WPA – Wildlife (Protection) Act, 1972, VU – Vulnerable; NT- Near Threatened; LC - Least Concern

3.9.5.2 RET Mammals

The Indian Wildlife Protection Act (1972) has also scheduled the animals in various categories for given them varying degree of protection. Among recorded mammals, only Red Panda and Clouded leopard are the Schedule-I species as per the wildlife Act 1972. Rest of the species falls in schedule II, II, IV and V of WLA 1972.

3.9.5.3 Avifauna

Bird survey was conducted on the same transects and trails marked for mammal's survey. The whole sampling was carried out in a fixed width trails of 2-4 km wherever the terrain permits and point counts were carried out at a fixed distance at more or less at regular intervals. A prismatic field binocular (10X50) was used for the bird watching during transect walk mostly during morning and evening hours at nearby habitations as well as near to water bodies in the study area. An on-spot identification of birds has been carried out with the help of pictorial guides/literature published by Grimmettet al. (2011). In Project area (in between the barrage and power house sites) a total of 91 species of birds belonging to 13 orders like Galliformes, Charadriformes, Columbiformes, Falconiformes, Psitaciformes, Coraciformes, Piciformes and Passeriformes etc were recorded **(Table3.60).** Order Passeriformes is the largest group comprising more than 50% of the total bird species.

Table 3.60: Birds observed in the Study Area

Sl. No	Common name	Order	Schedule as per WPA (1972)	Habit
1	*Ardea goliath*	Ciconiformes	IV	R
2	*Spizaetus nipalensis nipalensis*	Falconiformes	IV	R
3	*Arborophila torqueola*	Galliformes	IV	R
4	*Lophura leucomelanos melanota*	Galliformes	IV	R
5	*Charadriiformes vanellusduvaucelii*	Charadriiformes	IV	WV
6	*Vanellus leucurus*	Charadriiformes	IV	WV
7	*Vanellus indicus*	Charadriiformes	IV	AM
8	*Charadrius mongolus*	Charadriiformes	IV	WV
9	*Charadrius dubius*	Charadriiformes	IV	R
10	*Tringa totanus*	Charadriiformes	IV	WV
11	*Tringa ochropus*	Charadriiformes	IV	WV
12	*Treron sphenura*	Columbiformes	IV	AM
13	*Macropygia unchall*	Columbiformes	IV	R
14	*Streptopelia chinensis suratensis*	Columbiformes	IV	AM
15	*Streptopelia orientalis*	Columbiformes	IV	AM
16	*Psittacula himalayana*	Psittaciformes	IV	R
17	*Psittacula eupatria*	Psittaciformes	IV	LM
18	*Cuculus micropterus*	Cuculiformes	IV	LM
19	*Cuculus canorus*	Cuculiformes	IV	LM
20	*Cacomantis merulinus*	Cuculiformes	IV	M
21	*Otus scops*	Strigiformes	IV	R
22	*Bubo nipalensis*	Strigiformes	IV	R
23	*Ketupa flavipes*	Strigiformes	IV	R
24	*Glaucidium cuculoides cuculoides*	Strigiformes	IV	AM
25	*Strixaluco nivicola*	Strigiformes	IV	R
26	*Collocalia brevirostris*	Apodiformes	-	R
27	*Apus pacificus*	Apodiformes	-	R
28	*Apus affinis*	Apodiformes	-	R
29	*Tachymarptis melba*	Coraciformes	-	SV
30	*Harpactes erythrocephalus*	Coraciformes	IV	R
31	*Alcedo hercules*	Coraciformes	IV	R

32	*Alcedo atthis*	Coraciformes	IV	R
33	*Alcedo meninting*	Coraciformes	IV	R
34	*Halcyon capensis*	Coraciformes	IV	R
35	*Upupa epops*	Coraciformes	IV	R
36	*Megalaima siatica*	Piciformes	IV	R
37	*Megalaima lineata*	Piciformes	IV	R
38	*Picus canus*	Piciformes	IV	R
39	*Dendrocoposhyperythrus*	Piciformes	IV	R
40	*Dendrocopos darjellensis*	Piciformes	IV	R
41	*Serilophus lunatus*	Passeriformes	-	R
42	*Pitta nipalensis*	Passeriformes	IV	AM
43	*Hirundo rustica*	Passeriformes	-	R
44	*Hirundo rupestris*	Passeriformes	-	WV
45	*Delichon nipalensis*	Passeriformes	-	AM
46	*Irena puella*	Passeriformes	IV	R
47	*Pycnonotus melanicterus*	Passeriformes	IV	R
48	*Pycnonotus leucogenys*	Passeriformes	IV	R
49	*Pycnonotus cafer bengalensis*	Passeriformes	IV	R
50	*Pycnonotus jocosus*	Passeriformes	IV	R
51	*Hypsipetes leucocephalus*	Passeriformes	IV	R
52	*Hypothymis azurea*	Passeriformes	IV	R
53	*Muscicapa sibirica*	Passeriformes	IV	AM
54	*Ficedula tricolor*	Passeriformes	IV	R
55	*Eumyias thalassina*	Passeriformes	IV	R
56	*Spelaeornis caudatus*	Passeriformes	IV	R
57	*Spelaeornis formosus*	Passeriformes	IV	R
58	*Sphenocichla humei humei*	Passeriformes	IV	R
59	*Stachyris chrysaea chrysaea*	Passeriformes	IV	R
60	*Stachyris nigriceps*	Passeriformes	IV	R
61	*Macronous gularis*	Passeriformes	IV	R
62	*Timalina pileata*	Passeriformes	IV	R
63	*Garrulax albogularis*	Passeriformes	IV	R
64	*Garrulax leucolophus*	Passeriformes	IV	R
65	*Garrulax striatus*	Passeriformes	IV	R
66	*Garrulax ruficollis*	Passeriformes	IV	R
67	*Garrulax squamatus*	Passeriformes	IV	R
68	*Yuhina castaniceps rufigenis*	Passeriformes	-	R
69	*Yuhina bakeri*	Passeriformes	-	R
70	*Yuhina flavicollis flavicollis*	Passeriformes	-	R
71	*Phoenicurus frontalis*	Passeriformes	-	AM
72	*Phoenicurus ochruros rufiventris*	Passeriformes	-	SV

73	*Chaimarrornis leucocephalus*	Passeriformes	-	R
74	*Rhyacornis fuliginosus*	Passeriformes	-	R
75	*Myophonus caeruleus*	Passeriformes	-	R
76	*Enicurus immaculatus*	Passeriformes	-	R
77	*Enicurus schistaceus*	Passeriformes	-	R
78	*Enicurus leschenaulti*	Passeriformes	-	R
79	*Enicurus maculatus*	Passeriformes	-	R
80	*Laniusschach tricolor*	Passeriformes	-	SV
81	*Dicrurus annectans*	Passeriformes	IV	R
82	*Garrulus glandarius*	Passeriformes	IV	R
83	*Urocissa flavirostris flavirostris*	Passeriformes	IV	R
84	*Dendrocitta formosae*	Passeriformes	IV	R
85	*Dendrocitta vagabunda*	Passeriformes	IV	R
86	*Corvus splendens splendens*	Passeriformes	V	R
87	*Corvus corax*	Passeriformes		R
88	*Acridotheres tristis tristis*	Passeriformes	IV	R
89	*Parus monticolus*	Passeriformes	IV	R
90	*Parus xanthogenys*	Passeriformes	IV	R
91	*Passer domesticus*	Passeriformes	-	R

AM = Altitudinal migrant, LM = Local migrant, R = Resident, M = Migrant, V = Vagrant, SV = Summer visitor, WV = winter visitor

3.9.5.4 RET Avifauna

On the basis of WPA (1972) a majority of birds are categorized as Schedule-IV. There are no species which are included in the Schedule-I. Rest of the species reported in study area are categorized in the Schedule-IV or V.

3.9.5.5 Herpetofauna

The amphibian and reptiles were sampled with the same transect marked for mammals/birds. The sampling also carried out along the banks of River and adjoining ponds of submergence and downstream sections of proposed barrage. Sampling was repeated during night following the time constrained Visual Encounter Rates (VES) method. There were 2 species of amphibians, 12 species of snakes and Lizards has been recorded/confirmed in the study area. **(Table 3.61)**.

Table 3.61: Herpetofauna observed in the Study Area

S.N.	Common Name	Scientific Name	Vernacular Name	Family	Schedule
Amphibians					
1	Frog	*Rana tigrina*	-	Ranidae	IV
2	Indian bull frog	*Hoplobatrachus tigerinus*	-	Dicroglossidae	IV
Reptiles					
3	Binocellate cobra	*Naja naja*	Nag	Elapidae	II
4	Monitor Lizard	*Varanus bengalensis*	-	Varanidae	II

5	Asiatic water snake	*Xenochrophis piscator*	-	Colubridae	II
6	Monocled cobra	*Naza kaouthia*		Elapidae	II
7	Indian Krait	*Bungarus coeruleus*	-	Elapidae	IV
8	Russell's Viper	*Vipera russellis*	-	Crotalidae	II
9	Rat snake	*Ptyas mucosus*	Dhaman	Colubridae	II
10	Keelblack	*Xenochrophis piscator*	-	Colubridae	II
11	Garden Lizard	*Calotes versicolor*	-	Agamidae	II
12	Brooks geeko	*Hemidactylis brooki*	-	Gekkonidae	II
13	Common Sand Boa	*Gongylophis conicus*		Boidae	II
14	Oriental Garden Lizard	*Calotes versicolor*	Girgit	Agamidae	II

3.9.5.6 Butterflies

During the survey period follwing species **(Table 3.62)** of the butterflies were recorded in study area.

Table 3.62: Butterfly Recorded in the study area during primary study

Common Name	Scientific Name	Common Name	Scientific Name
Common blue bottle	*Graphium sorpedon sorpedon*	Common leopard	*Phalanta phalanta*
Glassy blue bottle	*Graphium cloanthus*	Large Yeoman	*Cirrochroa aoris aoris*
Veined jay	*Graphium bathycles chiron*	Common Yeoman	*Cirrochroa tyche mithila*
Great wind mill	*Atrophaneura dasarada dasarada*	Queen of Spain fritillary	*Issoria lathonia issaea*
Common rose	*Pachiopta aristolochiae*	Indian Fritillary	*Argyreus hyperbius hyperbius*
Lime butterfly	*Princeps demoleus*	Large silverstripe	*Children childron childroni*
Spangle	*Princeps protentor protentor*	Balck vein fritillary	*Melitaea arcesia sikkimensis*
Great mormon	*Princeps mormon agenor*	Yellow pansy	*Precis hierta magna*
Common mormon	*Princeps polytes ramulus*	Blue Pansy	*Precis orithya ocyale*
Paris peacock	*Princeps paris paris*	Grey pansy	*Precis atlites*
Krishna peacock	*Princeps krishna*	Himalayan jester	*Symbrenthia hypestis cotanda*
Psyche	*Leptosia nina nina*	Autumn leaf	*Daleschallia bisaltide indica*
Choclate albatross	*Appias lycida lyncida*	Blue oakleaf	*Kalima hordefieldi*
Spot puffin	*Appias lalage durnasa*	Common map	*Cyrestic thyodemas thyodemas*
Great orange tip	*Hebomoia glaucippe glaucippe*	Yellow jack Sailor	*Lassipa viraja viraja*
Hill jezebel	*Delias bellanona ithiela*	Common lascar	*Pantoporia hordonia hordonia*
Redbase jezebel	*Delias aglaia*	Black vein sergeant	*Parathyma ranga ranga*
Common gem	*Poritia hewitsoni hewitsoni*	Common sergeant	*Parathyma prius*
Bright sunbeam	*Curetis buliss*	Staff sergeant	*Parathyma selenophora selenophora*
Longbrandedsilverline	*Spindasis lohita himalayensis*	Commodore	*Moduza procris procris*
Pea blue	*Lampides boeticus*	Green commodere	*Limetis daraxa*
Dark cerulean	*Jampides bochus*	Scarce white commodore	*Limetis zulene*
Zebra blue	*Syntarucus plinius*	Knight	*Labadea martha martha*
Plains cupid	*Edales pandana*	Blue baron	*Euthalia telchima*
Lesser punch	*Dodena dipaea*	Common baron	*Euthalia aconthea suddhodana*
Tailed punch	*Dodena eugenes venox*	Gawdy baron	*Euthalia lubentina indica*
Mixed punch	*Dodena ovida ovida*	French duke	*Euthalia franciae franciae*
Common evening brown	*Melanitis leda isimene*	Blue duchess	*Euthalia duda*
Dark evening brown	*Melanitis phedumа bela*	Green duke	*Euthalia sahadeva sahadeva*
Lilane bush brown	*Mycalsis fransisca santana*	Cruiser	*Vindula erota erota*

White edged bush brown	*Mycalsis nestra vetus*	Red lacewing	*Cethosia biblis tisamena*
Niger	*Orsotricoena medus medus*	Choclate tiger	*Parantica melaneus platiniston*
Common fivering	*Yipthima baldus baldus*	Blue tiger	*Tircimala limniace*
Pallied nawab	*Polyura arja*	Darkblue tiger	*Tircimala septentrionis*
Stately nawab	*Polyura dolon centralis*	Common tiger	*Danaus genutia*
Circe	*Hestena nama*	Magpie crow	*Euploea radamaanthus*
Yellow kansir	*Penthema lisrada lisrada*	Long branded blue crow	*Euploea algen deione*
Tabby	*Psuedergolis wedah*	Orange owlet	*Bibasis jaina jaina*
Angled castor	*Ariadne ariadne pallidior*	Common spotted flat	*Celaenorrhinus leucocera*
Water snow flat	*Tagides litigiosa litigiosa*	Purple Red eye	*Matapa purpurascens*
Chestnut angle	*Odontoptilum angulata angulata*		

3.9.6 Aquatic Ecology

Water and ecological quality are the important concern for human use of lentic and lotic ecosystems. These water bodies have significant economic values including hydropower generation, supplying water for drinking water for irrigation, providing food via fish and aquatic products, and preserving the health and biodiversity of important life support ecosystem. However, all these functions depend on a well-balanced environment in terms of its physical, chemical and biological variables. Like water quality monitoring, biological or aquatic monitoring is an ecosystem assessment tool which can be used as the basis for management programmes, restoring and maintaining the physico-chemical and biological integrity of freshwater. Live organisms provide valuable information by their presence, absence and abundance regarding their surrounding habitat and can be used to evaluate the local environmental impact by their physical, chemical and biological properties and their cumulative effects.

In the present project, to assess the aquatic ecological status, aquatic micro-phytoplankton, micro-zooplankton, macro-invertebrates and benthos was monitored within study area of project. Samples have been collected from 6 locations in the study area covering three seasons (Winter, Pre-monsoon and Monsoon) for analysis of aquatic ecological parameters. Primary data regarding fisheries, fish diversity composition, their migration and breeding grounds has been collected from the study area, where as secondary data on fish and fisheries has also been collected from Fisheries Department of Shimla

3.9.6.1 Methodology of Aquatic Study

Collection and preservation of Phytoplankton sample: The plankton samples were collected from sub surface water. In the case of phytoplankton, 500 ml sample water was collected in polyethylene bottles and 1ml of Lugol's solution was added for fixation and preservation. The samples were centrifuged and decanted. A volume of 10 ml was collected in double stoppered polyethylene bottles for further qualitative analysis of phytoplankton. Identification of phytoplankton was dome with the help of standard books and monographs (Turner, 1892; smith, 1924, Ward and Whipple 1959).

Collection and preservation of Zooplankton sample: The zooplankton samples were collected by filtering 100 liters of sub-surface water through plankton net made up of bolting silk cloth no 20. A sub sample of 30 ml was collected again, in polyethylene double stoppered bottles and 4-5 drops of formalin and glycerin were added. The samples were stored for further qualitative and quantitative study of zooplanktonic organism. The identification of zooplankton was done up to species in most cases, according to the reference books including that of Ward and Wipples (1959), Koste (1978), Battish (1992) and Dhanapathi (2000).

Collection and preservation of macro-invertebrate and benthic samples: Samples have been collected on monthly basis with the help of Ekman's dredge, scoop and D-frame nets. Samples were sieved through a sieve having mesh size of 0.5 to 0.6 mm. The animals were picked up by hand picking and preserved in 4% formalin solution.

3.9.6.2 Sampling Locations

Surface water samples were collected from 3 locations for analysis of aquatic ecological status. Sampling location details are provided in **Table 3.63**.

Table 3.63: Locations of Aquatic Studies

S. N.	Sampling Location	Habitat	Source	Substrate Type
1	D/s of the Barrage site	Flowing Water	Ronnichu	Predominance of Sand and grevels
2	u/s of Barrage site	Flowing Water	Ronnichu	Predominance of Sand and grevels
3	Near Powerhouse site	Flowing Water	Ronnichu	Predominance of Sand and grevels

3.9.6.3 Phytoplankton

A total of 49 species of phytoplankton/ Phytobenthos were observed in the river at diffent locations. Among the Phytoplanktons maximum 28 species recorded at up stream of the barrage site and minimum species recorded at powerhouse site. Among the Phytobenthos maximum 24 species recorded at up stream of the barrage site and minimum species recorded at powerhouse site. Details list of the Phytoplankto/Phytobenthos community recorded from the study area is presented in **Table 3.64.**

Table 3.64:Phytoplankto/Phytobenthos community recorded from the study area

Sl. No.	Taxa	Phytoplankton			Phytobenthos		
		S1	S2	S3	S1	S2	S3
1	*Achnanthes biasolettiana*	+	+	+	+	+	+
2	*A. gibberula*	+	-	-	+	-	-
3	*A. haukiana*	-	-	-	-	+	-
4	*A. lanceolata*	+	-	-	-	-	+
5	*A. linearis*	-	+	+	+	+	-
7	*A. minutissima*	+	+	+	+	-	+
8	*A. minutissima cryptocephala*	+	+	-	-	+	-
9	*A. affinis*	+	+	+	+	-	+
10	*Achnanthes* sp. 1	+	-	-	+	-	+
11	*Achnanthes* sp. 2	-	+	+	+	+	-
12	*Achnanthes* sp. 3	-	-	-	+	+	+
13	*A. undata*	-	-	-	+	+	-

14	*Amoneis* sp.	-	-	-	+	-	+
15	*Cocconeis placentula euglypta*	-	+	+	+	+	-
16	*Cymbella ventricosa*	+	-	+	+	-	+
17	*C. linearis*	-	-	-	+	-	-
18	*C. turgida*	+	-	-	-	+	-
19	*C. affinis*	+	-	+	+	-	+
20	*C. nagpurense*	+	+	+	-	+	-
21	*Cymbella* sp.	-	+	-	+	-	+
22	*Amphora eneta*	-	+	-	-	-	-
23	*Reimaria sinuata*	+	+	+	-	+	+
24	*Diploneis* sp.	-	+	-	+	-	+
25	*Diatoma anceps*	-	+	-	-	-	-
26	*D. hiemale*	-	+	-	-	-	-
27	*Eunotia lunaris*	+	-	+	-	-	-
28	*Eunotia* sp.	+	+	-	-	-	-
29	*Fragilaria capucina*	+	+	+	+	+	+
30	*F. vaucherea*	+	+	+	+	+	+
31	*Gomphonema intricatum*	+	+	+	-	+	-
32	*G. oliaceum*	+	+	+	-	+	+
33	*G. parvulum*	-	+	-	+	+	-
34	*G. sphaerophorum*	-	+	-	-	+	+
35	*Hannaea arcus* var. *linearis*	+	+	+	-	+	-
36	*Navicula exigua*	-	+	-	-	-	-
37	*N. hustedtii*	+	+	+	-	-	-
38	*N. halophila*	-	+	-	+	+	
39	*N. pupula*	-	-	+	-	+	-
40	*N. radiosa*	+	-	-	-	-	+
41	*N. radiosa tenella*	+	-	-	+	+	-
42	*N. rhynchocephala*	-	-	+	-	-	+
43	*Nedium* sp.	-	-	+	-	+	-
44	*Nitzschia ignorata*	-	+	-			
45	*N. palea*	-	-	+	-	+	-
46	*Synedra ulna*	+	-	-	-	-	+
47	*S. ulna oxyrhynchus*	+	+	+	-	-	-
48	*S. ulna amphithynchus*	-	+	-	-	-	-
49	*S. rumpens*	+	-	-	+	+	-
		25	28	22	22	24	19

3.9.6.4 Benthic Macro invertebrate Fauna

A total of 9 benthic macro-invertebrate's taxa were recorded during primary survey. Upstream of Barrage site was the richest community in terms of benthic fauna **(Table 3.65).**

Table 3.65: Invertebrate distribution at different sampling stations

S.No.	TAXA	S1	S2	S3
A	**Ehemeroptera**			
1	Heptagenidae	+	+	-
2	Baetidae	+	-	+
3	Ephemerellidae	+	+	+
B	**Plecoptera**	**-**	**+**	**+**
1	Isoperlidae	-	+	-
2	Perlidae	+	+	+
C	**Trichoptera**	**+**	**-**	**+**
1	Hydropsychidae	+	+	-
2	Helicopsychidae	-	+	+
D	**Diptera**	**+**	**+**	**+**
1	Chironomidae	+	+	+
2	Ephydridae	+	-	-
3	Psychodidae	-	+	-
4	Culucidae	+	+	+
		9	11	9

3.9.6 Fish in Rongni Chhu

Rongni Chhu is one of the largest tributaries of Teesta and originates from western slopes of a peak (3,924 m) in East Sikkim. After traversing a total distance of about 36 km, it confluences with river Teesta at Singtam. In lower stretch from Ranipul to Singtam, the right bank vicinity of river is thickly populated and high intensity of agricultural practices. The proposed H.E. project is located across the river Rongni Chhu at an elevation of 696 m.

Fishing is not a prime occupation of the villagers. Fishes contribute significantly to the diet of human being and play a vital role in the economy as well. They are top creatures in the hierarchy of fresh water ecosystem. Apart from food value, fishes are widely used for recreation and sport fishing also. In recent years, increasing industrialization and demand of energy have led regulation of many streams in India, resulting in habitat destruction of fish and adverse effects on water quality. Due to regulation and deterioration in water quality many species of fish have been struggling for their subsistence. The present study deals with the fish composition, distribution, and status of fish in Rongni Chhu and likely impact of proposed H.E. project on the fish and fisheries. The major fishes of the area are Catli, Budhana, Kavrey and Korang etc. List of fishes is given in following **Table 3.66**

Table 3.66: Fish Species Reported in Study Area

Sl. No.	Species	Local name
Family Cyprinidae		
1	*Acrossocheilus hexagonolepis*	Catli
2	*Schizothorax richardsonii*	Asla
3	*Schizothoraicthys progastus*	Chucheasla
4	*Puntius clavatus*	–
5	*Barilius bendelisis*	Korang, Joia
6	*B. bendelisis chedra*	Korang, Joia
7	*B. vagra*	Chirkay

8	*Danio aequipinnatus*	Vhitti
9	*Garra gotyla gotyla*	Budhna
10	*G. gotyla stenorhynchus*	Budhna
11	*G. annandalei*	Budhna
12	*G. lamta*	Budhna
13	*G. mcclellandi*	Budhna
14	*G. mullya*	Budhna
Family Sisoridae		
15	*Pseudecheneis sulcatus*	Kavrey
16	*Glyptothorax gracilis*	Kahray
17	*G. sinense manipurensis*	Kahray
18	*G. sinense sikkimensis*	Kahray
Family Cobitidae		
18	*Nemacheilus butanensis*	Gadela
19	*N. carletoni*	Gadela
20	*N. corica*	Gadela
21	*N. devdevi*	Gadela
22	*N. sikkimensis*	Gadela
23	*N. kanjupkhulensis*	Gadela
24	*N. multifaciatus*	Gadela
Family Channidae		
25	*Channa gachua*	Hilay

3.10 SOCIO-ECONOMIC ENVIRONMENT

The present socio-economic assessment involves primary field survey of socio-economic status of the people of the study area in general and the project affected villages and the PAF in general. Review of secondary data, such as District Census Statistical Handbooks-2011 and the records of National Informatics Center data, for the parameters of demography, occupational structure of people within the study area which mainly comprises of the villages, where the project area is located as per revenue records. The information in this context was gathered on the following socio-economic parameters viz.Demographicprofile,Educationallevels,OccupationalProfile,Cropping pattern and other socio-economic parameters.

3.10.1 District Profile

Sikkim is a tiny hilly state located between 27^0 04' 46" and 28^0 07' 48” North latitude and 88^0 00' 58" and 88^0 55' 25” East longitude in the North Eastern Himalayan region covering an area of 7096 Km^2. It stretches 112 kms. from North to South and 64 kms. from East to West. It is extended upto Tibet Plateau (China) and the kingdom of Bhutan on the east. On the west lies the kingdom of Nepal and on the south it touches the Darjeeling district in the state of West Bengal. In this manner, three of its districts share their boundaries with the neighboring countries except the South district. Nearly two third of its hilly regions are very high mountains perpetually covered with snow are the sources of glaciers like Talung, Zemu, Lhonak etc. Sikkim state has four districts which are named according to their regional locations viz., North District ,WestDistrict,South District and East District. Each district is further divided into smaller administrative division as sub-divisions. East district has got three sub-divisions viz. Gangtok ,Pakyong and Rongli.

The description of the demography of East Sikkimi district and two sub-divisions which cover the project is presented in **Table 3.67**. It could be well inferred from the data above that there are total 61567 house hold in district with total population of 283583 comprised of 151432 males and 132151 females with sex ratio of 873.There are total 20353house holds in Gangtok Sub division with total population of 102846 comprised of 57118 males and 45728 females with sex ratio of 800. There are total 7738house holds in Pakyong Sub division with total population of 36392 comprised of 18795 males and 17597 females with sex ratio of 936.

Table 3.67: Demographic Details of Project District and Sub Divisions

S. N.	District/Sub div.	H.H.	Population						Sex Ratio
			Total	Male	Female	Below 6Yr	Male <6Y	Fem <6Y	
1	East Sikkim Distt	61567	283583	151432	132151	27984	14277	13707	873
2	Gangtok Sub div.	20353	102846	57118	45728	10154	5170	4984	800
3	Pakyong Sub div.	7738	36392	18795	17597	3720	1847	1873	936

Table 3.68 gives a description of religion wise distribution in district. As per official census 2011 and population data 2019 of East Sikkim district, Hindu are majority in East Sikkim state. Total population of East Sikkim district is 283,583 as per census 2011. Hinduism constitutes 62.74% of East Sikkim population. Buddhist plays important role in electoral of East Sikkim state forming significant 25.55% of total population. Christian are minority in East Sikkim state forming significant 8.25% of total population.

Table 3.68: Religion wise distribution of Population

Description	Percentage
Hindu	62.74
Muslims	2.19
Christian	8.25
Sikh	0.30
Buddhist	25.55
Jain	0.08
Others	0.61
Not Stated	0.29

The **Table 3.69** provides detailed information about the SC, ST population in East Sikkim district as well asin project sub divisions. The total SC population indistrict is 15305, which is 5.4% of the total population, while ST population is78436, which is 27.7% of the total population in district. The SC population in Gangtok Sub divisionand PakyongSub division is 6183 (5.1%) and 2015 (5.5%) respectively. The ST population in Gangtok Sub division and Pakyong Sub division is 31165 (30.3%) and 11589 (31.8%) respectively.

Table 3.69: Caste wise distribution of population

S. N.	District/Sub div.	Schedule Caste (SC)		Schedule Tribes (ST)	
		Total	% of SC	Total	% of ST
1	East Sikkim Distt	15305	5.4	78436	27.7

2	Gangtok Sub div.	6183	5.1	31165	30.3
3	Pakyong Sub div.	2015	5.5	11589	31.8

The details of literacy rate and literate people in East Sikkim District and 2Sub-divisions) are provided in **Table 3.70.** In the district there are 214239literates(83.8%) of which males and females are 121345(88.5%) and 92984(78.5%)with a gender gap of 9.0%.In Gangtok Sub div. there are 75332literates(81.3%) of which males and females are 45202 (87%) and 30130(74%) with a gender gap of 13.0%.In Pakyong Sub div. there are 25422 literates(77.8%) of which males and females are 13987 (82.5%) and 11435(65.7%) with a gender gap of 16.8%.

Table 3.70: Literacy Rate of Project District and Tehsils

S. N.	District/Sub div.	Number of Literate			Literacy Rate			Gender Gap
		Total	Male	Female	Total %	Male	Female	
1	East Sikkim Distt	214239	121345	92984	83.8	88.5	78.5	9.0
2	Gangtok Sub div.	75332	45202	30130	81.3	87.0	74.0	13.0
3	Pakyong Sub div.	25422	13987	11435	77.8	82.5	65.7	16.8

Table3.71 describes two sections of workers main and marginal with a third category which is non-worker; the total number of workers at district level is 139678(49.3%) out of which main workers represent 39.2% of the total workers, marginalized workers have a share of 10.1 % in total workers while rest 50.7% workers are non-workers.The total number of workers in Gangtok sub-division is 57236(55.7%) out of which main workers represent 42.5% of the total workers, marginalized workers have a share of 13.2 % in total workers while rest 44.3% workers are non-workers. The total number of workers in Gangtok sub-division is 57236 (55.7%) out of which main workers represent 42.5% of the total workers, marginalized workers have a share of 13.2 % in total workers while rest 44.3% workers are non-workers. The total number of workers in Pakyong sub-division is 19823 (54.5%) out of which main workers represent 41.2% of the total workers, marginalized workers have a share of 13.3 % in total workers while rest 44.5% workers are non-workers.It is thus implied that labour is available in plenty.

Table 3.71: Main workers, marginal worker of Project District and Sub Div.

S. N.	District/Sub Div.	Total workers	Total worker %	Main workers	Main workers %	Marginal workers	Marginal workers %	Non-workers	Non-workers %
1	East Sikkim	139678	49.3	111058	39.2	28620	10.1	143905	50.7
2	Gangtok S. Div	57236	55.7	43737	42.5	13499	13.2	45610	44.3
3	PakyongS.Div	19823	54.5	15007	41.2	4816	13.3	16559	45.5

3.10.2 Details of Village Level Information

There are three project affected rvenue blocks(project affected villages) in Gangtok Sub division, viz.,Sumen,Namli and Central Pendam.Besides this there are two project affected rvenue blocks(project affected villages) in Pakyong Sub division, viz.,Namcheybung and Yangtam.The demographic profile of the (Revenue blocks) is presented in **Table 3.72**. In the project affected villages the total house hold is 3120,while the total population is 13490 which comprises of male and female population of 6994 and 6496 respectively. It implies that the sex ratio is 935female per thousand males.Central Pendam has maximum population (5434) whereas Yangtam has the minimum (420).Thethe sex ratio is highest in Yangtam being 972 female per thousand males.

Table 3.72: Demographic Profile of the Study Area

S. N.	Village	H.H.	Population						Sex Ratio
			Total	Male	Female	Below 6Yr	Male <6Y	Fem <6Y	
1	Sumen	244	1305	680	625	153	85	68	919
2	Central Pendam	1149	5434	2764	2670	580	288	272	966
3	Namli	261	1203	634	569	125	68	57	897
4	Namcheybung	1126	5128	2703	2425	524	260	264	897
5	Yangtam	89	420	213	207	60	29	31	972
Total		**2869**	**13490**	**6994**	**6496**	**1442**	**730**	**692**	**935**

**Source: Census of India, 2011*

The cast wise distribution in the project affected villages is depicted in **Table 3.73.** It is inferred from the table that in project affected villages the total population of the scheduled caste and scheduled tribe is 913(6.77%) and 3749 (27.8%) respectively. The maximum schedule cast population (8.9%) lives in village Namli whereas scheduled tribes' population is highest in Sumen.

Table 3.73: Details of SC and ST population of Study Area

S. N.	Village	Schedule Caste (SC)				Schedule Tribes (ST)			
		Total	Male	Female	Total % of SC	Total	Male	Female	Total % of ST
1	Sumen	29	15	14	2.2	684	356	328	52.4
2	Central Pendam	606	311	295	11.2	851	445	406	15.7
3	Namli	107	60	47	8.9	360	187	173	29.9
4	Namcheybung	151	78	73	2.9	1717	880	837	33.5
5	Yangtam	20	8	12	4.8	137	63	74	32.6
Total		**913**	**472**	**441**	**6.77**	**3749**	**1931**	**1818**	**27.8**

*Source: Census of India, 2011

The literacy profile of the project affected villages is presented in **Table 3.74**. It is manifest from the Table that the total literate population is 9340 (77.52%) of which male and female literate population is 5125(82.34%) and 4215(72.62%) respectively, which implies that the gender gap in literacy rate is 9.72%.From the data above, it could be inferred that Yangtam has the highest literacy rate (98.6 %), whereasSumen has the least literacy rate (56.4 %).

Table 3.74: Literacy and Gender gap of the Study Area

S. N.	Village	Number of Literate			Literacy Rate			Gender Gap
		Total	Male	Female	Total	Male	Female	
1	Sumen	650	363	287	56.4	61.0	51.5	9.5
2	Central Pendam	3909	2118	1791	80.2	85.5	74.5	11.0
3	Namli	872	484	388	80.9	85.5	75.8	9.7

S. N.	Village	Number of Literate			Literacy Rate			Gender Gap
		Total	Male	Female	Total	Male	Female	
4	Namcheybung	3624	2003	1621	78.7	82.0	75.0	7.0
5	Yangtam	285	157	128	98.6	85.3	72.7	12.6
Total		**9340**	**5125**	**4215**	**77.52**	**82.34**	**72.62**	**9.72**

*Source: Census of India, 2011

The worker participation in the project affected villages is elucidated in **Table 3.75.** The data above states that there are total 6909 (51.80%) workers of which 4126(59%) are male and 2783 (42.80%) are female, which implies there is a gender gap of 16.20%. Namli has the highest percentage of workers(66.7%), while Central Pendam has the least percentage of workers(43.8%)

Table 3.75: Work Participation Rate of the Study Area

S. N.	Village	Total Worker			Work Participation Rate (WPR)			Gender Gap in WPR
		Total	Male	Female	Total	Male	Female	
1	Sumen	600	364	236	46.0	53.5	37.8	15.7
2	Central Pendam	2378	1475	903	43.8	53.4	32.7	20.7
3	Namli	803	431	372	66.7	68.0	65.4	2.6
4	Namcheybung	2870	1710	1160	56.0	63.3	47.8	15.5
5	Yangtam	258	146	112	61.4	68.5	54.1	14.4
Total		**6909**	**4126**	**2783**	**51.2**	**59.0**	**42.8**	**16.2**

*Source: Census of India, 2011

The village wise statistics of main and marginal workers has been abstracted and presented in **Table 3.76**. It is evident from Table that the main workers are 5313 (39.4%), whereas the marginal workers are 1596(11.80%). This implies that 48.80 % of population is comprised of non-workers.

Table 3.76: Main Worker and Marginal Worker

S. N.	Town	Main Worker				Marginal Worker			
		Total	Male	Female	%	Total	Male	Female	%
1	Sumen	199	170	29	15.2	401	194	207	30.7
2	Central Pendam	2004	1329	675	36.9	374	146	228	6.9
3	Namli	528	311	217	43.9	275	120	155	22.9
4	Namcheybung	2349	1476	874	45.8	521	235	286	10.16
5	Yangtam	233	135	98	55.5	25	11	14	5.95
Total		**5313**	**3421**	**1893**	**39.4**	**1596**	**706**	**890**	**11.80**

**Source: Census of India, 2011*

The distribution in different categories of the main workers is shown in **Table 3.77**. The main workers have been categorized in four categories namely as cultivators, agricultural labors, HH labors and other labors. The distribution of main workers is cultivators 1416(26.65%), agriculture labour 729(13.72%), house hold workers 77(1.45%) and other workers 3111 (58.18%). Sumen has the highest contribution of cultivators (42.7%);.Yangtam has the highest contribution ofagriculture labourers (27.47%); Sumen has the highest contribution of house hold workers (10.6%) and %) andCentral Pendamhas the highest contribution ofother workers (62.5%).

Table 3.77: Categorization of Main Worker

S. N.	Town	Cultivators		Agricultural Labourers		Household Industrial Workers		Other Workers	
		Number	%	Number	%	Number	%	Number	%
1	Sumen	85	42.7	31	15.6	21	10.6	62	31.1
2	Central Pendam	581	29.0	142	7.1	29	1.4	1262	62.5
3	Namli	191	36.17	81	15.34	1	0.19	265	48.3
4	Namcheybung	506	21.54	411	17.50	26	1.1	1406	59.86
5	Yangtam	53	22.75	64	27.47	0	0	116	49.78
Total		**1416**	**26.65**	**729**	**13.72**	**77**	**1.45**	**3111**	**58.18**

**Source: Census of India, 2011*

The education facilities in the project affected villages are shown in **Table 3.78.** There are primary school,middle school and secondary schools in three projected villagesaffected. Senior secondary school in only one village while there are no degree college in any of the project affected revenue blocks .The college facilities are available in the nearby Tehsil head quarter.

Table 3.78: Education facilities in village

S.N.	Village	Primary	Middle	Secondary	S.Secondary	Degree College
1	Sumen	2	1	1	0	0
2	Central Pendam	8	3	2	1	-
3	Namli	0	0	0	0	0
4	Namcheybung	7	3	2	0	1
5	Yangtam	0	0	0	0	0

**Source: Census of India, 2011*

TheHealth facilities at village level is given in **Table 3.79.** The table above states that there is no CHC in any of affected revenue block,whereas PHS facilities exist in 3 revenue blocks. The Veterinary Hospital exist in 2 revenue blocksand family welfare centre in 4 revenue blocks.

Table 3.79: Primary Health facilities at village level

S. No.	Village	Community Health Centre	Primary Health Centre	Veterinary Hospital	Primary Health Sub-centre	Family Welfare Centre
1	Sumen	0	0	1	1	1
2	Central Pendam	0	0	1	1	1
3	Namli	0	0	0	0	0
4	Namcheybung	0	1	0	1	1
5	Yangtam	0	0	0	0	1
Total		0	1	2	3	4

The availability of water sources in the project affected villages is shown in **Table 3.80.** The data states that tap and spring water facility are availaable in all villages.

Table 3.80: Water sources at village level

S. N.	Village	Tap	Tube well	Well	River	Spring
1	Sumen	Yes	No	No	No	Yes
2	Central Pendam	Yes	No	No	No	Yes
3	Namli	Yes	No	No	No	Yes
4	Namcheybung	Yes	No	No	No	Yes
5	Yangtam	Yes	No	No	No	Yes

3.10.3 Village wise project affected families

There are 5 project affected villages which are being impacted due to acquisition of private land and other assets. The total private land requirement for the project is 11.3895 ha. The village-wise details of Project Affected Family and Displaced Family are given in **Table 3.81.**

Table 3.81: Village-Wise Details Of PAF

S.N.	Name of Village	Land To be Acquired (ha)	No. of PAF	No. of D.F.
1	Sumen	0.8510	19	0
2	Central Pendam	5.013	15	0
3	Namli	3.2860	11	0
4	Namcheybung	0.9005	12	0
5	Yangtam	1.3390	5	0
Total		**11.3895**	**62**	0

4 ANTICIPATED ENVIRONMENTAL IMPACTS

4.1 GENERAL

It is expected that there will be certain changes in the overall environmental matrix of the study area. The baseline data of the existing environment, in the absence of the proposed activity, provides the status of natural environment and with the proposed activity it further provides a mechanism for prediction of the changes that are likely to occur. In the present study, evaluation of land, water, air, noise, flora, fauna and socio-economics was undertaken to understand the baseline environmental status of the area and estimation were made as how this will change with the commencement of the proposed activities. Anticipating the quantum of change, efforts were also made to analyze the degree of alternations and strategies for suitable management to ameliorate the negative impacts project activities. This exercise has provided a sound basis for formulation of different management plans, which are presented in the EMP document of the project

4.2 IMPACTS DUE TO PROJECT LOCATION AND MITIGATION

The environmental impacts before the construction are identified during planning phase. This happens due to identification of the project in a location which may be susceptible to adverse impacts due to natural environment conditions. Impacts of the project due to its location are as follows:

(i) Displacement of People
(ii) Loss of land
(iii) Geological Risk
(iv) Risk due to seismicity & earthquake

4.2.1 Displacement of people

For execution of the projecttotal land requirement has been assessed as 59.8720 ha of which private land is 11.3895 ha, forest land 48.4825 ha.The project affected villages are those villages within the bounds of which the project and ancillary works are located and which are impacted during construction and thereafter either due to project activities or acquisition of private land and other assets, including the forest and which are proposed to be utilized for the project purpose in public interest. There arefive project affected revenue blocks(villages) of which all are being impacted due to acquisition of private land and other assets but none shall be fully submerged. There shall be 62 PAF of which none shall be displaced. Land owner have been adequately compensated as per provision of NRRP-2007. The location of barrage has been finalized keeping in view minimum displacement of people.

4.2.2 Loss of land

Due to project there shall be loss of11.3895 ha agricultural land and consequently loss of production from the land. The project affected families have been adequately compensated for land loss and cost of land acquired as per provision underNRRP-2007. Besides this,48.4825ha of forest land has been diverted for project components along with standing trees.

4.2.3 Geological Risk

Geological investigation for the project was carried out and details of the geology of the project area have been discussed in Chapter 3 of this report. As per site observations, the rock formations in the area are inherently loose and prone to landslides at various locations. However, as per site specific investigations, the geological formations in the selected project sites are judged stable and will be able to withstand the impacts of drilling and blasting. However, at any unstable formation encountered during tunneling and underground excavation, blasting may lead to high vibrations, which in turn may result in soil erosion, subsidence and loss of vegetation. Hence, controlled blasting with use of multi-second delay detonators is to be adopted at such geologically fragile locations.

The folloing geological surprises were witnessed(i) extremely poor geology (Class V- flaky rock/mud) encountered during the excavation of the last 1128 m section of HRT between Adit- 3 and Surge Shaft (II) heavy flow of slush (muck mixed with ingress of water) encountered during excavation of Lower Horizontal Pressure Shaft (LHPS) (iii)during excavation of Vertical Pressure Shaft (VPS) from the top, continuous heavy water ingress was encountered at a depth of 150 m.

Since, the project is located in seismic zone IV as per Seismic Zonation Map of India and designing of the barrage and reservoir will be as per design code. Therefore, possible occurrence of earthquake shall not pose any danger to the civil structures as suitable seismic co-efficient has been accounted for in the design..

The intensity of anticipated environmental impact on geology of the area will be medium and extent of anticipated impact will be local.Duration of impact will be medium leading to low significance of the impact. No impact is anticipated on the geology of the area during the operation phase

4.2.4 Risks due to seismicity and earthquake

The project area is located in seismic zone V as per Seismic Zone Map 2014.Therefore, for designing of earthquake resilient structure site-specific seismic study was required. It has been carried out by IIT, Roorkee and approved by the National Committee on Seismic Design Parameters (NCSDP).The site specific design earthquake parameters forMCEandDBEconditions are recommended as 0.65g and 0.34g for horizontaland vertical ground motion.The design seismic coefficient for preliminary design of barrage are evaluated as $\alpha h=0.26$ and $\alpha v=0.25$ respectively.

4.3 IMPACTS ON LAND ENVIRONMENT

4.3.1 Changes in land use and land cover

- The land use class of 2.62 ha forest land and 4.39 ha agriculture land involved in submergence shall change into waterbody. The change shall be permanent and irreversible. The forest land cover within the submergence area shall reduce due to project during construction.
- The land use class of forest land and agriculture land required for project components and internal roads shall have land use class changed to built-up area.
- The land use class of 4.5 ha forest land required for quarry sites shall remain unchanged as the quarry sites shall later on developed with vegetal cover.

- The present land use ofagriculture landinvolved in muck sites shall permanently change into forest land use after completion of the work and creation of vegetal canopy by way of plantation over the spoil tips.
- The land use category of 6.274 ha forestland acquired for construction of buildings shall change to land use category settlement.
- The land use class of 2.50ha forestlandrequired for underground components will not cause any change in the present land use.

4.3.2 Immigration of Labour

During peak construction phase congregation of approximately 1000 workers is likely to take place in the project area, for which semi-permanent / temporary accommodation would be required. Due to labour inflex, pressure on land and water resource would occur. The disposal of sewage, solid waste would be required. If the labour force is not provided with proper fuel arrangements, the pressure on adjoining forest for fuel wood may take place. To reduce the dependence on forest the project proponent / contractors shall provide alternate fuel substituting fuelwood with LPG for cooking and domestic electricity connection for lighting. Conflict between the migrants and the local population may occur for employment. In order to mitigate the adverse impact due to labour immigration the labourers shall be provided accommodation in labour colony equipped with safe drinking water supply and sanitation arrangement with installation of STP. Medical facilities shall be provided to workforce by establishing a small dispensary near labour colony for which provisions has been made under the EMP. The impact due to labour immigration during construction shall be of temporary nature and shall cease to exist after the completion of the work as the labour shall be repatriated from the construction site

In the operation phase the project will have full-fledged infrastructure to meet the requirement of the reduced strength of project workers. Contractorslabour engaged in construction activity will also move away once the project work is completed; therefore, no additional impact is expected.

4.3.3 Quarry operation and Muck Disposal

The muck generated from excavation has been assessed as (5.16 lakh cum). The muck excavated is being utilized as raw material for captive brick plant, a part is also being used for filling/leveling low lying area and the balance muck has been disposed of at pre-identified ten dump yards, which has been provided with retaining structure(gabion structure/wire crate) andfully saturated sites have been vegetated.Thus, muck disposal was neither be problematic nor caused any adverse impact on the environment.

The total raw material requirement for sand and stone has been assessed as 1.75 lakh cum and 11.86 lakh ton. Sand and boulder/metal has been met from the approved river bed Quarry and consumptive use of muck retrieved from excavation sites.The mitigation measures have been suggested under the restoration of borrow area plan under EMP.

4.3.4 Change in Land Quality including Waste Disposal

Due to excavation activities there shall be disturbance to the land profile which triggers land erosion. The soil erosion in the catchment area of the reservoir and transport of detached material through the drainage network generally gives rise to a series of problems, notably depletion of flow capacity, steady loss of storage capacity. The lack of proper vegetal cover is a factor to cause degradation and thereby results in severe run off/soil erosion, and subsequently premature siltation of the reservoir. Another important factor that adds to the sediment load and which contributes to soil degradation is grazing pressure. A well-designed Catchment Area Treatment (CAT) Plan to ameliorate the adverse cause and process of soil erosion is being implemented by Forest Department. The project activities shall not create any waste *per se*.About 5000 kg/month municipal waste is being generated from septic tanks which is vermi-composed and used as manure for green belt development

Other source of waste during construction will be construction waste primarily including waste (arising out of the batching & mixing plant), slurry and washings from bins of coarse and fine aggregates etc. If not properly managed, construction waste can reduce land fertility of the project area. Increased dust also deteriorates the land fertility if proper mitigation measures are not taken. The leakage of POL and washings of workshop floors bring oil and grease with it, which is being collected in oil separators before disposal on land. The soil contamination with oil is being totally avoided.

4.3.5 River Bank and Their Stability

The river bank in the reservoir area are stable and no intervention of banks is contemplated except that the banks shall be subject to fluctuating water levels during initial filling and routine regulation/operation of the pond .But the water level drawdown shall be gradual and there is no case for sudden drawdown of the reservoir in normal conditions to ddisturb the stability of banks.

4.3.6 Impact Due to Submergence

Due to submergence, the major impacts will be on river regime which will change from riverine to lacustrine state, which implies that the area of water body shall increase as the existing land use under agriculture and forest shall change to water body. The change in land use shall be permanent. The increased water surface area will result in reducing the aridity of the settlement area near the reservoir.

4.4 IMPACTS ON WATER ENVIRONMENT

4.4.1 Change in surface and ground water Quality

Stratification can limit the mixing of the water body, leading to depletion of DO levels. This can lead to reducing conditions in waters. Being R-O-R scheme, the pond is dynamic as the water is always abstracted from it continuously which would prevent formation of any significant temperature stratification. Thus, no problems related to reservoir stratification are anticipated. Enrichment of impounded water with organic and inorganic nutrients will be the main water quality problem immediately on commencement of the operation. However, this phenomenon is likely to last for a short duration of few years from the filling up of the reservoir. Therefore, any significant impact on reservoir water quality is not anticipated.

Another significant impact, which can accrue in the pond, is the problem of eutrophication. This occurs mainly due to the disposal of nutrient rich effluents from the agricultural fields. However, within the catchment, the proportion of agriculture land irrigated is low. The agro-chemical dosing is low in the area. Even in the post project phase, use of fertilizers in the project catchment area is not expected to raise significantly in view of the maximum rainfed crops being grown in the area. Considering the low fertilizer usage in the area, significant loading of nutrients is not anticipated. Thus, problems due to eutrophication are not anticipated in the proposed project

Construction Phase

- During the construction phase, the river water on d/s of barrage is supposed to catch considerable amount of sediment from the underground works for which the water coming out from such area will be dislodged of sediment in the silt trapping tanks before being released to river.
- The silt laden water emanating from all other open-air works and from the foundation works of power house, however will require sediment extraction before releasing the water into the river section.
- The muck disposal yards, quarry areas would be the areas of concerns for leaching of sediments during rains.
- The discharge coming out of batching and crushing plants would also bring considerable sediments in water due to washing of plants and aggregate material.
- The sewage generated at the labour camps and other residential areas may also bring considerable pollutants to river sections, if disposed of in the river section without treatment.

Operation Phase

- In the operation phase of the proposed project the water environment in general will not deteriorate as the water will be continuously used for power generation and will be released simultaneously.
- For downstream usages of river course will have a minimum environmental flow of 0.71 cumec released from barrageduring lean months (December-March).
- The regular flushing operation of reservoir through barrage bays during monsoon shall not lead to the development of unwanted heaps / shoal in the flow section of the river bed which cause change in the river regime.

4.4.2 Impact due to change in Hydrological Cycle

From intake structure a maximum diverted discharge of 31.56cumec shall be carriedthrough water conductorsystem to surface power house for power generation and thereafter released to the Rangpo Chhu through TRC outfall. The abstraction of water through intake shall reduce the flow of Rongni Chhu d/s of barrage as the diverted water is repatriated to Rangpo Chhu .Thus there shall be remarkable change in hydrological cycle of Rongni Chhu and Rangpo Chhu as the discharge of former shall reduce and increase for the latter.

4.4.3 Impact on Ground and Surface Water Use

At present on main Rongni Chhu there does not exist any medium/majorirrigation project or hydro-project neither on upstream of proposed Rongnichhu HEP nor on downstream.Namchepung, Pekyong, Phekchu, Sumin, Namnang, Burung and Rapdong are situated downstream of the barrage site up to the confluence of Rongni Chhu with Teesta river. These villages are lying well above the Rongni Chhu river bed. The villagers are dependent upon the water from small streams joining Rongni Chhu on either side. The paucity of water flow in this stretch of Rongni Chhu, therefore, would have little effect on the human population in this region.In the study area, irrigation canal / gules off-take from local nalas to meet the water requirement of crops being raised in nearby villages. The irrigated area is very insignificant as always is the case in the hill and the irrigation water requirement is very little due to low evapo-transpiration rates and the variety of the crops raised.

4.4.4 Impact due to Ground Water Pollution

The baseline study of water quality in respect of surface water and ground water (spring) has revealed that both are of good quality and the various water characteristics are within the tolerance limit as set-out under IS:2260. The surface water meets the standards of drinking water quality. Therefore, seepage of good quality surface water from pond shall least impair the obtaining quality of ground water.

4.4.5 Backwater Effect

The proposed pond shall extend into riverabout 1.0 km and also into stream/rivulet directly draining into the reservoir in this stretch. Therefore, the natural effect of backwater shall be restricted with in this stretch of river.

4.4.6 Impact on Performance of Existing Projects

At present on main Rongni Chhu there does not exist any medium/major irrigation project or hydro-project neither on upstream of proposed Rongnichhu HEP nor on downstream. A small hydro project by name Upper Rongnichhu(8MW) was condtructed in 1994-95 with intake at about 50m d/s of present site,but it has become defunct for more than 8/10 years. That project was conceived to utilize discharge of Rongnichhu and Andhra khola with power house at Nimtar.The project shall have no impact on other small power projects which harness water of other Kholas on downstream. These projects are Jali power house (2.1MW) constructed in 1966 and Rongni Chhu Stage-II(2.5MW) constructed in 1988-89..

4.4.7 Impact on Turbidity in Construction Phase

The impact of silt laden water, during construction phase, emanating from excavation of the open-air works at barragecomplex and from dewatering during underground excavation in power house cavern / adits / shafts and also from discharge coming out of batching and crushing plants bringing considerable sediments, have been discussed in the report along with suggestive measures for redressing. The impact shall be felt during construction with the slight increase in turbidity in the river water d/s of barrage despite resorting to de-silting of silt laden discharge coming from various excavation points, but the transparency of the water shall not be impaired to the extent that the available sunlight ceases to power the photosynthetic reactions.

4.4.8 Impact on Flood Moderation & Drought Mitigation

Though the reservoir has a small live storage capacity of 0.33 MCM only but in view of the fact that the diverted water for power generation is discharged into other river, viz., Rangpo Chhu,the flood discharge of Rongni Chhu shall be slightly moderated to the extent of quantum of diverted water.

4.4.9 Steps to Develop Pisciculture and recreation facilities

The reservoirs invariably offer scope for inland fish production, if managed on scientific lines and for various other kinds of enhancement leading to higher productivity and income generation for the local community. They have the advantage of enabling quick enhancement of yield due to their small size and easy maneuverability of fish stock. For promoting pisciculture and to generate economical help and to maintain fishing rights of tribal, Fisheries management plan has been incorporated in the EMP.

4.4.10 Change in Hydraulic Regime and Downstream Flows

Construction Phase

Construction of proposed project may lead to two types of impact on the hydrology of the area i.e. surface water and ground water hydrology. These impacts have been described below:

Impact on the Surface Water Hydrology

The water requirement during construction will be met from Rongni Chhuand its tributaries at differentlocations.. Hence, these divided water source will ensure that there is no excessive water demand on any single water resource point. Moreover, groundwater encountered during underground excavation/ tunneling operations, is being used for construction requirements and drinking purpose after filteration and conventional treatment to reduce surface water requirement. Further the existing drainage system in the area will not be modified or affected during the construction phase. The domestic/ drinking water requirement shall be met from local water supply scheme.Hence, the intensity of anticipated environmental impacts during construction is judged as low, based on environmental value and degree of disturbance.However during operation, intensity of anticipated environmental impact on hydrology of the area will be immensein view of the fact that the diverted water for power generation is discharged into other river, viz., Rangpo Chhu.

Impact on Ground Water Resource

The ground water levels in the region could not be established, as is often the case in mountainous terrain. Since the water usage will be mainly from the river water for construction purposes, no adverse impact on groundwater availability is expected. Dumping of wastes shall also be undertaken at specified exposed surface locations only and hence, no negative effect is envisaged on the groundwater quality of the area.

A few seasonal surface streams shall cross the diversion tunnel alignment with the stream bed well above the crown of the tunnel at the point of crossing. Hence, there shall not be any disturbance to ground water regime consequent to blasting for tunneling. Moreover, the underground tunnel shall be aligned deep in the mountain below the ground profile. The ground water position of the area shall not change due to existing steep slope of surface and water tight lining of the tunnel. It is only in the area near diversion structure where the ground water level is likely to raise due to maintaining of higher pond level in the river during operation phase.

Operation Phase

During operation phase, the water (maximum 31.56 cumec) from Rongni Chhu will be diverted for power generation through intake. Following guidelines issued by the Ministry of Environment & Forest, Govt. of India, the minimum flow based on 15% of average lean weather flow will be maintained in the river will downstream of barrage for meeting ecological flow requirement.. Since, the water from the river is not used by the villages along the river for domestic and irrigation purpose, the reduced flow d/s of barrage is not likely to have any significant adverse impact.

4.4.11 Water Pollution Due to Disposal of Sewage

Two small colonies at headworks and powerhouse has been developed for the staff. The domestic water requirement for the project staff shall be of the order of 14m3/day @ 70 lpcd for 200 persons. Assuming that about 80% of the water supplied will be generated as sewage, i.e., 12m^3/day. The BOD load contributed by domestic sources will be about 237.50 mg /litre, assuming per capita BOD contribution as 19 g/day. The sewage waste shall be disposed after treatment through STP. The effluent to be discharged should conform to the Standard adopted vide GSR1265(E), dated 13.10. 2017 **(Table 4.1).** It must be ensured the limits in respect of parameters are not exceeded.

Table 4.1: Effluent Discharge Standard

S.N.	Effluent discharge parameter	Concentration
1	pH	6.5-9.0
2	Bio- Chemical Oxygen Demand (BOD)	<30 mg/litre
3	Total Suspended Solids (TSS)	<100 mg/litre
4	Fecal Coliform (FC) (Most Probable Number per 100 milliliter, MPN/100ml	<1000

4.4.12 Water Pollution from Labour colonies/Camps and Washing Equipment

Thecamp area has been created at suitable sites near to work sites. O&M staff complex has been developed near powerhouse. About 1000 workers (labour and staff) would be engaged temporarily during peak construction period. It is expected that 70% of the total work force shall be locally available from adjacent areas and thus labour colony shall be designed to house 300 workforces. It is proposed to provide family residences to 30 workers while the balance shall remain in bachelor accommodation. Proper care has to be taken to manage the solid waste generated from the labour colony for a population of 420 residential persons and 15 floating population i.e. for 435 persons.

The domestic water requirement for the construction worker and the technical staff migrating into the project area is of the order of 30.5 m3/day @ 70lpcd. Assuming that about 80% of the water supplied will be generated as sewage, i.e., 24.4 m3/day. The BOD load contributed by domestic sources will be about 237.5mg / litre, assuming per capita BOD contribution as 19 g/day. The size of colony is not big. The sewerage system consist of soak pit/septic tank.

The disposal of untreated sewage can lead to water pollution, resulting in increase in coliforms and other various pathogens, which can lead to incidence of water borne diseases. Therefore, project authorities would be taking appropriate measures to check such disposal into the river. In order to avoid any deterioration in water quality due to disposal of untreated sewage from labour camps, appropriate sewage treatment facilities will be commissioned in the labour camps. The sewage waste shall be disposed after treatment through STP. The effluent to be discharged should conform to the laid down Standard (**Table 4.1**).

The leakage of POL and washings of workshop floors and washing of vehicle and equipment bring oil and grease with it and shall increase the concentration of oil and grease in water, if discharged into the river section. Therefore, it shall be collected in oil separators provided in the concrete drains before disposal on water body/ land. The water and soil contamination with oil and grease shall be totally avoided. Even during construction period vigil should be taken by not allowing washing of any vehicle in the river section. The workshop shall be planned away from the river.

4.5 IMPACTS ON AIR ENVIRONMENT

4.5.1 Change in Ambient air and GLC

The air pollution impact of excavation in ordinary earth and boulders and also rock is directly dependent upon construction methodology, annual rate of excavation, mode of transport within the construction site, mode of screening and method of crushing. The air pollution sources at the proposed barrage site can be broadly classified into three categories, viz. area source, line source and instantaneous point source.

Extraction of stone by various activities in barrage complex area is construed as an area source which includes excavation pit(s) and activities happening in the excavation area like drilling, blasting, hauling and loading/unloading. The dust emission from these areas will be fugitive in nature. The excavator operations, loading/unloading operations will also cause dust emission though it will be confined to the area of operation of the machinery. The gaseous emission from their operation shall be minimal and limited within the project area.

Transportation of excavated material from the barrage site to either dumping sites or the stone crusher unit are categorized as line source. Since the dumper movement on haul road will be within the barrage complex area, no adverse impact shall be felt in the settlement area.

Blasting is the major source of instantaneous emission sources of particulate matter and NOx. The large quantity of dust will be wind borne. With the proposed control measures, the fugitive emissions will be minimized in terms of their impact on environment

4.5.2 Dust Dispersion Modelling for Excavation Operation

In the present study, United States Environmental Protection Agency (USEPA–42 series) approved mathematical equations have been used to predict concentrations for different operations in mining including the material transportation. In order to predict the particulate emissions, Aermod View ver. 9.8.1 (Air Dispersion Modelling Software) an interface based on ISCST3 - was used to predict changes in air quality i.e., maximum ground level concentration (GLC's) of Particulate Matter. Short term model options were opted for uniform emissions rates. The concentration of other gaseous pollutants i.e. SO2 and NOx was found to be much lower than the threshold limit (80 µg/m3), the air modelling was restricted to determination of particulate matter i.e. PM10 in the present case. The emission factors adopted for various excavation operations are mentioned below:

Emission Factor for Drilling and Blasting

For drilling operations, the default value of PM10 has been adopted as 0.31kg/hole.

For blasting the default value of PM10 has been adopted as

EFPM10 = 0.000114 X A1.5, in kg/blast, where A is the area blasted

Emission Factor for Excavation and Material Loading

For excavation and material handling the emission factor for PM10 has been adopted as per USEPA – 42 series.

For Dozing Operation:

EFPM10 (kg/hr.) = 0.34 X s1.5(%) / M1.4(%)

Where,

EFPM10 (kg/hr.) = emission factor in kg/hr.

S = silt contents in percentage by weight

M = moisture content in percentage by weight

For Material Loading:

EFPM10 (kg/hr.) = 0.34 [0.119 / M0.9]

Where,

EFPM10 (kg/hr.) = emission factor in kg/tonne

M = moisture content in percentage by weight.

Emission Factor for Material Haulage within excavation area:

The emission rate is dependent on several factors which include soil properties, climatic conditions, vehicular traffic, wind forces and machinery operation. The Empirical equation for calculation of emission rate is as under.

E= k*(1.7) *(s/12) *(S/48) *(W/2.7)0.7*(W/2.7)0.7 (w/4)0.5 * (365-p/365) g/VKT

Where,

E=Emission Rate

K = Particle size multiplier

s=Silt Content of the Road surface material

S= Mean Vehicle Speed (km/hr.)

W=Mean Vehicle Weight (tonnes)

w=Mean number of wheels

p= Number of days with at least 0.254mm of precipitation per year

Isopleth developed is shown in **Figure 4.1.** The maximum GLC due to excavation activities and crushing was found to be 9.3 µg/m3 at barrage complex excavation area and the anticipated values of GLC at different receptors are shown in **Table 4.2** which shows that the predicted GLC at the nearby settlement viz. Namli and Yangtam would be 0.4 µg/m3 and 2.3 µg/m3 respectively.

Table 4.2: Maximum Concentration at receptors

NCART Details	X-Cord.	Y-Cord.	Conc (µg/m3)
Barrage Site	657279.05	3017181.95	9.3
Namli	657229.86	3017221.06	0.4
Mangtam	657300.41	3017202.06	2.3

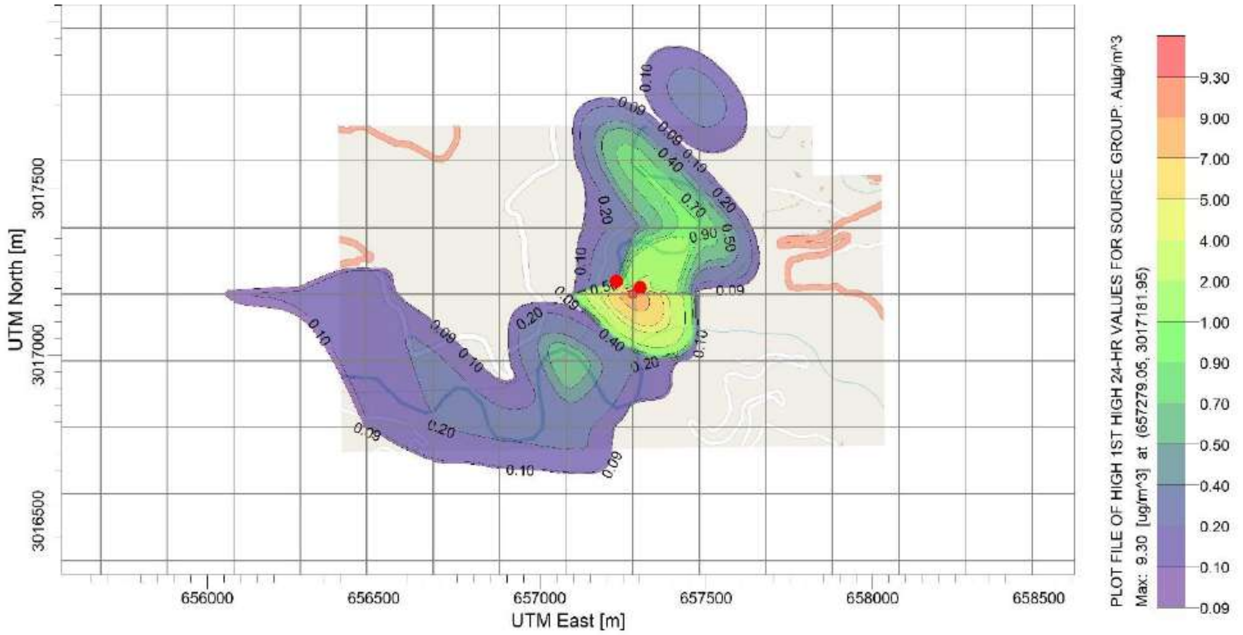


Figure 4.1: Isopleth of Maximum Predicted 24 hourly Ground – Level Concentrations

The resultant impact due to construction activities on the Ambient air quality for PM10 at the barrage complex, nearest air monitoring stations Namli andTangtam is presented in **Table 4.3** which shows that, the resultant concentration level at each of the locations are within the NAAQS.

Table 4.3 : Resultant Levels Due To Excavation At Barrage Complex

Station Name	Max. Conc.	Predicted GLC (PM10)	Resultant concentration	NAAQS (µg/m3)	Direction	Distance
Barrage Site	55	9.3	64.3	100	-	-
Namli	55	0.4	55.4	100	N-W	200m
Mangtam	44	2.3	46.3	100	S-E	150m

Mitigation Measures

Following mitigation measures shall be adopted during excavation activities to control air pollution load below the prescribed limits:

Dust generated due to drilling, blasting, ripping, and vehicular movements will be suppressed by water spraying during and after the operations.

Water sprinkling will be done on the haul road and other roads at regular intervals.

To avoid the dust generation during the drilling operations, wet drilling method will be practiced or wet drill machine will be used.

- Dust mask will also be provided to the workers.
- Proper regular maintenance of machineries will be done.
- Speed of the vehicles will be kept within the prescribed limits.
- Trucks/ dumpers will not be over loaded.
- At the feeding points stone crusher air mist spray shall be carried out.
- Hooded conveyer belts shall be used.

4.5.3 Effects on Soil Materials, Vegetation and Human Health

Excavation results in land degradation and formation of loose soil particles which are mainly fugitive dust. The transportation of excavated/construction material on unpaved roads cause fugitive dust emission. These dust particles are usually blown away along the wind direction and get deposited on the canopy of surrounding vegetation and agricultural crops thereby interfering with photosynthesis and other physiological activities of the green cover. Finally, this may result in reduced ecological functions of the forest ecosystems as well as economic productivity of the agro-ecosystems. Since the work is being carried out in river bed plain and the fugitive dust particles neither move far away from point of emission nor ground level concentration (GLC) is not high as has been found from dust dispersion modelling (2.3 $\mu g/m^3$) at the nearest settlement; there shall not be significant impact.

Drilling and blasting invariably results in land degradation and formation of loose soil particles which are mainly fugitive dust. These dust particles are usually blown away along the wind direction and get deposited on the canopy of surrounding vegetation and agricultural crops thereby interfering with photosynthesis and other physiological activities of the green cover. Finally, this may result in reduced ecological functions of the forest ecosystems as well as economic productivity of the agro-ecosystems. Nitrogen oxides also upset the chemical balance of nutrients in the water, which can cause problems with the animals and plants that are dependent upon the water, leading to reduction of the fish and shellfish population.

The gaseous pollutant Oxides of Nitrogen (NOx) react in the atmosphere to form Nitrogen Dioxide (NO 2) which can have adverse effects on health, particularly among people with respiratory illness. NOx are pollutants that cause lung irritation and weaken the body's defenses against respiratory infections such as pneumonia and influenza, can cause shortness of breath and chest pains and increase a person's susceptibility to asthma. The air quality modelling has revealed that the increased GLC in respect of NOx were insignificant being 0.12 µg/m3 up to 25m and 0.11 µg/m3 up to 50m and 0.10 µg/m3 up to 1km.

Carbon monoxide (CO) is a product of incomplete combustion and at low concentrations it may pose a health risk and is especially dangerous to the elderly, people with cardiovascular disease or other circulation disorders, anemic individuals, young infants, and pregnant women. CO reduces the blood's oxygen carrying capacity, and, when inhaled, blocks the transport of oxygen to the brain, heart, and other vital organs in the body. Extreme levels of exposure, such as might occur due to blockages in tailpipes, can be fatal. Fetuses, new-born children, and people with chronic illnesses are especially susceptible to the effects of CO. In addition, carbon monoxide is directly linked to visual impairment, reduced work capacity and mental dexterity, poor learning ability, nausea, headaches, dizziness, and even death.

Sulfur dioxide can react in the atmosphere to form fine particles and poses the largest health risk to young children and asthmatics. Exposure to SO2 can create a number of health problems, including sweating, papillary constriction, muscle cramps, excessive salivation, dizziness, laboured breathing, nausea, vomiting, convulsions, and unconsciousness, as well as possibly being absorbed by the skin and creating severe diarrhoea. In addition, it may cause effects on the nervous system, resulting in respiratory depression. It is also quite deleterious for the environment.

Particulates are tiny solid particles consisting of particles of soot and metals which can bind to and clog the respiratory tract. These are detrimental when found in both fine (PM 2.5) and coarse (PM 10) forms as it accumulates in the respiratory system, and can lead to decreased lung function, respiratory disease and even death. PM2.5 consists of particles less than one-tenth the diameter of a human hair and poses the most serious threat to human health, particularly among those with existing respiratory disorders, as they can penetrate deep into lungs. Of the pollutants emitted by off-road vehicles, particulates are of special concern because their small size makes them easily respirable and thus deliverable directly into the lungs, causing any number of the aforementioned maladies.

4.5.4 Impacts of Emissions from DG Sets used for Power during construction

The requirement of Construction Power shall be around 6 MW. HPSEB power at 66 KV level is available nearby project site. In emergent situation resulting due to grid failure or load shedding four numbers 1 MVA, 415 V diesel generator set shall be deployed for captive power generation.

Emissions from diesel generator sets are a mixture of gases primarily comprising of Carbon Monoxide (CO), Oxides of Nitrogen (NOx), unburned Hydrocarbons (HC), and soot particles i.e. particulate matter). Their impact on human health has been brought out in sub-section 4.4.2.

The emission norms in India cover CO, NOx, PM, and HC and are specified based on the number of grams of these compounds present in diesel exhaust when one kilowatt-hour of electricity is generated. These norms have been revised in December 2013 (G.S.R. 771 (E) / 11th Dec 2013 notification), its amendment vide GSR 232(E) dated 31st March,2014 and GSR(E) dated 7th March ,2016 and have come in force from 1st July 2016. These norms are presented in **Table 4.4**.

Table 4.4 :Emissions Limits for DG Sets

Power Category	Emission Limits (g/kWh)			Smoke Limit (Light absorption co-efficient per meter)
	NOx+THCor NOx+NMHC or RHC	CO	PM	
Up to 19 kW	≤ 7.5	≤3.5	≤ 0.3	≤0.7
More than 19 kWUp to 75 kW	≤4.7	≤3.5	≤0.3	≤0.7
More than 75 kWUp to 800 kW	≤4.0	≤3.5	≤0.2	≤ 0.7

NOx also contributes to smog formation, the formation of particulate matter, acid rain, can damage vegetation and contributes to ground level ozone formation. Nitrogen oxides also upset the chemical balance of nutrients in the water, which can cause problems with the animals and plants that are dependent upon the water, leading to reduction of the fish and shellfish population. When carbon monoxide comes in contact with oxygen, carbon monoxide is formed which fall in category of greenhouse gases which contribute to global climate change.

To mitigate adverse impact DG sets should be located from the consideration of prominent and first prominent wind direction so that on the downwind direction the human habitats are least impacted by the flue gas emissions. The norms prescribed by the CPCB in respect of fixing the minimum stack height for generator, should be strictly complied with. In no case, it should be lesser than the 20% of the under root of generator capacity in KVA added to the height of the building where it is installed

4.5.5 Pollution Due to Fuel Combustion in Equipment and Vehicle

The increased traffic load in any particular segment of the road will result into direct increase in pollutants released from the vehicles. The rate of emissions of various types of vehicles is presented in**Table 4.5.** However, the extent of these impacts, at any given time will depend upon the rate of vehicular emission within a given stretch of the road; and the prevailing meteorological conditions. The impacts will have strong temporal dependence as both of these factors vary with time. The temporal dependence would have diurnal, seasonal as well as long-term components.

Table 4.5: Emission factors by vehicle type (gm/km/vehicle)

CPCB/ ARAI (Automotive Research Association of India) - Emission Factor development for Indian Vehicles – 2008						
Type of vehicle	Make considered	Emission norms	Emission Factors (g/km)			
			CO	NO2	PM10	SO2*
Trucks(HCV Diesel driven)	Post 2000	BS-II	6.00	9.30	1.24	0.03
PassengerCars (Diesel driven)	Post 2005	BS-II	0.06	0.28	0.015	0.004
BusesHCV Diesel driven)	Post 2005	BS-II	3.92	6.53	0.30	0.026

* Note: Emission Factor of SO2 is calculated based on Sulphur content calculations considering Bharat Stage IV fuel norms

California Line Source Dispersion Model (Caline 4 ver.2.1) was used to assess the emission load for PM10 and NOx due to increased transportation. During construction phase 210 tipper trucks (10 tonne) shall be deployed on the road for carriage of muck, construction material (cement and steel) and crushed stone aggregate/sand. The model was run for one hour considering worst case angle. The receptors location and model results for worst case wind angle are shown in Table 8.2. The results show that at 25 m predicted concentration is 8.6 µg/m3 which reduces to 5.4 µg/m3, 2.4µg/m3 and 1.0 µg/m3 at 50m, 150m and 500m respectively. Thus, the impact on the pollutant level (PM10) due to increased traffic due to transportation of mineral shall be minimal. The increased GLC in respect of NOx were insignificant being 0.12 µg/m3 up to 25m and 0.11 µg/m3 up to 50m and 0.10 µg/m3 up to 1km.

Table 4.6 :Receptor Locations and Model Results (Worst Case Wind Angle)

Distance from the Road (m)	Incremental GLC PM 10(ug/cum)	Incremental GLC NOx (µg/m3)
25	8.6	0.12
50	5.4	0.11
100	3.2	0.10
150	2.4	0.10

200	1.9	0.10
300	1.4	0.10
400	1.1	0.10
500	1.0	0.10
750	0.8	0.10
1000	0.8	0.10

Following control measures have been suggested to prevent air pollution due to the transportation activities:

- Transport trucks/tippers shall be properly maintained.
- Only PUC certificate issued vehicles shall be used.
- Avoiding of overloading of trucks beyond stipulated capacity by installing weigh bridges.
- Strict compliance of traffic rules and regulation

Operation Phase

The ambient air quality during the operation phase either at barrage site/poerhouse/ muck disposal site is expected to improve as the fugitive dust and flue gas emission sources of air pollution shall be conspicuously absent

4.5.6 Fugitive Emissions from Various Sources

Basically, dust sources in excavation at construction site can be categorized as primary sources that generate the dust and secondary sources, which disperse the dust and carry it from place to place called as fugitive dust.

Impacts of surface excavation with or without drilling and blasting on air quality are cause for concern mainly due to fugitive emissions of particulate matter. The major operations producing dust are drilling and blasting, pit excavation, segregation and screening of material, loading and transporting. Exhaust emissions from vehicles deployed are also likely to result in inconsequential increase in the levels of SO_2, NO_x, and CO.

4.5.7 Impact on Micro-Climate

Major construction activities involve surface excavation and concreting works atsite and excavation in borrow areas. These activities shall not affect the ambient temperature, humidity, rainfall, wind speed and direction and other meteorological parameters during construction.

Wind Speed: The wind speed in any area is dependent upon local topography and is intimately connected with the development as high- and low-pressure zones. The controlling factors for the pressure changes lie much beyond the mining operation in small mining area which stands inconsequential as compared to the vast extent of a region in general. Thus, no adverse impact on the regional wind speed is anticipated due to the construction activities.

Rainfall: The trend of rainfall follows a regional pattern and is mainly governed by the south west monsoon and disturbances in the Arabian Sea. The construction activities, therefore, are not likely to have any adverse impacts on rainfall pattern.

Humidity: The pattern of relative humidity depends mainly on the rainfall, wind, temperature and other weather phenomenon that are regional in behavior. The excavation activities are not likely to have any impact on the relative humidity in the surrounding. However; the humidity in the area may slightly increase due to creation of waterbody. The change in land use pattern due to submergence will have impact on the local climate due to marginal increase in humidity.

Temperature: There shall be felling of trees in the reservoir area in the last year of construction before filling of the reservoir which may cause a localized temperature increase which shall be moderated by the trees in the green belt around the reservoir periphery. The temperature pattern is a regional behavior and is not likely to be affected appreciably by the construction activity.

4.6 IMPACTS DUE TO NOISE AND VIBRATION

4.6.1 Impact on Noise Level

A cumulative effect of surface excavation activities at barrage complex generates enormous noise and vibration in the project area and its surrounding areas. Prolonged exposure to high noise levels over a period of years invariably causes permanent damage to the auditory nerve and/or its sensory components (Banerjee and Chakraborty, 2006; Krishna Murthy et al,). The irreversible damage, commonly referred as noise-induced hearing loss (NIHL), is the commonest occupational diseases amongst the construction workers especially at such sites which have multiple noise sources. Besides this the fauna of surrounding area is also affected by noise as the wildlife is more sensitive to noise and vibration than the human beings (Mathur, 2005).

Noise Due to Drilling

The drilling is contemplated to be carried out by Jack hammer rock drills with air compressor which entail a noise level of 88.0 dB(A) and will be a worst-case scenario. Nonetheless, the noise generated due to drilling is within the standards prescribed by Occupational Safety and Health Administration (OSHA) for 8-hour exposure i.e. 90 dB (A). It is worth mentioning here that mining shall be carried in a shift of 8 hours and the equivalents noise level exposure during the shift shall be less than the safety limit of 90 dB(A),

Noise due to Blasting

Blasting generates instantaneous and impulsive noise and is site specific dependent on many factors like the dimension of the holes, type and quantity of explosive i.e. charge/delay and degree of stemming in the hole. At the blast site with the given diameter of holes and their pattern, the noise levels are expected to be in the range of 120-130 dB (A) and tend to decrease with increase in distance of receptor. As the blasting is envisaged over a fixed time period in a day the blasting is considered to last for 2-3 minutes for one blasting operation depending on the charge. The noise levels over this time would be instantaneous and short in duration thus implying that impact on noise levels from blasting are not of concern.

Noise due to crushing, Screening and Loading Plant

The average noise levels generated due to proposed crushing activities will be about 88.5 dB(A) which is within the exposure limit of 90 dB(A). The crusher shall be housed in a shed to contain noise. Screening activities shall generate average noise level of about 96.5 dB (A). Workers in the noise generating zone will be provided with earmuffs/earplugs besides dust mask.

Noise due to excavation and transportation

In order to predict ambient noise levels due to the construction activities from various sources at different location within the barrage complex the noise dispersion modeling has been done on the assumption that all noise sources are acting as a single source generating approximately 91 dB(A). Noise generated due to deployment of rock breaker, excavators, loaders and dump trucks are shown in **Table 4.7.**

Table 4.7: Standard Values of Noise Levels

S.No.	Machinery/ Activity	Noise Produced in dB(A) at 50 ft from source*
1.	Excavator/Shovel	85
2.	Front end loader	85
3.	Dump Truck/ Tippers (at full throttle)	92
4	Near Haul road (while dumpers are moving)	88
5	Dozer (when dozing)	102
6	Drill machine (drilling with Jack hammer)	88
7	Aggregate processing unit / Stone Crusher (outside crusher cabin)	100
8	Aggregate processing unit / Stone Crusher (inside crusher cabin)	86

*50 feet from source = 15.24 meters

Source: U.S. Department of Transportation (Federal Highway Administration) – Construction Noise Handbook

Model for sound wave propagation during mining

For an approximate estimation of dispersion of noise in the ambient air from the point source, a standard mathematical model for sound wave propagation is used. The noise generated by equipment decreases with increased distance from the source due to wave divergence. An additional decrease in sound pressure level with distance from the source is expected due to atmospheric effect or its interaction with objects in the transmission path.

For hemispherical sound wave propagation through homogenous loss free medium, one can estimate noise levels at various locations, due to different source using model based on first principles, as per the following equation:

$LP2 = LP1 - 20 Log (r2 / r1) - AE$ ……………………………. (1)

Where,

LP2 and L P1 are the Sound Pressure Levels (SPL) at points located at r2 and r1 from the source. AE is attenuations due to Environmental conditions (E). The combined effect of the entire source can be determined at various locations by the following equation.

LP (total) = 10Log (10 (Lpa)/10 + 10 Lpb)/10 + 10 Lpc)/10 + ………) (2)

Where Lpa, LPb, LPc are noise pressure levels at a point due to different sources.

Environment Correction (AE)

The equivalent sound pressure level can be calculated from the measured sound pressure level (Leq measured) averaged over the measurement surface area 'S' and from corrections K1 and K2 and is given by;

(Leq measured) = (Leq measured) – K1 – K2 (3)

Where,

K1 = Factor for the background noise correction. The correction was not applied in this modelling exercise, as it was not possible to measure the background noise levels by putting off machines hence it was considered as zero.

K2 = Environmental correction

In the present study dhwani PRO Version 3.6, a noise propagation modelling software developed to undertake construction, industrial and traffic noise propagation studies. A variety of scenarios can be created quickly in dhwani PRO, allowing the user to determine the impact of changing the source, layout and adding /removing the effects of shielding due to noise mitigation devices such as barriers.

Input for the model

Base Map, Point Source and Receptors

Base maps identifying the location of the site, noise sources, receptors and other important characteristics of the surrounding area is the foremost requirement. In this study jpeg raster maps created in Google map showing the locations of the construction site where the maximum excavation is to be carried out has been captured and imported for registering the map and setting up of the scale. The point source is the location where the maximum noise generating construction equipment is to be operated. The receptors are the nearby settlements where the impact of propagation of noise is to be evaluated.

Hourly noise level

Hourly nose levels observed for 24 hours at the point source have been observed and adopted in studies. The noise levels to be generated intermittently due to running of construction equipment for different hours have also been incorporated. Besides this, the background levels at the receptors have been entered into the corresponding windows.

Model outputs

After running the model, the graphical results in the form of noise level contours (Figure 4.2) have been produced which has been captured and exported. Besides this the output in the tabular form showing the estimated noise levels at different receptors owing to the impact of operation of construction machinery has been generated. **(Table 4.8)**

Table 4.8: Modelling Output

Project Title: Noise Modelling Rongnichu

Project Subtitle: HEP Project Sikkim

Client: MBPCL

Receptor	Zone	X meter	Y meter	Estimated Level dB(A)	+Backgound* Level dB(A)*	Standards Lday dB(A)	Standards Lnight dB(A)
R_1-Namli	Residential area	1111.2	835.9	50.0	50.0	55.0	45.0
R_2-Yangta	Residential area	1370.0	645.9	47.0	48.0	55.0	45.0

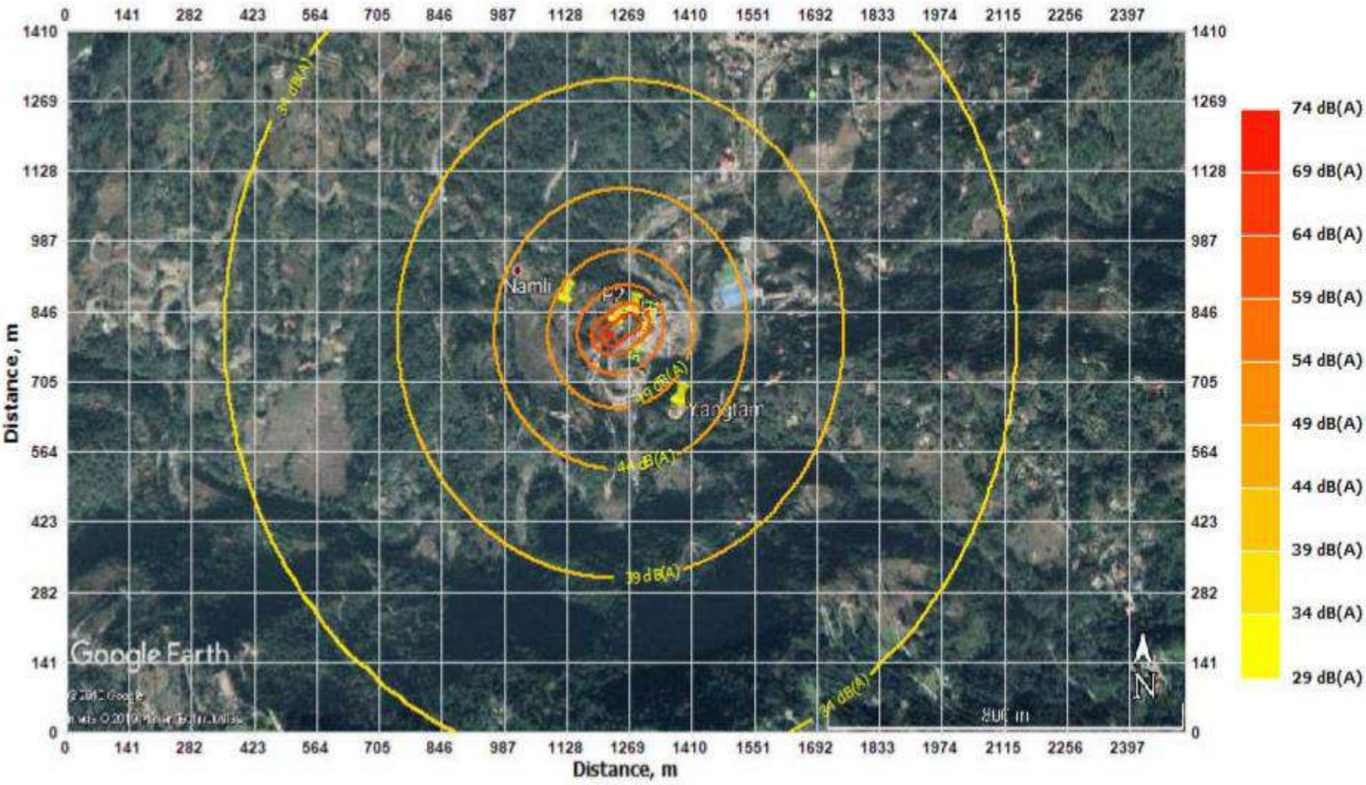


Figure 4.2: Noise Graphical Results

Inference and Mitigation Measures

It is evident from the graphical results that the noise level of 74 dB(A) gets attenuated to 48 dB(A), 42 dB(A) and 38 dB(A) about 300m, 600m and 1200 m respectively from the point source (barrage site). The estimated noise levels including the background level at receptors at Namli and Yangtam due to running of construction machinery, shall be 50 dB(A) and 48 dB(A) which are within the standard values. Thus, there will be marginal impact of running of construction & transport machinery for excavation operation.

The following control measures will be adopted at the points near to the source of noise to keep the ambient noise levels below permissible limits 75 dB (A).

- Provision and maintenance of thick tree belts to screen noise.
- Avenue plantation within the project area to dampen the noise.
- Proper maintenance of noise generating transport vehicles.
- Regular noise level monitoring shall be carried out for taking corrective action
- To check the noise, pollution noise filters may be erected around batching plant
- Regular maintenance of heavy earth vehicles may be adopted to reduce noise levels

To protect the workers from exposures to higher noise levels provision of protective devices like earmuffs/ear plugs to those workers who cannot be isolated from the source of noise and reducing the exposure time of workers to the higher noise levels by rotation.

During Operation Phase

After completion of the project and during the operational phase the noise levels shall not be impacted as there are no noises emitting sources except the noise created during passing of surplus discharge through spillway, which shall persist for a few hours till the flood recedes.

During the operation phase, due to filling of the reservoir the obtaining situation shall lead to reduction of the noise level owing to change in flow regime i.e. from riverine to lacustrine state. It is only during the opening of gates in flood season for spilling the water through spillway, the noise level shall increase.

During operation phase the noise levels in the power house shall increase. The space averaged turbine hall and generator floor sound levels will be governed by the following relation.

Sound level in dB(A) at turbine floor = 7 log 10 MW +80

Sound level in dB(A) at Generator floor = 82+3.5 log 10 MW

The noise levels predicted to result from running of one and two turbines at a time are shown in **Table 4.9.**

Table 4.9 : Predicted Noise Levels

No. of Turbines Running	Noise levels dB(A)	
	Turbine Hall	Generator Floor
One	92.3	88.2
Two	64.5	89.2

4.6.2 Impacts due to Ground Vibration (due to blasting)

The ground vibrations, noise and fly rock constitutes the chief environmental impact of blasting. The ground vibration sets the ground in transverse, longitudinal and vertical direction and which in turn causes the foundation of structure to vibrate in these directions and damage the structures. Air overpressure is transient impulse, which traverses through the atmosphere and is both audible and inaudible and has the energy to vibrate a structure like ground vibration and is much of concern as animals are more sensitive than human being.

Ground vibrations are acoustic waves that propagate through rocks. The various aspects of ground vibration triggered by open cast blasting and consequent-damaging effects on different types of structures is usually computed based on the value of the Peak Particle Velocity (PPV) induced at the foundation of the distant structure. PPV criteria are considered the best predictor for ground vibration caused by blasting. In case of surface excavation at the barrage site the PPV is worked out based on various empirical formulas. In the present case, the PPV has been worked out based on following empirical equation.

V=1400 (D/√Q)-1.265 mm/s, where,

D=Distance (m) between location of blast and gauge point

Q=Quantity (kg) of explosive per blasting

The resulting value of PPV has been compared with the limiting values for dominant excitation frequency less than 8 Hz as prescribed by the Director General of Mines Safety, India (DGMS) in Circular 7 of 1997. The study shows u located at distance mentioned against each as is evident from the following **Table 4.10.**

Table 4.10 : Computation of Peak Particle Velocity at Nearest Settlement from Barrage Site

Name of nearest village	Quantity of explosives / delay (kg)	Distance (D) from mine Site (m)	Peak Particle Velocity in mm/s	Limiting value of PPV (mm/s) prescribed by DGMS, India
Namli	15	400	3.97	5

In order to minimize vibration, the following shall be adopted:

- Blast holes shall be initiated by non-electric (NONEL down-the-hole (DTH) delay detonators.
- Care shall be taken to ensure that effective burden is not excessive and the face shall be kept sufficiently long.
- Optimum charge per delay shall be kept as low as possible.
- Adoption of two row blasting and V pattern of firing
- The firing of maximum possible no. of blast holes towards free face.
- Use of milli-second delay detonators between the holes and rows of blasting.

Control Blasting study was conducted by CMPDI, report enclosed as **Annexure -IV.**

4.6.3 Air Blast over Pressure

Propagation of blast induced air over pressure has been studied by various investigators and is generally reported as cubic root rather than square root scaled distance. In context of mining operation in the cluster the overpressure is predicted by equations applicable for confined bore hole charges.

p=3.3 [3√Q/R]1.2, where,

p= pressure in Kpa

Q=Explosive charge in kg

R= is a distance from the charge

On the basis of the distance and charge per delay the predicted air over pressure values are shown in **Table 4.11.**

Table 4.11: Predicted Air over Pressure

S. No.	Nearest Village	Distance (R) from barrage Site (m)	Charge / Delay (kg)	Predicted Air over pressure in dB(A)
1	Namli	400	15	111.3

The predicted air over pressure in dB(A) shall be lower due to attenuation and the blasting being carried out at pit level which are lower than the elevation of Namli which are higher level than the river bed which is subject to blasting on account of rock excavation.

4.7 IMPACTS ON RIVER ECOLOGY

4.7.1 Creation of Reservoir

Creation of a reservoir upstream of the barrage brings about changes in the riverine ecology to lacustrine ecology flooding the natural habitats that existed before the construction. Reservoirs contribute to greenhouse gas emissions as well. The initial filling of a reservoir floods the existing plant material, leading to the death and decomposition of the carbon-rich plants and trees. The rotting organic matter releases large amounts of carbon into the atmosphere. The decaying plant matter itself settles to the non-oxygenated bottom of the reservoir, which is almost at a stagnant state. The decomposition eventually releases dissolved methane.

4.7.2 Fragmentation of river ecosystems

The barrage shall act as a barrier between the upstream and downstream habitat of migratory fishes because neither any fish ladder / pass has been providedin orinal layout nor constructed.Since all barrage bays and u/s and d/s wing/walls and piers have been completed,nor it is now feasible to construct any fish pass.

In general, permanent inundation caused by reservoir flooding also alters the wetlands, forests and other habitats surrounding the river. Further ecosystem disruption occurs along the banks of the river and downstream. However, the river is flowing through deep gorges of rocky hills with steep slopes. The water is extremely cold and has torrent flow which consists of cascades and rapid habitat due to rocky substratum and high gradient that is attributed to the poor biodiversity. No wetland habitat, forests and sanctuary are found in the project influenced area.

4.7.3 Sedimentation Behind Barrage

Sedimentation in reservoir will reduce water-storage capacity due to the exchange of storage space for sediment which is generally reflected by the formation of shoals / islands on the u/s. The problem of siltation will not be serious as the reservoir shall be regularly flushed during monsoon when enough water is available for conducting flushing operation.

4.8 IMPACT ON BIOLOGICAL ENVIRONMENT

4.8.1 Impacts on Flora

2.62 ha of forest land shall be brought under submergence along with standing trees will affect the ecosystem of the forest consisting of flora (including medicinal plants) and fauna (including wildlife, migratory avi-fauna, rare and endangered species). It will also adversely impact the production and harvesting of non-timber forest products on which the livelihood of local people, especially tribal people depends. The trees falling in the submergence zone shall be felled up to level of FRL (-4m) will bring imbalance to ecology.

The construction activities, including movement of vehicles, men and material, camping places for the labour, storage of construction waste, etc., will have direct impact on the existing natural resources.

Due to construction of proposed project, riverine regime of submergence area will change into lacustrine environments.

It is evident from this study that from the submergence and influence zone of the proposed project none of tree species, shrub, herb or any climber or grass species are either vulnerable or endangered.

Interestingly the vegetation composition of the submergence zone is also widely distributed in the influence zone in abundance. However, any loss of riverine vegetation during the project activity period will be restored in the reservoir periphery in due course of time.

The floral abundance of the project area in post construction phase will increase by many folds as the plantation under catchment area treatment, reservoir rim treatment, green belt, restoration and landscaping will be completed.

4.8.2 Impacts on Fauna

The construction of barrage and reservoir shall fragment the forest area and restrict the movement of wildlife. The quarry and muck disposal area shall cause some hindrance for the free movement of wildlife. Threat due to poaching might increase. The edible fruits available in the forest on which the birds and animals depend may also be destroyed / consumed due to human interference.

As the both banks of the river on u/s and on d/s have very sparse human habitation and very little project related activities above the project site is expected, there will be no alteration to the existing habitat of faunal species. Increase in temporary stress levels of wildlife during construction phase due to noise, human interference and reduction in present habitat.

A few mammalian species were recorded during the survey. The primary reason for this low figure could be large-scale anthropogenic pressures: disturbance due to agriculture activities, road construction, etc. It is anticipated that with the upliftment of rural economy dependency on forest will be reduce poaching and will ease out pressure on wild life.

Operational Phase

Improved habitat for mainly water birds, reptiles, mammals, amphibians and plankton due to reservoir creation.

Improvement in food chain of some reptiles, birds and carnivorous mammals due to creation of reservoir and increase in humidity level.

The butterfly diversity in the area would be enhanced, as scrub habitat around the submergence will receive substantial amount of moisture, which will help in natural regeneration of forest canopy.

4.8.3 Impacts on Aquatic Life

The completion of the proposed project would bring about significant changes in the riverine ecology, as the river transforms from a flowing water system to a quiescent lacustrine environment. Such an alteration of the habitat would bring changes in physical, chemical and biotic life. Among the biotic communities, certain species can survive the transitional phase and can adapt to the changed riverine habitat. There are other species amongst the biotic communities, which, however, for varied reasons related to feeding and reproductive characteristics cannot acclimatize to the changed environment, and may disappear in the early years of impoundment of water. The micro-biotic organisms especially diatoms, blue-green and green algae before the operation of project, have their habitats beneath boulders, stones, fallen logs along the river, where depth is such that light penetration can take place.

The construction of project shall have impact on the fisheries as their movement for spawning shall be impacted.

The proposed project would envisage construction of labor camps to accommodate labors engaged in the project. Sewage generated from the labor colony may have impact on the aquatic ecology, if discharged directly into the river without any treatment or in case of open defecation.

The congregation of labor force in the project area may result in enhancement in indiscriminate fishing in the project area.

On creation of the reservoir and after implementing the fisheries development plan, it shall continue a habitat for the indigenous species as well as reservoir species.

4.9 IMPACTS ON SOCIO-ECONOMIC ASPECTS

4.9.1 Impacts on Local Community including Demographic Profile

During the construction phase, a large labour force, including skilled, semi-skilled and un-skilled labour force of the order of about 1000 persons, is expected to work in the project area at peak construction activity period. It is expected that 70% of the total work force shall be locally available and manpower to the tune of 300 persons shall migrate from other parts of the district or adjacent districts of the state. This will lead to a small change in demographic profile of the area albeit during construction phase only. The temporary labour camps will be established at suitable location in the project area. The fuel need of the labourers/ workers shall be attended in an organized manner by providing LPG and safe drinking water so that any altercation between migrated labour and locals' overuse of natural resources and facilities is averted.

During construction phase, migratory population though in limited numbers, is expected from other parts of the state having different cultural habits. However, no cultural conflicts are foreseen due to the migratory population, as they will be largely settled in separate conglomerates having all inbuilt facilities. Since major work force will be drawn from the local populace, which by interaction with outside labour during course of construction, shall develop affinity and friendship with the outside workers, thus, minimizing the chances of conflict.

4.9.2 Impacts on Socio-Economic Status

Apart from direct employment, the opportunities for indirect employment will also be generated which would provide great impetus to the economy of the local area. Various types of business-like shops, food-stall, tea stalls, etc. besides a variety of suppliers, traders, transporters will concentrate here and benefit immensely as demand will increase significantly for almost all types of goods and services. The locals will avail these opportunities arising from the project and increase their income levels. With the increase in the income levels, there will be an improvement in the infrastructure facilities in the area.

4.9.3 Impact on Human Health due to Water/Waterborne Dieses

Construction of the proposed project may cause impacts on health of local residents and the work force. Fuel and dust emission may cause respiratory problems like asthma for which mitigating measures like wet excavation of exposed surfaces shall be deployed. Frequent water sprinkling at least thrice a day shall be carried out on haul roads in the project activity area. All approach roads to site shall be metaled. Migrant workers might act as carriers of various diseases like AIDS, VDS, etc. The project authority should follow proper quarantine and screening procedures.

Due to dynamic pond the water level shall be subjected to fluctuation and the chances of water surface being still are not there. However, localized stagnation in borrow pit areas is expected during construction in some of the areas, which may require sprinkling of anti-bacterial/insecticides to control propagation of bacteria related disease. The influx of labour-force warrants proper sanitation and hygiene facilities to avoid diseases related to sewage pollutants such as Typhoid, Cholera & Gastroenteritis.

4.9.4 Impact on Increased Traffic

Increased use of existing public infrastructure i.e. road due to vehicular traffic involved in transportation of construction materials and muck and earthmovers may cause congestion on roads. However, the state highway and the national highways in the district in general have been designed keeping in view the futuristic vehicular traffic. At present the level of convenience based on traffic volume is “A” which shall not alter due to increased traffic on link road. The increased traffic shall cause more fugitive dust emission and gaseous pollution, which when added to the existing concentration the resultant concentration shall be within the limits. Regular maintenance of road and copious sprinkling of water shall be carried. Transport trucks/tippers shall be properly maintained. Only PUC certificate issued vehicles shall be used. Avoiding of overloading of trucks beyond stipulated capacity by installing weighbridges at the check posts or near to it. Strict compliance of traffic rules and regulations shall be ensured. The movement of trucks/trippers/tractors for loading /transportation within the project area and haul road area shall be regulated by a trained supervisor who shall be responsible for the safety of vehicle movement and prevention of accidents or incidents associated with the vehicular movement.

Table 4.12:Computation of Volume Capacity Ratio and LOS in Pre and Post Project Scenario

Design Service Volume	Existing Daily Traffic Data	Envisaged Traffic Movement Due	Cumulative Traffic Movement -	Volume / Capacity Ratio	Level of Service

PCU / Day			to Project Activities		Post Project Scenario					
	PCU / Day	PCU / Hour	PCU / Day	PCU / Hour	PCU / Day	PCU / Hour	Pre-Project	Post-Project	Pre-Project	Post-Project
3640	114	10	480	40	594	50	3%	16.3%	A	A

4.9.5 Impact on Holly Places and Tourism

The project is located in East Sikkim district with barrage and reservoir situated in rural set up, very close to NH-31 and capital city Gangtok. The proposed project shall create a substantial increase in tourism due to reservoir. For attracting people for picnic excursion, some picnic park shall have to be developed near barrage with facility for water sports.

4.9.6 Impact of Blasting

Blasting is accompanied by the generation of the dust and the fumes and fly rock. which pose a significant danger to the people who are in the vicinity of the work site. It also leads to ground vibrations which cause the ground to vibrate in transverse, longitudinal and the vertical direction leading to its damage. Due to blasting the people of the nearby villages are always physiologically impacted as they are constantly under apprehension of damage to their structures. Blasting also causes air overpressure is a transient impulse that travels through the atmosphere. Much of the air overpressure produced by blasting has a frequency below the audible limit of 20 Hz. Air overpressure, both audible and inaudible, can cause a structure to vibrate in much the same way as ground vibrations It is a frequent cause of the complaints as a person senses air overpressure more than vibrations. The noise due to air over pressure is instantaneous a short lived and may cause annoyance to vulnerable people

Blasting shall have adverse impact on fauna using the area contiguous with the surrounding habitation area as habitat. The noise generation has an adverse impact on terrestrial fauna and avi-fauna. Intervention in the project area will impact butterflies and birds which are quite sensitive to noise and human presence. The traffic noise has detrimental effect on the survival rates and breeding success of such fauna which reside in the small habitats along road side communicating using acoustic signals. Sometime as a result of habitat loss and physical disturbance, the fauna shall move from the habitat along road side. Based on the field observations and interaction with local people and forest officials it was noted that the project area does not constitute part of any wildlife migratory routes and mining activities won't affect animal movement.

All precautions shall be taken as envisaged under the relevant acts in respect of handling of explosive material and blasting which shall invariably be carried out by a qualified blaster.

4.9.7 Positive and Negative Impacts likely to be accrued due to Project

4.9.7.1 The positive impacts

The advent of project shall herald overt changes in the socio-economic conditions of the affected people and the population, living in the project affected zone who shall be directly benefitted. Some of prominent positive impacts are: -

•Additional annual generation of 413.78 MU of energy in a 90 % dependable year.

• 12 % free power of total generation will be given to state, which will help in regular power supply

•Employment opportunities/to locals in project work and fisheries.

•Benefits to economy and commerce.

•Access to improved infrastructure facilities.

•Recreation and tourism potential may boost.

•Improvement in environment through implementation of CAT, Compensatory Afforestation, Green belt Development and different several plans.

4.9.7.2 The negative impacts are -

•Five villages shall be affected due to acquisition of land and other assets for project purpose.

•There shall be 62 Project Affected Families of which none shall be displaced

•The loss of agriculture land (11.3895ha) and agriculture produce.

•Loss of forest habitat (48.4825ha).

•Loss of livelihood and income.

•The change of river status from riverine to lacustrine regime

•Likely decrease in agriculture and horticulture production due to air pollution

•Disturbance to the fauna of the study area during construction

•Pressure on the existing provincial / state road will increase.

4.10 IMPACTS MATRIX

Leopold et al were first to devise the use of matrix method for environmental impact assessment. Matrices are particularly useful as they reflect the impacts from series of interactions among the activities and the environmental elements. Although, the Leopold matrix is believed to largely depend on the subjective evaluation of experts that allows the judgments be converted into empirical numbers, but it is still a valid and widely used approach for the assessment of environmental impact. The Leopold matrix is a qualitative environmental impact assessment method pioneered in 1971. It is used to identify the potential impact of a project on the environment. In the matrix, the rows cover the key aspects of the environment and society, while the columns list the project's activities during all stages of the project. Environmental factors must correspond to all those that could be affected by the development of the activity in the project area and the area of influence.

A simplified/modified two-dimensional matrix inspired by Leopold matrix has been adopted for the environmental and social impact assessment of the project. Twenty-three key impact factors have been singled out from a wider list of less significant potential factors.

The interaction of activities and their impacts vary between construction and operational phase. Regarding the hydro electric project, major activities occur in the construction phase. Therefore, major impacts are anticipated during construction. Some of the impacts will be of short duration particularly during construction phase, whereas some impacts will be long lasting. Each impact was analyzed under the categories mentioned above and quantified using modified Leopold matrix. Each impact was assigned with a score using a scale of 0-4, (Table 4.13) depending on the magnitude and potential. The magnitude, potential and significance of an impact were assessed on the basis of the nature of the impact (short term/long term. reversible/irreversible. local/regional. direct/indirect. minor/major). A positive or negative sign was provided for beneficial and harmful nature of the impacts. The rows' totals of the matrix reflect the total impacts of an action on the various environmental components while the columns' total ls reflect the impact of all actions on one environmental variable.

Table 4.13:Criteria for Evaluation of Impact

S.N.	Criteria	Score
1	No impact	0
2	Minor Impact	1
3	Medium Impact	2
4	Significant Impact	3
5	Major Impact	4

Major positive and negative impact factor; major short term and long-term impacts and irreversible and reversible impacts and direct and indirect environmental impacts are interpreted in **Table 4.14** through **Table 4.17** respectively.

Table 4.18 and **Table 4.19** sum up the majority of the impacts during construction and operation phase of the project. Notably, the magnitude of negative impacts decreases considerably in the operational phase of the project. In the construction phase, total score is -47 of which 97 stands for negative impacts and 50 for positive impacts. During the operational phase total score changes to +28 of which negative impacts score are 23 and positive are 51. Considering the project actions during construction phase excavation, quarrying and migrant population are major activities which pose major impacts on the environmental and social components while community development is most positive impact.

Table 4.14:Major Positive and Negative Environmental Impacts

Description	Positive Impact Factor		Negative Impact Factor	
	Construction Period	Operation Period	Construction Period	Operation Period
Physical Environment	No Significant impact	Improvement in land status of command area Improvement of drainage of command area.	Land degradation due to excavation for project components, approach road Temporary increase in GLC of ambient air at construction site, approach roads. Increase in noise levels at construction site and nearby settlement. Water and soil pollution due to improper disposal of waste and mal-functioning of equipment. Spread of water borne disease.	No significant impact.
Biological Environment	No Significant impact.	Improvement in vegetal cover in submergence and command area. Improved habitat for mainly water bird, mammals, due to creation of approach channel. with the upliftment of rural economy dependency on forest will be reduce poaching and will ease out pressure on wild life.	Loss of habitat due to diversion of forest land. Increase in temporary stress levels of wildlife and loss of productivity. Inhibition of free movement of wild life. Threat due to poaching might increase.	No significant impact.

Description	Positive Impact Factor		Negative Impact Factor	
	Construction Period	Operation Period	Construction Period	Operation Period
Economic Environment	Enhancement in Temporary job opportunity. Increase in demand for fuel and other construction material.	Better opportunities for cattle rearing. Hike in the prices of land in the command area. Benefits to economy and commerce and better market facilities Recreation and tourism potential	The loss of agriculture land and agriculture produce. Loss of livelihood and income.	Likelihood of Loss of jobs.
Social & Cultural Environment	Creation of social unity amongst people of project area.	Betterment in social welfare of farmers of command area. Better living Standards for famers of command area. Sustained water availability for agriculture. Preventing migration to other cities for earning livelihood.	Loss of land assets over which the PAFs have developed affinity. Increase in pressure on the existing provincial / state road. Conflict for employment between local people and migratory labor population. Conflict between beneficiaries and non-beneficiaries.	Conflict between beneficiaries and non-beneficiaries.

Table 4.15:Major Short-term and Long-term Environmental Impacts

Description	Short- term Impact Factor		Long -term Impact Factor	
	Construction Period	Operation Period	Construction Period	Operation Period
Physical Environment	Land degradation due to excavation for project components, approach road and borrow/disposal area Temporary increase in GLC of ambient air at construction site, approach roads. Increase in noise levels at construction site and nearby settlement. Water and soil pollution due to improper disposal of waste and mal-functioning of equipment. Spread of water borne disease.	No significant impact	Change in the land use of agriculture land and forest land. Land degradation due to excavation for project components, approach road and borrow area. Spread of water borne disease due to stagnation of water in pits.	. Change in hydraulics and hydrological pattern of river flow. Decrease in water quality in the local streams due to run off from agriculture fields. Improvement in land status of command area fields due to command area development works. Spread of water borne disease due to stagnation of water in pits
Biological Environment	Increase in temporary stress levels of wildlife and loss of productivity. Inhibition of free movement of wild life. Threat due to poaching due to migration of labor	No significant impact.	Loss of habitat due to diversion of forest land. Disturbance in existing ecological balance.	Fragmentation of habitat. Improved habitat for mainly water bird mammals, due to creation of approach channel. Improvement in vegetal cover in command area. with the upliftment of rural economy dependency on forest will be decreased.

Description	Short- term Impact Factor		Long -term Impact Factor	
	Construction Period	Operation Period	Construction Period	Operation Period
Economic Environment	Increase in Temporary job opportunity Increase in demand for fuel and other construction material	Not applicable	The loss of agriculture land and agriculture produce for PAF. Loss of livelihood and income for PAF	Loss of jobs Better opportunities for cattle rearing. Employment in other sectors. Hike in the prices of land in the command area. Benefits to economy and commerce and better market facilities Recreation and tourism potential
Social &Cultural Environment	Conflict between beneficiaries and non-beneficiaries. Conflict for employment between local people and migratory labor population. Increase in pressure on the existing provincial / state road.	Not applicable	Loss of assets over which the PAFs have developed affinity	Betterment in social welfare of farmers of command area Better living Standards for famers of command area. Preventing migration to other cities for earning livelihood. Sustained water availability for agriculture.

Table 4.16:Major Reversible and Irreversible Environmental Impacts

Description	Irreversible Impact Factor		Reversible Impact Factor	
	Construction Period	Operation Period	Construction Period	Operation Period
Physical Environment	Change in the land use of agriculture and forest land. Land degradation due to excavation for project components, approach road and borrow area .	Change in hydraulics and hydrological pattern of river flow. Decrease in water quality in the local streams due to run off from agriculture fields. Improvement in land status of command area fields due to command area development works	Temporary increase in GLC of ambient air at construction site, approach roads. Increase in noise levels at construction site and nearby settlement. Water and soil pollution due to improper disposal of waste and mal-functioning of equipment Spread of water borne disease due to stagnation of water in pits.	Spread of water borne disease due to stagnation of water in pits
Biological Environment	Loss of habitat due to diversion of forest land. Fragmentation of habitat and disturbance in existing ecological balance.	Loss of habitat due to diversion of forest land. Fragmentation of habitat and disturbance in existing ecological balance.	No significant impact.	No significant impact.

Description	Irreversible Impact Factor		Reversible Impact Factor	
	Construction Period	Operation Period	Construction Period	Operation Period
Economic Environment	Hike in the prices of land in the command area.	Loss of jobs Better opportunities for cattle rearing. Employment in other sectors. Hike in the prices of land in command area. Benefits to economy and commerce and better market facilities Recreation and tourism potential	Increase in Temporary job opportunity Increase in demand for fuel and other construction material	No significant impact
Social &Cultural Environment	The pang of involuntary acquisition of land shall cause many social pressures and stress on the affected families	The pang of involuntary acquisition of land shall cause many social pressures and stress on the affected families Betterment in social welfare of farmers of command area Better living Standards for famers of command area. Preventing migration to other cities for earning livelihood. Sustained water availability for agriculture.	Conflict between beneficiaries and non-beneficiaries. Conflict for employment between local people and migratory labor population. Increase in pressure on the existing provincial / state road.	No significant impact

Table 4.17: Major Direct and Indirect Environmental Impacts

Description	Direct Impact Factor		Indirect Impact Factor	
	Construction Period	Operation Period	Construction Period	Operation Period
Physical Environment	Land degradation due to excavation for project components, approach road and borrow/disposal area Temporary increase in GLC of ambient air at construction site, approach roads. Increase in noise levels at construction site and nearby settlement. Water and soil pollution due to improper disposal of waste and mal-functioning of equipment. .	Change in the land use of agriculture and forest land. Change in hydraulics and hydrological pattern of river flow. Decrease in water quality in the local streams due to run off from agriculture fields. Improvement in land status of command area fields due to command area development works.	Spread of water borne disease due to stagnation of water in pits.	Spread of water borne disease due to stagnation of water in pits
Biological Environment	Increase in temporary stress levels of wildlife and loss of productivity. Inhibition of free movement of wild life. Threat due to poaching due to migration of labour.	No significant impact.	Loss of habitat due to diversion of forest land. Fragmentation of habitat and disturbance in existing ecological balance.	Fragmentation of habitat. Improved habitat for mainly water bird mammals, due to creation of approach channel. Improvement in vegetal cover in command area. with the upliftment of rural economy dependency on forest will be decreased.

Description	Direct Impact Factor		Indirect Impact Factor	
	Construction Period	Operation Period	Construction Period	Operation Period
Economic Environment	Increase in Temporary job opportunity Increase in demand for fuel and other construction material	Not applicable	The loss of agriculture land and agriculture produce for PAF. Loss of livelihood and income for PAF	Loss of jobs Better opportunities for cattle rearing. Employment in other sectors. Hike in the prices of land in the command area. Benefits to economy and commerce and better market facilities Recreation and tourism potential
Social &Cultural Environment	Increase in pressure on the existing provincial / state road. Involuntary acquisition of land assets. Loss of assets over which the PAFs have developed affinity	Betterment in social welfare of farmers of command area Better living Standards for famers of command area. Preventing migration to other cities for earning livelihood. Sustained water availability for agriculture	Conflict between beneficiaries and non-beneficiaries. Conflict for employment between local people and migratory labor population.	Betterment in social welfare of farmers of command area Better living Standards for famers of command area. Preventing migration to other cities for earning livelihood. Sustained water availability for agriculture.

Table 4.18: Modified Leopold Matrix of Environment Impacts in Construction Phase

Environmental Effects →	Physical Environment											Biotic Environment				Economic				Social and Cultural				Total -ve	Total +ve	Total
Development Activities	Landscape	Hydraulics of	Water pollution	Air pollution	Noise pollution	Vibration	Land degradation	D/s water users	Exploitation of resources	Spread of Malaria	Ground water	Aquatic life and Fisheries	Fragmented	Ecological balance	Stress on	Employment	Social values	Basic Amenities	Marketing	Cultural conflict	Archaeological	Demographic changes	S.S. Business			
Barrage excavation	-2	0	-1	-1	-1	0	-1	0	0	0	-1	0	-2	-1	-2	+2	0	0	0	0	0	0	0	-12	+2	-10
Road construction	-2	0	-1	-2	-1	0	-2	0	0	-1	0	-1	-2	-1	-2	+2	0	+1	+1	0	0	0	0	-15	+4	-11
Tunnelling	-1	0	-1	-1	-2	-1	-1	0	0	0	-1	0	0	0	0	+2	0	+1	+1	0	0	0	0	-8	+4	-4
Powerhouse	-1	0	-2	-1	-1	-1	-1	0	0	0	0	0	0	-1	0	+2	0	+1	+1	0	0	0	0	-8	+4	-4
Submergence	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dumping	-1	0	-1	-1	-1	0	0	0	0	0	0	-1	0	0	0	0	0	0	0	0	0	0	0	-5	0	-5
Quarrying	0	0	-2	-2	-1	0	0	0	0	-2	0	-1	0	-1	-2	0	0	0	0	0	0	0	0	-11	0	-11
Colony	-1	0	0	0	0	0	-1	0	0	0	0	0	0	-1	0	0	0	0	0	0	0	0	0	-3	0	-3
Diversion	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CAT& other EMP	0	0	+1	0	0	0	0	0	0	+2	0	0	0	+1	0	+4	+1	0	0	+2	0	0	0	0	+11	+11
Vehicular Movement	0	0	0	-3	-3	0	0	0	0	0	0	0	0	0	-1	0	+1	+1	0	0	0	0	+1	-7	+3	-4
Migrant Population	0	0	-2	0	0	0	0	0	-2	0	-1	-2	0	-1	-2	0	-2	+4	+2	-3	0	-1	+4	-16	+10	-6

Environmental Effects →	Physical Environment											Biotic Environment				Economic				Social and Cultural				Total -ve	Total +ve	Total
Development Activities	**Landscape**	**Hydraulics of**	**Water pollution**	**Air pollution**	**Noise pollution**	**Vibration**	**Land degradation**	**D/s water users**	**Exploitation of resources**	**Spread of Malaria**	**Ground water**	**Aquatic life and Fisheries**	**Fragmented**	**Ecological balance**	**Stress on**	**Employment**	**Social values**	**Basic Amenities**	**Marketing**	**Cultural conflict**	**Archaeological**	**Demographic changes**	**S.S. Business**			
Land assets acquisition	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-2	-4	-3	0	0	0	-3	0	-12	0	-12
Comm. Development	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	+4	+2	+3	+2	0	0	0	+1	0	+12	+12
Energy Generation	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	-8	0	-9	-11	-10	-2	-6	0	-2	-1	-3	-5	-4	-5	-9	+14	-2	+8	+7	-1	0	-4	+6	-97	+50	-47

Table 4.19: Modified Leopold Matrix of Environment Impacts in Operation Phase

Environmental Effects →	Physical Environment											Biotic Environment				Economic				Social and Cultural				Total -ve	Total +ve	Total
Development Activities ↓	Landscape	Hydraulics of	Water pollution	Air pollution	Noise pollution	Vibration	Land degradation	D/s water users	Exploitation of	Spread of Malaria	Ground water	Aquatic life and	Fragmented	Ecological balance	Stress on	Employment	Social values	Basic Amenities	Marketing	Cultural conflict	Archaeological	Demographic	S.S. Business			
Barrageexcavation	0	-2	0	0	0	0	0	0	0	0	0	0	-1	0	0	+1	0	0	0	0	0	0	0	-3	+1	-2
Road construction	-1	0	0	0	0	0	-1	0	0	0	0	0	0	0	-1	0	0	+2	0	0	0	0	0	-3	+2	-1
Tunnelling	0	0	0	0	0	0	-1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-1	0	-1
Power house	-1	+4	-1	0	-1	-1	0	0	0	0	0	+2	0	0	0	+2	0	0	+2	0	0	0	0	-4	+10	+6
Submergence	+2	0	-1	0	0	0	-2	-1	0	-2	0	+2	-1	-1	0	+2	+1	0	0	0	0	0	0	-8	+7	-1
Dumping	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Quarrying	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Colony	0	0	0	0	0	0	0	0	-1	0	-1	0	0	0	0	0	0	0	+1	0	0	0	+1	-2	+2	0
Diversion	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CAT& other EMP	0	0	0	0	0	0	0	0	0	0	+3	0	0	+3	0	0	0	+1	0	0	0	0	0	0	+7	+7
Vehicular Movement	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	+1	0	0	0	0	0	0	+1	+1
Migrant Population	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	+1	+1	-1	0	-1	0	-2	+2	0
Land assets	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Environmental Effects →	**Physical Environment**											**Biotic Environment**				**Economic**				**Social and Cultural**				**Total -ve**	**Total +ve**	**Total**
Development Activities ↓	Landscape	Hydraulics of	Water pollution	Air pollution	Noise pollution	Vibration	Land degradation	D/s water users	Exploitation of	Spread of Malaria	Ground water	Aquatic life and	Fragmented	Ecological balance	Stress on	Employment	Social values	Basic Amenities	Marketing	Cultural conflict	Archaeological	Demographic	S.S. Business			
acquisition																										
Comm. Development	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	+3	+1	+3	+1	0	0	0	+1	0	+9	+9
Energy Generation	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	+3	+2	+2	+3	0	0	0	0	0	+10	+10
Total	0	+2	-2	0	-1	-1	-4	-1	-1	-2	+2	+4	-2	+2	-1	+11	+4	+10	+8	-1	0	-1	+2	-23	+51	+28

5 ANALYSIS OF ALTERNATIVES

5.1 INTRODUCTION

The consideration of alternatives from environmental and project economics is one of the cardinal and proactive aspects in conception of a project. It is mainly instrumental for proper project planning, safe and economical designing and adoption of state-of-the-art technology through examining options instead of only focusing on the more defensive task of reducing adverse impacts of a single design. This includes the systematic comparison of feasibility alternatives to the proposed project, inter alia specific project site, technological and operational alternatives. Alternatives are compared in terms of their potential environmental impacts, project economics, and suitability under local conditions.

In the process of EIA, analysis of alternatives is the key tool to examine the extent of environmental impacts both beneficial and adverse, posed by the construction and operation of the proposed project vis-à-vis the environmental status of the region without the development of the project. It also involves comparison and environmental evaluation of the different alternatives proposed in the project. The assessment has been carried out for project alternative in no hydropower scenario, the with and without project scenario, alternate sites and different tunneling methods

5.2 PROJECT ALTERNATIVE

The installed capacity of the project is 115 MW and it would generate 396.57GWh of power in a 90% dependable year. In no project scenario, in order to generate this power by thermal power plant about 0.42 million tons of the coal would be utilized considering specific fuel consumption as 1.06 kg/KWh. The state is known to have no fossil fuel and thus thermal power generation by importing coal is not at all a lucrative and valuable proposition mush so when the state is bestowed with enormous hydro-power potential.

5.3 NO PROJECT SCENARIO

In the interest of energy security and achieving a low carbon growth, it is required to tap available hydro potential in the country. A “no-project” scenario will ensure that the resulting increased demand-supply gap for electricity will be filled up by development of additional coal fired power stations (the fuel of choice given India’s abundant coal reserves) during off-peak time and small diesel or coal fired plants during peak time. These would result in significant net increase in GHG emissions.

Due to the finite nature and limited number of feasible hydropower projects, it is unlikely that a gap created by not developing HEP project can be filled up by developing another hydropower project.

At the state level, hydropower is a major resource in state, important for the state’s economic progress and revenue accrual. A “no-project” scenario would mean an annual revenue loss for the state. It is unlikely that a coal-fired plant (that would come up as a response to the “no project” scenario) may come up within state, being away from both the coal mines and the centers of power demand. Overall, the "no project" alternative is not a desirable option

5.3.1 Environmental Conditions

The environmental conditions have been assessed in both the scenarios viz. with and without project for the two aspects viz.

- The impact of construction and operation of the project
- The environmental status of the area if the project is not undertaken.

The analysis has been carried out for the 'with project' and 'without project' scenario associated with hydrology, air quality, flora and fauna, socio-economic and infrastructure. No analysis has been carried out with respect to climatology and meteorological conditions which will be localized and insignificant impact on either of the scenarios.

Table 5.1: Alternative Analysis for Proposed Project

Issues	Without Project	With Project
Hydrology	The surface and groundwater hydrology will not be altered. The river water is not used for any purposes downstream of the intake point up to confluence with Teesta.	From intake structure a maximum diverted discharge of 31.56cumec through intake shall reduce the river flow d/s of the barrage to the extent discharge flowing through HRT tunnel.Thus there shall be remarkable change in hydrological cycle of Rongni Chhu and Rangpo Chhu as the discharge of former shall reduce and increase for the latter. The project does not envisage draft of underground water; therefore, underground hydrology will not charge. The annual recharge shall not be affected due to the project
Land use and Soil	The study area has open forest with percentage as high as 45.4%. The tree density is found thin in the project area mainly due to illegal felling of trees. The cultivable land is also less. This situation is likely to worsen if some mitigative measures are not timely adopted.	The land use class of 2.62 ha forest land and 4.39 ha agriculture land involved in submergence shall change into waterbody. The land use class of forest land and agriculture land required for project components and internal roads shall have land use class changed to built-up area. The land use class of forest land required for quarry and muck disposal sites shall remain unchanged as these sites shall later developed with vegetal cover. The implementation of various management plans viz. CAT plan, compensatory afforestation, greenbelt etc. shall improve the land cover of the area. Hence the land use will improve in the long run.
Air Quality & Noise Level	Ambient air quality is good to satisfactory and noise levels are not high at present. Due to socio-	Air quality may deteriorate during the construction period at project sites. However, this will be a temporary

Issues	Without Project	With Project
	economic factors and development activities in the area these are expected to deteriorate gradually with time.	phenomenon, and will be confined to the location and duration of the construction activities. The air quality is thus likely to improve due to improved road conditions proposed in the project for transportation of construction material. The noise quality of the area is likely to be moderately affected during the operation phase and construction phase due to sporadic use of DG sets and increased traffic. However, since the DG sets will be housed inside enclosure and the increase in traffic will be negligible post construction, no significant adverse impact is envisaged.
Rehabilitation and Resettlement	No resettlement and rehabilitation issues arise without the project	There are six project affected villages which are being impacted due to acquisition of private land (33.9483 ha) . There shall be 63 PAF of which none shall be displaced. The PAF have been adequately compensated as per provision of NRRP- 2007.
Ecological Impact	The vegetation of study area comprises dense/open forest and cultivatedland. The situation is not expected to change without project scenario. There will be no impact on wildlife in such a scenario	Site selection throughout the length of the project is such that there is minimal tree cutting involved. Further, because most of the proposed components are underground, tree felling will be mainly involved at the tunnel portals and in submergence. Owing to the underground activities at considerable depth from the surface, the wildlife of the area will also not be affected other than during the construction phase for which Wildlife Management Plan has been formulated. The construction of project shall have impact on the fisheries as their movement for spawning shall be impacted.
Socio-culture issue	The residents are mainly cultivators and make a living by selling their produce in local market and exporting apples. However, with increasing population, requirement for other job opportunities is also being felt	Due to project activities, local and regional people will get direct and indirect employment opportunities not only during construction phase but also during the operation phase, too. The staff residences are proposed for running and maintenance of the power plant. With proper measures no impact is expected on local crops.

Based on the above discussions, it is found that with the project, no significant impact is likely although air and noise quality will deteriorate during the construction phase. The project implementation shall however lead to economic benefits to the local people. However, considering the national importance of the project in generation of the much-needed electricity, the 'with project' option along with proposed mitigation measures is preferred.

5.4 ALTERNATIVE STUDIES FOR SITING

Based on reconnaissance survey and geological mapping of the designated area,various alternatives were studied stretching from headworks downstream of Namlivillage to surface powerhouse site near the Rangpo river on its right bank. All possible locations in this stretch were studied from geological view point. On thebasis of various traverses taken by Geological Survey of India, two alternates were identified which have beendesignated as first Alternative-1 and Second as Alternative-2.

5.5 ALTERNATIVE STUDIES FOR SELECTION OF PROJECT LAYOUT

The following alternative studies were carried out to explore the selection of project layout

5.5.1 Alternative-1: Dam and Surface Powerhouse at Right Bank of Rangpo Chhu

Initially,the NHPC carried out preliminary survey in respect of the project . and during February,2005,submitted PFR.As per PFR, NHPC had recommended development by conceiving 170m high concrete gravity dam on Rongni chhuand diversion of water through HRT to a proposed surface powerhouse(195 MW) on right bank of Rangpo Chhu. The later studies conducted by M/s SMECIndiaPvt.Ltd. found that PFR was over estimated in terms of height of dam.

5.5.2 Alternative-2: Barrageand SurfacePowerhouse at Right Bank of Rangpo Chhu

The alternative scheme conceived byM/s SMECIndiaPvt.Ltd encompassed construction of barrage about 80m upstream of an existing low head weir near village Namli and u/s of confluence of RongniChhueith Andheri Khola and surface powerhouseon right bank of Rangpo Chhu, but downstream of location of powerhouse in the earlier PFR of NHPC.The advantage of new powerhouse site was that sufficient flat land was available andgaining of additional head for power generation. Alternative-2 has been found most suitable and hence selected.

5.6 ALTERNATIVES FOR TUNNELING METHODS

The project will involve construction activities in hilly terrain, more specifically through rocky hills, where tunneling is required. Tunneling can be carried out using following two methods.

- By 'Tunnel Boring Machines (TBM)' and
- Conventional drilling and blasting

These two techniques are analyzed on techno-economic and environmental aspects **(Table 5.2).**

Table 5.2: Comparison of Tunnelling Techniques

S.N.	Issues	Tunnel Boring Machine	Drilling and Blasting
Techno economic Feasibility			
1	Techno economic feasibility	Requires larger platform for its functioning. Machines are heavy and require specific efforts for its movement and handling especially in difficult	Drilling and blasting can be carried out in rocky terrains. Although the rock formations are soft in general, but the tunnel routing has been

S.N.	Issues	Tunnel Boring Machine	Drilling and Blasting
		terrains. The project area has steep inclinations and is prone to landslide at certain locations. Development of required platform at various adit points, is in itself a difficult task and expensive. Such operations may not be techno-economically feasible	considered through stable formations in the mountains. Hence, drilling and blasting is considered feasible
		Environmental Feasibility	
2	Noise and vibration	The generation of noise and vibration would be of medium intensity, through it will be continuous in nature	The generation of noise and vibration would be of high intensity but will be instantaneous and intermittent in nature. Since, tunneling would be about half a kilometer under the surface and through stable formations, vibrations are not likely to traverse long distances. Noise will also be contained within the tunneling area
3	Air Emissions	There will be continuous dust generation of small magnitude which will have to be ventilated out though ID fans. The use of water sprinkler system on the dust plume trail will ensure the non-dispersion of the dust to long distances	There will be intermittent dust generation of medium magnitude which will be ventilated out though ID fans. The use of water sprinkler system on the dust plume trail will ensure the non-dispersion of the dust to long distance
4	Seepage water generation and disposal	The detection of water seepage can be easily noticed. However, as per the hydro-geological report, there are no aquifers in the tunneling routes. Hence, the seepage water generation likelihood is less	Due to blasting, the flooding of the tunnels may be sudden. However, since there is no presence of water aquifers, the possibility of flooding in the tunnel due to blasting is not anticipated
5	Debris disposal	The debris generated from tunneling will be disposed in identified disposal sites and shall not affect the environment adversely	The debris generated from tunneling will be disposed in identified disposal sites and shall not affect the environment adversely
6	Impact on flora and fauna	The continuous generation and dispersion of dust from tunneling may affect the productivity of apple orchards. Hence water sprinklers shall be used to control the dust dispersion	The intermittent generation and dispersion of dust from tunneling may affect the productivity of apple orchards. Hence, water sprinklers shall be used to control the dust dispersion.

Based on above analysis, it is inferred that the environmental impact associated with the above two methods of tunneling are similar and that no major preference can be attached to either of the techniques on environmental considerations. However, due to the emerging techno-economic feasibility, the drilling and blasting method is found to be the more feasible option.

6 ENVIRONMENTAL MONITORING PROGRAMME

6.1 INTRODUCTION

Sustainability of water resource project depends on continuous monitoring. Monitoring is an integral part of any environmental assessment process. Water resource development project creates a new environment with complex inter-relationships between people and natural resources. The magnitude of changes being created due to alteration of landscape, water, air and noise quality and other environmental parameters can be quantified and evaluated only by carrying out monitoring of various parameters during different phases of project construction and operation.

The monitoring and evaluation of environmental parameters indicates potential changes occurring in the environment which paves way for implementation of rectifying measures wherever required to maintain the status of the natural environment. Evaluation is also a very effective tool to judge the effectiveness or deficiency of the measures adopted and provides insight for future corrections.

6.2 AREAS OF CONCERN

In case of hydro power projects, the changes relating to water, aquatic biota, air, noise, biodiversity of the area and compensatory afforestation programmes need special attention, from monitoring point of view, during project construction as well post construction stages to judge the efficacy of measures implemented for conservation of environment.

6.3 ENVIRONMENTAL MONITORING

The overall impact assessment of the proposed project was carried out and monitoring plans have been framed based on the severity of impacts in different areas. During the EIA study it has been observed that the air quality and water quality are not going to be affected significantly and only, temporary changes in these parameters are expected. The preventive/ curative measures to reduce the ill effects of construction activities on these parameters have been suggested under various plans. A holistic approach has been adapted for monitoring of air, noise and water related factors under different heads with suitable financial provisions for their implementation.

6.3.1 Air Quality Monitoring and Management

Pollutant which may be generated during the construction phase of the project will alter the local environment temporally and shall subside once the major constructional activities are over. During the construction phase of the project, the ground level concentration of the pollutant like SO2, NOx and PM10 are likely to increase but the resultant concentration shall be within the threshold limit especially in surface excavation areas but may exceed the threshold limit for underground work areas which is to be controlled by use of ventilator fans. It should be made mandatory on the part of the contractors that they use the required equipment for monitoring gaseous pollutants in and around the project and submit a detailed report every fortnight to the project authorities for evaluation and monitoring purposes. The air quality in and around the project area can be improved by the application of following practices/ methods.

- Excavation work may be carried out by pre-splitting and controlled blasting techniques

- Control blasting be carried out as far as possible and use of explosive also be bare minimum.
- The type of explosive used in blasting may be selected as per the requirement.
- To settle down the dust in project area especially around crushing plants, excessive use of water sprinklers is the best method.

The work of Air Quality Monitoring may be assigned to eitherSPCBor any other agency approved by MOEF. For this a lump-sum provision of Rs 28 Lakh for 10 years and Rs 2.80 lakh for 1 years during construction and operation phases respectively shall be sufficient to cater to the quarterly monitoring of air quality parameters such as SO_2, NOx, and PM_{10} at following sites:

- Barrage Site (Namli)
- Adit-II (Sumin)
- Powerhousesite.

6.3.2 Noise Quality Monitoring and Management

The level of noise will definitely rise above threshold level in the project area due to different types of construction activities: blasting for tunnels, powerhouse, barrage etc., movement of heavy and small vehicles and the crushing plants. All these activities will generate high noise and vibrations which can cause health hazards among the labours, local inhabitants and wildlife present in the area. Therefore, it would be most appropriate if following measures are rigorously applied during construction phase of the project.

- Continuous monitoring of sound level within the project area.
- Extensive plantation to be carried out in the project area as plants absorb sound and make a barrier for its travel to long distances.
- Pre-split and controlled blasting.
- Provision of Air muffs to workers working in underground excavation works.
- Compulsory Periodic Maintenance of high earth movers, batching and crushing plants.

Monitoring and measuring the sound level can be again assigned to eitherSPCBor any other external agency. The financial implication for monitoring of noise pollution is proposed for every three months during construction phase of ten years and post construction phase for one years. The total financial implication for construction and post-construction phase works out to Rs. 5.0 and 0.50 lakh. The noise shall be monitored at the following locations: -

- Barrage Site (Namli)
- Adit-II (Sumin)
- Powerhouse site.

6.3.3 Water Quality Monitoring and Management

Water is one of most precious natural resources. Human beings are highly dependent on water for various purposes such as domestic needs, sanitation irrigation, industry, and disposal of wastes etc.

The catchment of river up to the barrage site does not host any industry. Thus, the stream water is almost free from major industrial chemical pollutants. Besides this, the catchment is sparsely populated with small chunks of agricultural fields. Therefore, the water of river bears some load of silt mainly from glacier melts i.e. moraine deposit and domestic wastes. Further, due to congregation of labourers during the construction phase, the water quality in this stretch may get deteriorated if proper sanitation facilities are not provided to them. The probable water pollutants which may cause pollution during the construction phase of this project are: -

- Suspended solids
- Biodegradable organic matters
- Pathogens and vectors
- Nutrients
- Dissolved inorganic solids

6.3.4 Proposed Water Quality Monitoring Plan

It is anticipated that during the construction period of the project the generation of waste water from construction sites, residential colonies and labour camps may increase and facilitate transport of sediment laden waters to the river. Pollutants resulting from the sewage waste would definitely degrade river water quality further. The following measures are, therefore, proposed for water quality management:

- Sufficient water should be supplied to the labour camps and residential colonies
- Water should be treated before use to prevent pathogenic and coli form organisms
- Sewage waste be released in river only after proper treatment

It is proposed that the sediment laden water from different project components may be collected in sedimentation tanks/water tanks to dislodge the sediments before releasing the sediment free water to river/streams.

Adequate solid waste management practices shall be adopted in colonies and labour camps as suggested in solid waste management plan. It would be eco-friendly if sewage water after disposal of solid waste may be used in watering of parks and gardens. In addition to this, periodical monitoring of water for its physico-chemical and bacteriological parameters may be conducted quarterly at under mentioned sites.

- Rongni Chhu 200m u/s of barrage site
- Rongni Chhu 100m d/s of barrage site
- Rangpo Chhu 100 m d/s ofpowerhouse site

The financial provision of Rs 16.0lakh however is made for the period of ten years from the date of project execution and Rs 1.60 lakh for one-year post-construction. The water quality parameters to be monitored quarterly and compared with IS: 2296-1982 are shown in **Table 6.1.**

Table 6.1: Water Quality Parameters to be Monitored Periodically

Parameters	Parameters	Parameters
pH	Phosphates	DO
Electrical Conductivity	Fluorides	Fluorides
Turbidity	Nitrates	BOD
Water Temperature	Sulphates	COD
TDS	Alkanity	Total Coliform
Total hardness	Chlorides	E-Coli
Magnesium	Iron	
Calcium	Manganese	

6.3.5 Soil Quality Monitoring and Management

The transportation of excavated/construction material on unpaved roads and excavation results in land degradation and formation of loose soil particles which are mainly fugitive dust. cause fugitive dust emission. These dust particles are usually blown away along the wind direction and get deposited on the canopy of surrounding vegetation and agricultural crops thereby resulting in reduced ecological functions of the forest ecosystems as well as economic productivity of the agro-ecosystems.The following measures are, therefore, proposed for soil quality management:

- At the feeding points stone crusher air mist spray shall be carried out.
- Wet drilling shall be carried out
- Copious sprinkling of water on unpaved access/approach roads
- The leakage of POL and washings of workshop floors bring oil and grease with it. It shall be collected in oil separators before disposal on land. The soil contamination with oil shall be totally avoided.

Sampling and analysis of soil can be again assigned to eitherSPCBor any other external agency. The financial implication for taking grab samples of soil and analysis for parameters like texture, macro-nutrients, Sulphur, organic carbon, pH and EC and other physical parameters is proposed for every six months during construction phase of five years and post construction phase for two years. The total financial implication for construction and post-construction phase works out to Rs. 8.80 lakh. The soil samples shall be grabbedfrom following locations: -

- BarrageSite(Namli)
- Sangkholavillage
- Sumin Village.

6.3.6 Monitoring of Incidences of Water-Related Diseases

Identification of water related diseases, adequacy of local vector control and curative measures, status of public health are some of the parameters which need close monitoring. The monitoring of water related vectors may be executed in collaboration with State Health Department and data so generated may also be preserved by them for future reference. For monitoring twice, a year for five years during construction and two-year post-construction a provision of Rs. 5.0 lakh and Rs. 0.50 lakh respectively has been made.

6.4 MONITORING OF EROSION & SILTATION

During the construction period, the project proponent shall monitor daily the suspended silt load of the Tons. Besides this, the stability of river banks shall be closely monitored. After completion of the project, the project proponent shall monitor the daily suspended silt load of the Satluj and work out yearly silt load in ham/year/100 sq. km of the catchment area and keep a record of it. On these counts a financial provision of Rs 11.0 lakh for monitoring during construction alone is being made as the post construction daily monitoring of silt load is the requirement for running the machines and the responsibility anyway rests with the project proponent.

6.5 ENVIRONMENT MONITORING THROUGH REMOTE SENSING

The use of remote sensing technology can be aptly made for monitoring of the progress of the works proposed under catchment area treatment, compensatory afforestation, and green belt. This can be achieved by the periodically study of digital satellite data IRS P6 LISS-IV for the specific site and evaluated on ERDAS imagine software. The standard False Colour Composite (FCC) generated by assigning blue, green and red colours to visible green, visible red and near infrared bands respectively. Expressing image pixel addresses in terms of a map coordinate base is often referred to as geo-coding. As various thematic layers are to be overlaid for this project, all the layers shall be geo-referenced to real world coordinates. The comparative study of change in land use pattern, the change in extent of forest areas, the growth of new plantation, the development of new landslide zones can be established by periodical study of the scene obtained from the satellite. The technique can also be made use of in establishing the expanse of sedimentation in the reservoir by comparing the scene obtained from remote sensing after every three years or so.

6.6 ECOSYSTEM STUDIES

Efficacy of conservation measures to be implemented in catchment area treatment plan such as afforestation and soil conservation measures, and their effects on flora, terrestrial fauna, aquatic fauna (fish migration) are the aspects which should be evaluated and monitored under the head monitoring of ecosystem. The findings of this study should be made available to authority implementing CAT plan, restoration of muck disposal and quarry areas, reservoir rim treatment on periodic basis so as to make necessary change if need arise and the implementation more meaningful during construction and operation phase of the project. Since, the study is subject specific, services of expert agencies will be required to carry out the same.

6.7 MONITORING OF MUCK DISPOSAL

It has already been made eloquent in the relevant muck management plan that the excavated material shall be evacuated from site with suitable usable muck to be utilized in project works by the project proponents and also allowed to be used by private users and the non-usable muck is to be disposed of on designated areas so as not be interfere with either environment/ecology or the river flow regime. Thus, these is an imperative need to monitor regularly the quantum of muck generated and its disposal for which purpose the project proponent shall furnish monthly statement of muck/debris disposal to project proponent and SPCB.

6.8 MONITORING OF MINIMUM FLOW

During operational phase, minimum release of water as prescribed immediately downstream of diversion structures shall be monitored daily by the project proponent who is bound to submit monthly statement to SPCB, who should also conduct surprise checking in this regard and submit its report to the MoEFCC, New Delhi.

6.9 SHARING OF MONITORING RESULTS

The results of monitoring of various environment attributes either during or post construction would be shared by the monitoring agency, whosoever including SPCB, with the project proponents and other agencies of the Government as and when required. Monitoring agency may disseminate the results in any other forms.

6.10 COST OF ENVIRONMENT MONITORING PROGRAMME

The total cost of environment monitoring plan works out to **Rs. 90.00 lakh** and is given in **Table 6.2**.

Table 6.2: Summary of Environment Monitoring Programme

Sl. No.	Aspect	Parameters to be monitored	Frequency		Location	Cost Estimates (Rs. lakh)			Implementing and Pursuing Agency
			During Construction	During Operation		During Construction	During Operation	Total	
1	Air Quality monitoring	SO_2, NO_X, PM_{10}	Quarterly for 10yr.	Quarterly for 1 year	3 locations as already specified	28.0	2.80	30.80	SPCB or any approved agency of MOEF
2	Noise Quality Monitoring	Noise level	Quarterly for 10yr.	Quarterly for 1 year	3 locations as already specified	5.0	0.50	5.50	SPCB or any approved agency of MOEF
3	Water quality Monitoring	All parameters given in water quality	Quarterly for 10yr.	Quarterly for 1 year	3 locations as already specified	16.00	1.60	17.60	SPCBor any approved agency of MOEF
4	Soil quality Monitoring	All parameters given in soil quality	Quarterly for 10yr.	Quarterly for 1 year	3 locations as already specified	8.00	0.80	8.80	SPCB or any approved agency of MOEF
4	Water-related diseases	Identification of water-related diseases,	Half yearly for 10yr.	Half yearly for 2 year	Villages adjacent to project	5.00	0.50	5.50	C. M. O.
5.	Erosion and Siltation	Soil erosion rates, Stability of banks	summer and post monsoon for 5 years	Daily Silt observation	Barrage site	11.00	0.00	11.00	Project Proponent
6.	Celebration of Environment Day		Yearly for 10 years	-	At village Nimtar	5.00	0.50	5.50	Project proponent
7.	Study on ecological flow and research on endemic fish fauna					5.00	-	5.00	Project proponent
Total						**83.00**	**6.70**	**89.70**	
Say								**90.00**	

7 ADDITIONAL STUDIES

7.1 GENERAL

After having gone through the various aspects of project activities involved in construction of barrage at the proposed site and the related documents like Form–I and PFR, the MoEFCC, set out the scoping clearance and issued ToR for environmental impact assessment studies and preparation of environmental management plan for the project and for submission of report. The Terms of Reference issued by the MoEFCC are very comprehensive and subjective covering every aspect of project activity and the related environmental issues to be addressed.

7.2 PUBLIC HEARING

Public hearing of the project was conducted on 28th Oct 2006.

Further, in compliance with theToR issued by MoEF&CC,New Delhi, the draft report shall be submitted to the SPCB, Sikkim, for uploading in the website for one month for inviting opinion/suggestion/objection from stakeholder/ public and thereafter forward their views to project proponent for addressing these in the EIA report,before submitting final report to MoEF&CC, New Delhi.

7.3 RISK ASSESSMENT

The project activities involve certain types of hazards, during construction and operation, which can disrupt normal activities abruptly and lead to disaster like fires, failure of machinery, explosion, to name a few. The impending dangers or risks, which need be investigated addressed, disaster management plan formulated with an aim to taking precautionary steps to avert disaster and to take such action after the disaster, which limits the damage to the minimum. Following problem may be encountered during construction at the project site.

- Accidents due to explosives/blasting
- Failure of stripped slope.
- Accidents due to HEMM
- Sabotage in case of magazine

In order to take care of above hazards/disasters, the following safety measures will be strictly complied with in the current project:

- Handling of explosives, charging and blasting shall be carried out by competent persons only.
- Provision of magazine at a safe place with proper fencing and necessary watch and ward. Adequate safety equipment will be provided at magazine and project site.
- Regular maintenance and testing of all project equipment/machinery and transport vehicles as per manufacturers guidelines
- Entry of unauthorized persons will be prohibited.

- Firefighting and first –aid provisions in the project office/complex and project area and ensuring periodic checking of worthiness of firefighting and first aid provision.
- Training and refresher courses for all the employees working in hazardous points. All employees shall have to undergo the training at a regular interval.
- As a part of disaster management plan, a rescue team will be formed by imparting specialized training to select project staff.

7.4 POSSIBLE HAZARDS

There are various factors which singularly and severally can cause disaster in a river valley project. The project activity is associated with many hazards which are discussed in the following sub sections:

7.4.1 Blasting

The accidents from the blasting are mainly manifest as projectiles which some time traverse beyond the danger zone and trespass the project boundary. It is largely due to overcharging of blast holes and also during secondary blasting. During initial and final blasting operations flying rocks are encountered. Ground Vibration caused due to blasting lead to displacement of adjoining areas and result in fallout of loose rock-mass if not properly scaled in earlier blasting cycle. The following measures are suggested to avoid accidents due to blasting:

- All blasting operations shall be supervised by a competent person appointed for the purpose and strictly conducted as per guidelines contained
- Danger zone area falling within a radius of 500m from the blast site shall be demarcated;
- Guards shall be posted at all access points leading to the blast area to prevent and control movement of persons/ stray animal;
- All employees and equipment shall be cleared off the blast area to a safe location prior to any scheduled blasting; and
- Audible signals such as sirens whistles and mikes etc., shall be put to use to caution the workers, passer-by about the scheduled blasting events.

7.4.2 Heavy Machinery

Most of accidents during transport of dumpers, excavators, dozers and other transport vehicles are often attributed to mechanical failures and human errors and can be significantly averted by adapting to following:

- All HEMM and transport vehicle movement within the project area should be carried out under the direct supervision and control of the management;
- All project machinery and vehicles should be periodically maintained and weekly checked by a competent person authorized by the management;
- Conspicuous sign board should be provided at each and every bend for guidance of the operators/drivers during day/night time; and

- To avoid dangers while reversing the trackless vehicles, especially at the embankment and tripping points, all areas for reversing of vehicles should, as far as possible, be made man free, and should be a light and sound device to indicate reversing of trucks/project machinery.

7.4.3 Storage of Explosive

The explosive magazine shall be located outside the project area. For the purpose of transportation of explosives, explosive van shall be deployed. The main hazard associated with the storage, transport and handling of explosives is fire and explosion. The rules as per Indian Explosive Act-1983 and Explosive Rules-2008 should be followed for handling of explosives, which includes transportation, storage and use of explosives.

7.4.4 Fuel Storage

All project machinery will operate on diesel for which no storage point is envisaged in the project area. It will be stored in the central workshop area of the proponent.

7.5 DISASTER MANAGEMENT PLAN DURING CONSTRUCTION

In order to handle disaster/emergency situations, an organizational chart entrusting responsibility to various project personnel will be prepared with their specific roles during emergency.

7.5.1 Planning

- Identification and Prevention of Possible Emergency Situations
- Possible emergency situations can broadly be classified into vehicle collision, and inundation off project area. Some of the ways of preventing emergencies are as follows:
- Preparation of a Preventive Maintenance Schedule Programme and also covering maintenance schedules for all project machinery/equipment and instruments as well as transport vehicles as per recommendations of the manufacturer's user manuals
- Ensuring the compliance of traffic rules strictly along Kuccha roads (haul roads) within the project lease area as well as outside the project lease area.
- Emergent situation arises due to happening of some incident culminating into an abnormal situation. It implies that sufficient time space running from a few seconds to few minutes is always invariably available to arrest an incident of abnormal situation from turning in to an emergency.

7.5.2 Implementation

Following key personnel, identified for carrying out specific and assigned duties in case of any kind of emergency, shall be available on call on holidays and off duty also.

- Project Manager
- Personnel Officer
- Foreman
- Essential workers

7.5.3 Responsibilities of Project Manager

- To take overall charge at the place of incident and activate the Emergency Preparedness Plan according to severity of situation.
- Inform doctor to be ready for treatment of affected employees and intimate their relatives.
- To depute staff, carry out following functions -
- To liaison with district administration and other departments and guide their personnel
- To supervise assembly and evacuation at all points
- To look after patients who are bed ridden and any casualties and give psychological support
- Inform and liaison with project proponent, Police department and District Emergency Authority.
- Arrange for chronological records of emergency to be maintained.
- Issue authorized statements to news media.

7.5.4 Responsibilities of Projects Foreman

- To take immediate charge at the site of incident and ensure that immediate steps as per Emergency Preparedness Plan are taken and immediately inform Projects manager.
- Shall disseminate the information regarding emergency by blowing of siren / hooter.
- Supervise assembly and evacuation as per plan, if required and ensure that casualties are receiving proper medical care.
- Ensure accounting for personnel and rescue of missing persons.
- Control traffic movement in project area.

7.5.5 Responsibilities of Trained Workers

A task force comprising of specially trained staff to act and deliver in the emergency situation shall carry out the following work.

- Fire-fighting and spill control till fire brigade takes the charge and thereafter assist the fire brigade
- Ensuring safety and isolating equipment, materials, urgent repairing or replacement, electrical work etc.
- Controlling movement of equipment, transport vehicles, special vehicle at the project site.
- Extending first - aid and medical help.
- Assistance at casualty's reception areas to record details of casualties

7.6 DISASTER MANAGEMENT PLAN DURING OPERATION

Through through detailed field investigations it has been ensured that the barrage is founded on permeable foundation, designed for suitable seismic design parameters and the spillway has been designed for passing 1195 cumecs discharge, yet in view of that uncertain element of "Force majeure" the eventuality of a disaster caused due to barrage break cannot be ignored but a rescue plan must be devised for confronting such an exigency without being caught in the vast realm of unpreparedness. The barrage break analysis and detailed disaster management plan have been dealt in depth under Environmental Management Plan (Chapter-10).

8 PROJECT BENEFITS

RonnichuHEP envisages utilization of the water of Rongni Chhu, for power generation in a run of river type development. The proposed project will have long term beneficial effect on area, region and the country. The project will lead to infrastructural development in the area which would result in better quality of life for the entire human population of the area. Several such facilities would be created for the benefit and use of general public. Various benefits of the proposed project are described in following sections.

8.1 POWER BENEFITS

The project with a proposed installation of 115 MW would afford an annual design energy generation of 413.78 GWh in a 90% dependable year. It will contribute in reduction in gap between demand and supply of power in the state and country.

8.2 FREE ELECTRICITY TO STATE

As per the norms, 12 % free power of total generation will be given to state, which will help in regular power supply in the area.

8.3 FREE POWER TO LOCAL AREA DEVELOPMENT FUND

The project proponent shallcontribute 1% free power to local area development fund .

8.4 IMPROVEMENT IN SOCIO-ECONOMIC CONDITION

The proposed project will have significant beneficial impacts on social infrastructure of the area. Improved income and employment opportunities for local people during construction and operation phase of the project, will significantly contribute to improvement in social infrastructure. Benefits of the proposed project on social infrastructures in terms of income and amenities/ infrastructure are described in the following paragraphs.

8.5 EMPLOYMENT POTENTIAL

The proposed project will require large number of skilled, semi-skilled and un-skilled manpower during construction and operation phases. The project is likely to be completed in 10 years, during which manpower will be needed to take part in various project activities. These manpower requirements will be mostly met through locals.

Direct and indirect employment opportunities during construction phase will significantly contribute in uplifting quality of life of people of the region. During operation phase also, local people will get employment opportunity in operation, maintenance and auxiliary activities.

8.6 ECONOMIC DEVELOPMENT

Since water is a renewable resource it can be effectively harnessedfor sustainable socio-economic development purposes. The water development planning based on the sustainable development strategy would be necessary for careful exploration and utilization of these natural resources. The development strategy would incorporate and maintain balanced harmony with the prevailing ecosystem. Thus, augmented water supply would play a vital role in the overall economic, social and industrial development in the region.

The activity will also generate employment during construction and operation phases of the project. This will benefit the economy, both national and local levels.

As discussed above, the proposed project would require a large number of workers, officers and other staff. As a result of increased population and with more surplus income at their command, together with enhanced requirements of food grains, vegetables, milk, clothing and other grocery items, there would be a sharp increase in the business activity and turnover of existing businessmen. This would also lead to establishment of new markets and growth of local economy. In addition to the prospering business establishments, there would be requirement of some ancillary local level industry for providing hardware to the project activities, which again would result in upliftment of local economy and better quality of life.

8.7 PHYSICAL INFRASTRUCTURE

The construction of the proposed project will lead to improvement of physical infrastructure such as, roads, communication, transport, education, medical facilities. It will benefit local people leading to improvement of their Quality of Life. Provision of green belt in the periphery of the reservoir, landscaping will enhance the scenic beauty and tourist spots of the area and attract the local and outside tourists.

8.8 TOURISM POTENTIAL: ECOTOURISM

Tourism has the potential of contributing significantly to the economy. Construction of barrage along with other developments like green belt, eco-park, access roads, etc. would add value to the tourism & recreation potential of the area as well as state.

8.9 IMPROVEMENT IN VALUED BIOLOGICAL COMPONENTS

8.9.1 Afforestation

Apart from the Compensatory Afforestation Plan prepared by State Forest Department for Diversion of Forest land for non-forest purpose, which enhances greenery, an Eco- Park in the study area has been proposed in EMP as an ex-situ conservation. The proposed park would act as repositories and would be of special interest for biodiversity conservation, scientific research, education and environmental awareness.

Reservoir rim along both banks is proposed for development by planting trees with tree guards. Simultaneously, area around the reservoir is proposed for development of grass and protecting the area with bunds so that visitors can enjoy the greenery.

Multistoried and multipurpose plantations are proposed to be raised on the muck dumping sites and along road side strips using grasses, shrubs, bushes and trees. Nursery raised grass slips, seedlings of shrubs & bushes and tree species would be planted in the area along with grass sowing in patches. Scenic viewpoints will be created within the reclaimed area for thetourists.

8.9.2 Wildlife Protection

For conservation of wildlife during construction period, anti-poaching camps are proposed, with fully equipped facilities, which will help in the surveillance on illegal poaching of wildlife in the area. Scientific approach through habitat restoration of Endangered/ Scheduled wildlife, will improve conservation value of the revealed species.

8.9.3 Aquaculture Development

Supplementary stocking programmes for the reservoir area and the upstream & downstream of the barrage site during monsoon, will increase fish conservation value of indigenous fish species.

9 ENVIRONMENTAL COST BENEFIT ANALYSIS

After having gone through the various aspects of theproject at the proposed site and the related documents like Form–I and PFR, the MoEF while setting out the scoping clearance and had not recommended any study on Environmental cost benefit analysis.

10 ENVIRONMENTAL MANAGEMENT PLAN

The anticipated impact and mitigation measures have been detailed in the Chapter 4. A site-specific Environmental Management Plan (EMP) has been prepared for avoiding, mitigating, checking the adverse impacts envisaged during EIA studies on various environmental components during construction and operational phase of the project. The environmental management plan covering the following components, as specified in the ToR, has been discussed in following section.

10.1 CATCHMENT AREA TREATMENT PLAN

10.1.1 Introduction

The study of erosion and sediment yield from catchment is of utmost importance as the deposition of sediment in reservoir reduces its capacity, thus affecting the water available for the designated use. The eroded sediment from catchment when deposited on streambeds and banks causes braiding of river reach. The removal of top fertile soil from catchment also adversely affects the agricultural production.

The catchment area treatment involves the understanding of the erosion characteristics of the terrain and suggesting remedial measures to reduce the erosion rate. For this reason, the catchment of the directly draining rivers, streams, tributaries, etc. are treated and the cost is included in the project cost.

Catchment Area Treatment (CAT) plan for the free draining catchment area of the proposed project has been prepared for areas with high soil erosion intensity. The CAT Plan targets towards overall improvement in the environmental conditions of the region. All the activities are aimed at treating the degraded and potential areas with severe soil erosion. The plan provides benefits due to biological and engineering measures and its utility in maintaining the ecosystem health. The plan with objectives addresses issues such as prevention of gully erosion, enhancing the forest cover for increasing soil holding capacity; and arresting total sediment flow in the reservoir and flowing waters.

10.1.2 Objectives

Integrated watershed management plan minimizes the sedimentation of reservoir. The main aim of the Catchment Area Treatment Plan is to rejuvenate various potential and degraded ecosystems in the catchment area for longevity of the reservoir storage capacity.

10.1.3 Catchment Area

Rongni Chhu drains a gross catchment area of about 190 Sq. Km up to the proposed barrage site of which there is no intercepted catchment by Hydro and medium/major irrigation projects.Thus the entire catchment is free draining catchment.

As per Watershed Atlas of India, the free draining catchment area of HEP falls in 13sub-watersheds. The nomenclature of micro-watersheds has been assigned as follows: Brahmputrta Region (3); Brahmaputra right bankuptoLohit Confluence Basin (3A); Teesta to Manas confluence Catchment (3B1); Teesta Upper Sub-Catchment (3A1B); Watershed (3A1B3) and stream Rongni and

Dikchhu.The area under different sub-watersheds is illustrated in **Table 10.1** and the satellite imagery of the free draining catchment is presented in **Figure 10.1** and the sub-watershed location is shown in **Figure 10.2.**

Table 10.1: Basin Characteristics of Different Sub-watershed

S.N.	SWS Code	Area
1	3A1B3(1)	24.94
2	3A1B3(2)	14.44
3	3A1B3(3)	17.46
4	3A1B3(4)	11.80
5	3A1B3(5)	21.40
6	3A1B3(6)	16.45
7	3A1B3(7)	9.55
8	3A1B3(8)	13.97
9	3A1B3(9)	6.49
10	3A1B3(10)	14.66
11	3A1B3(11)	16.61
12	3A1B3(12)	10.26
13	3A1B3(13)	11.97
		190.00

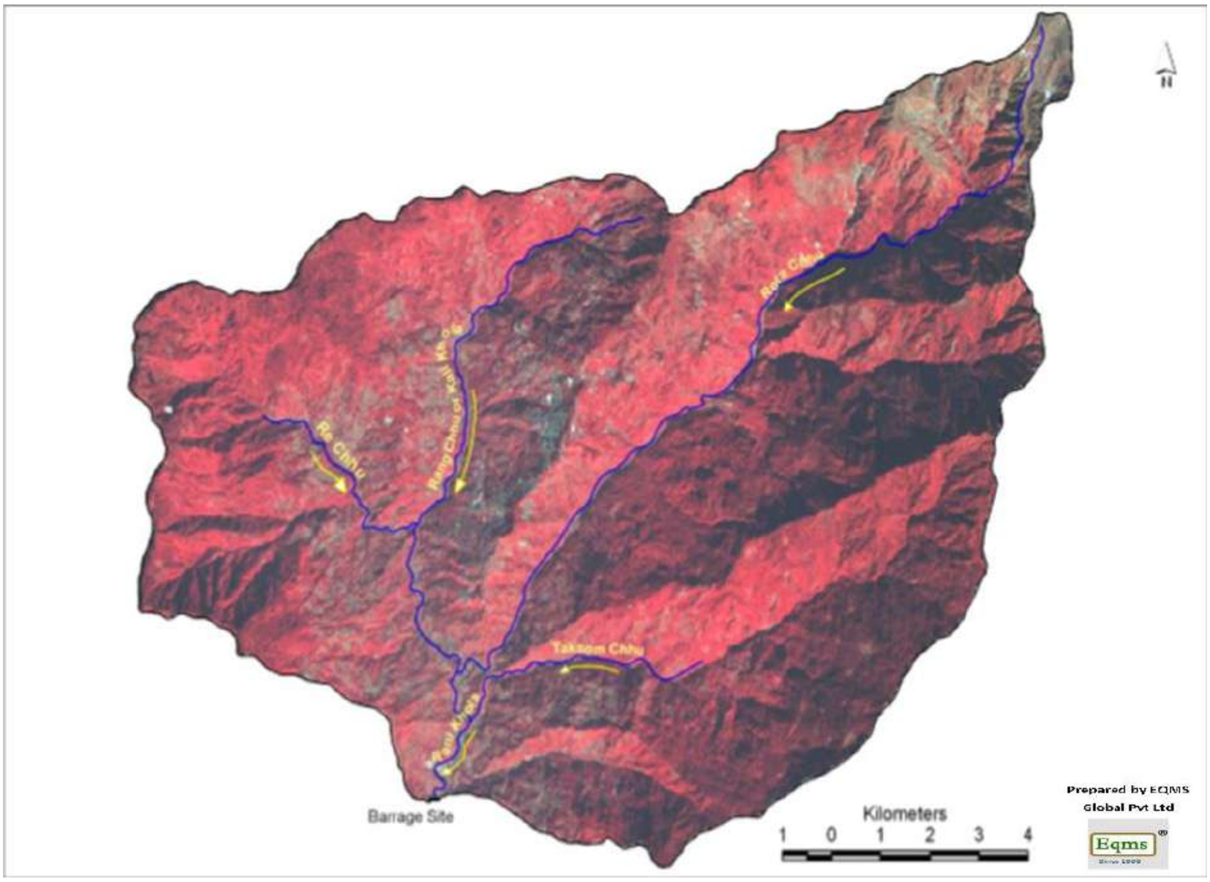


Figure 10.1: : FCC Map of free Draining Catchment Area

10.1.4 Topography

The entire free draining catchment area is mountainous and lies in Himalaya.The topography is highly precipitous, consisting of series of peaks. In upstream of the project flat land/terraces can be seen on the both on right and left riverbanks. The area forms part of the drainage basin of Teesta river.The drainage map of catchment is shown in **Figure 10.3.**

Figure 10.2: Map Showing Location of Sub-watersheds

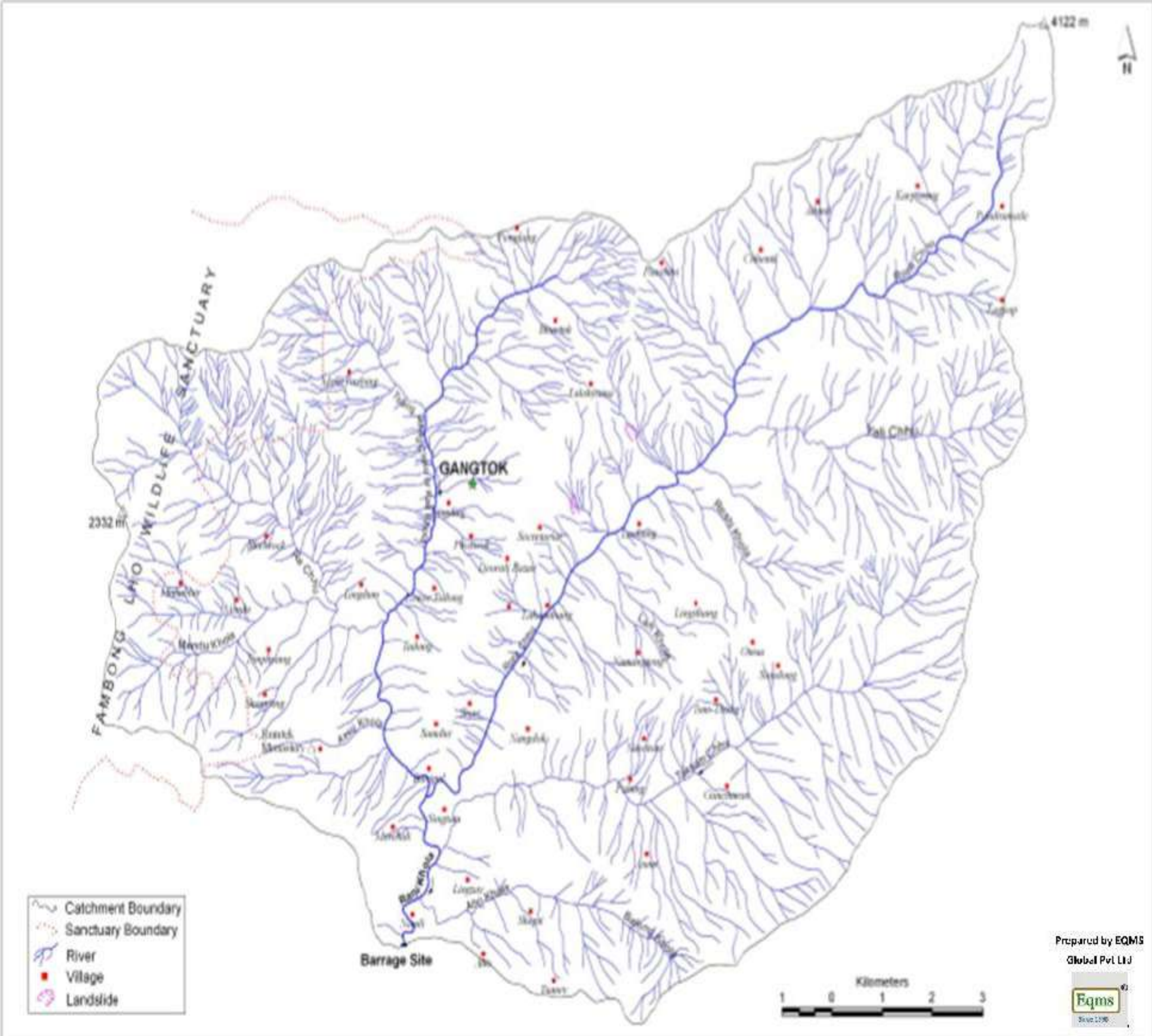


Figure 10.3: Drainage Map of Catchment Area

10.1.5 Soil

Among the soil series Maling-Rayong is predominant in the upper most reaches, contributing 11.01% of the catchment. The nature of the soil is coarse loamy and mixed thermic. This soil series in the upper reaches followed by the Samudar-Khedi-Bhusuk, SajongTarnu, Rongnek-Sajong and Khedi-Dikling series. These series cover about 15.6% of the total catchment area These associations comprise coarse loamy and mixed thermic soils. The Sajong-Tarnu series is suitable for terrace cultivation but susceptible for the erosion. The soil series associations Rumtek-Prik-Mangjing and DaragoanGaucharan-Dharamdin expand from higher reaches to the valleys. The nature of soils is characterized by the coarse loamy and fine loamy and mixed thermic. The soils are good for terrace cultivation. These associations share about 19.3% in the catchment. Mangreg-KarfecterMangjing and Namchi-Synggyang association are predominant in the lower reaches and found along the river course. These series cover about 9.6% of the catchment area. The description of the soil of different units of the free draining catchment is given **Table 10.2.** The soil map is presented in **Figure 10.4.**

Table 10.2: Soil types and their description with Taxonomy

Soil Unit	Description
1	Coarse loamy, mixed thermic, HumicDystrudepts. Maling soils are associated with Rayong soils. Moderately deep, strongly acidic and sandy loam. Required to be area should be kept under forest. However, maize is also grown in some packets with medium yield.
2	Loamy skeletal, mixed thermic, family of Lithic Ustorthents. Associated with the Salem soils. Very shallow, light textured and extremely gravelly. The nutrient status is also poor. However, these soils have the potentiality of supporting a good forest growth
3	Loamy skeletal, mixed thermic, Lithic Udorthents. Associated with the rock outcrops. Soils are very shallow and developed on rocky cliffs. Require preservation to maintain the ecological balance
4	Fine-loamy, mixed thermic, HumicDystrudepts. Associated with the Singrep and Chatten soils. Moderately deep, acidic with low organic carbon content. They have severe limitation of slope. Cultivation with terracing to some extent controls soil erosion
5	Loamy skeletal, mixed thermic, HumicDystrudepts. Associated with the Karporang and Tibik soils. Soils are moderately shallow with fair amount of coarse fragments. Due to topography and soil condition, the areas may be kept under forest
6	Coarse loamy, mixed thermic, family of Typic Udorthents. Associated with the Hilley soils. Moderately shallow, coarse loamy and light textured. The soils are subject to severe erosion and suitable for afforestation programme
7	Coarse loamy, mixed mesic, HumicDystrocryepts. Associated with the Yumthang and Thangu Soils. Soils are developed under isomesic soil temperature and perudic soil moisture regime with a thickness of 36cm of solum. The area is under extensive forest. Indigenous forest species may be introduced in afforestation programme.
8	Coarse loamy, mixed, thermic, typic Udorthents Associated with the Chautare and halumthang soils. Coarse in texture underlined by the weathered parent material, developed on steep slope, severe erosion, high soil acidity, etc. These soils are mostly under open forest, may be used for terrace cultivation.
9	Coarse loamy, mixed, thermic family of Typic Dystrudepts Associated with Tibik, Ruglo and Lingthem soils. Moderately shallow, lighter in texture and poor in water holding capacity and is marginally suitable for maize
10	Coarse-loamy, mixed thermic, Typic Hapludalfs. Associated with the Rorethang and Bhasme soils. Coarse loamy in texture underlined by weathered parent material and are developed on moderately steep slope with severe erosion. These soils are used for terraced cultivation of maize, rice etc.
12	Coarse-loamy, mixed, thermic family of Typic Udorthents. Associated with the Chautare and Chalumthang soils. Coarser in texture developed on steep slope prone to severe erosion, characteristic of open forests
13	Coarse loamy, mixed hyperthermic, Typic Endoaquepts. Associated with the Dharamdin soils. Moderately suitable for maize, rice and wheat. Other agricultural crops like mustards, vegetables, ginger, millets may be grown effectively through proper soil conservation measures
14	Fine loamy, mixed thermic, Fluventic Eutrudepts. Associated with the Lingthse and Karfecter soils. Soils are deep, fine textured with good water holding capacity. Suitable maize cultivation

15	Coarse loamy, mixed hyperthermic, HumicEutrudepts. Associated with the Karfecter and Mangjing soils. Developed on escarpments have been brought under maize and vegetable cultivation. Soil conservation measures must be adopted to arrest soil erosion
16	Fine loamy, mixed thermic, family of HumicHapludalfs. Associated with the Phong and Chautare soils. Fine loamy in texture with high acidity developed on very steep slopes with moderate soil erosion. These soils are mostly under forest and are not suitable for cultivation
22	Coarse loamy, mixed thermic, Enticapludolls. Associated with the Legship and Damthang soils. Soils are coarse loamy, acidic and excessively drained. Proper soil conservation measures and diversification of drainage lines is ssential to protect soils from landslides.
24	Fine loamy, mixed thermic, Typic Argiudolls. Associated with the Khedi and Samdur soils. Soils are deep with high content of clay and organic carbon. Soils are moderately suitable for rice and maize. Adequate soil conservation measures are to be taken to control erosion.
26	Fine, mixed thermic, family of Humic Hapludults. Associated with the Hilley and Khedi soils. Fine textured and developed on granite gneiss with steep slopes, prone to severe erosion hazard, very strong soil acidity and low base status. These soils are moderately to marginally suitable for terraced cultivation
28	Fine-loamy, mixed thermic, HumicEutrudepts. Associated with the Khedi and Bhusuk soils. Fine textured, developed on very steep hill slope and are moderately eroded. These soils are under cultivated for rice, maize through terracing and bunding
30	Fine- loamy, mixed thermic, family of Humic Hapludults. Associated with the Tumin and Pirik soils. Fine- loamy in texture, developed on steeply sloping hill slope from granite gneiss parent material, and are susceptible to erosion. These soils are mostly under forest but can be used for terraced cultivation
32	Loamy skeletal, mixed thermic, HumicDystrudepts. Associated with the Karporang and Tibik soils. Soils are moderately shallow with fair amount of coarse fragments. Due to topography and soil condition, the areas may be kept under forest.
34	Fine- loamy, mixed thermic, family of HumicEutrudepts Associated with the Bhusuk and Singgyang soils. Fine-loamy in texture and are susceptible to erosion due to steep slope and gravely substratum. These soils are mostly under forest and terraced cultivation.
38	Coarse-loamy, mixed, thermic family of HumicDystrudets Associated with the Mangjing and Rumtek soils. Coarse loamy in texture, developed on steeply sloping hills with moderate erosion. These soils are used for terraced cultivation of rice, maize etc
39	Fine- loamy, mixed, thermic family of Typic Eutrudepts. Associated with the Gaucharan andDharamdin soils. Fine loamy in texture and have been developed from granite gneiss parent materials on moderately steeply sloping hill slope, prone to moderate erosion. Suitable for terrace cultivation
40	Fine loamy, mixed thermic, Fluventic Eutrudepts. Associated with the Lingthse and Karfecter soils. Soils are deep, fine textured with good water holding capacity. Suitable maize cultivation
42	Fine- loamy, mixed thermic, family of Humic Hapludults. Associated with the Chongrang and Singgyang soils. Fine loamy in texture and have developed on very steeply sloping hills with strong soil acidity. These soils are mostly under
48	Fine, mixed thermic, Typic Paleudolls. Associated with the Tarnu andSajong soils. Soils are deep and matured. Moderately suitable for maize cultivation with adequate soil conservation measures
50	Coarse-loamy, mixed thermic, family of HumicDystrudepts.Associated with the Chakung and Tarnu soils. Coarse textured and have been developed on granite gneiss with steep slope, prone to severe erosion hazard, very strong soil acidity and low base status. These soils are moderately to marginally

	suitable for terraced cultivation.
52	Coarse-loamy, mixed thermic, family of Typic Hapludalfs. Associated with the Maniram and Rongnek soils. Coarse in texture that are underlined by weathered parent material, developed on steep slopes with moderate erosion. Susceptible to mass movement/ landslide. These are mostly under rice cultivation and open forest.
54	Coarse-loamy, mixed thermic, family of Typic Udorthents. Associated with the Khedi and Sajong soils. Coarse textured underlined by weathered parent material, susceptible to erosion due to steep slope. These soils are mostly under forest.
56	Coarse-loamy, mixed thermic, family of Typic Hapludalfs. Associated with the Maniram and Rongnek soils. Coarse in texture that are underlined by weathered parent material, developed on steep slopes with moderate erosion. Susceptible to mass movement/ landslide. These are mostly under rice cultivation and open forest.
58	Coarse loamy, mixed thermic, family of Typic Udorthents. Associated soils :Goucharan soils. Moderately deep, light textured soils, poor in nutrient contents. Suitable for the forestry operations

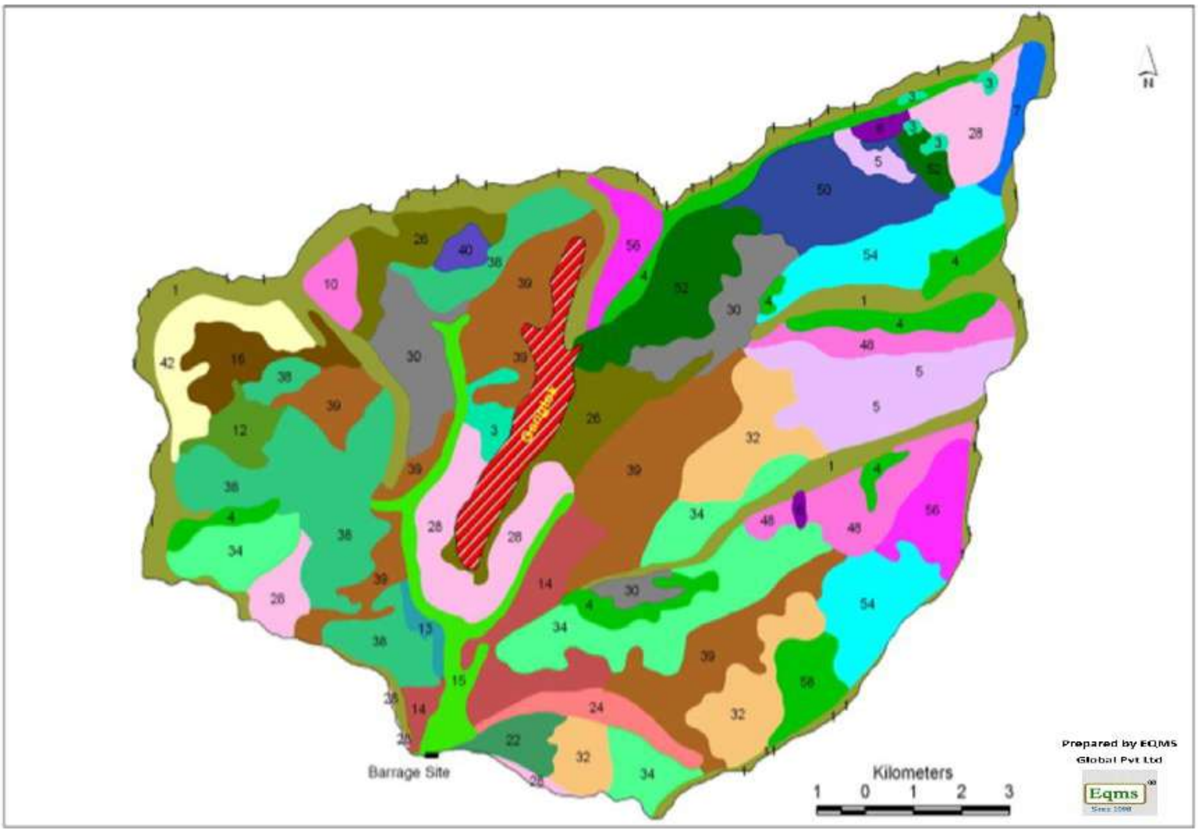


Figure 10.4: Soil Map of the Free Draining Catchment

10.1.6 Land use

Based on satellite data and topo-sheets, a land-use map has been prepared and will be verified in detail during ground surveys i.e. cross checked with ground truths. Dense Forest covers around 18.44% of the free draining catchment area, while,Open Forest covers around 29.77%. Scrubcovers around 25.37.Grassland/meadows cover around 1.26% of the free draining catchment area.

Agricultural land and settlement cover around 22.08% andmoraiescover 0.2% of the free draining catchment area. The Land use/ Land-cover map of the free draining catchment area is presented in **Figure 10.5** and its details are presented in **Table 10.3**.

Table 10.3: Land use/Land Cover Details of Free Draining Catchment

Land use/ Landcover Class	Area (ha)	Area (%)
Dense Forest	3503.73	18.44
Open Forest	5657.07	29.77
Scrub	4820.93	25.37
Alpine meadows	240.22	1.26
Agricultural Land/ Settlement	4195.50	22.08
Barren/Rocky land	545.21	2.87
Moraines	37.34	0.20
	19000.00	**100.00**

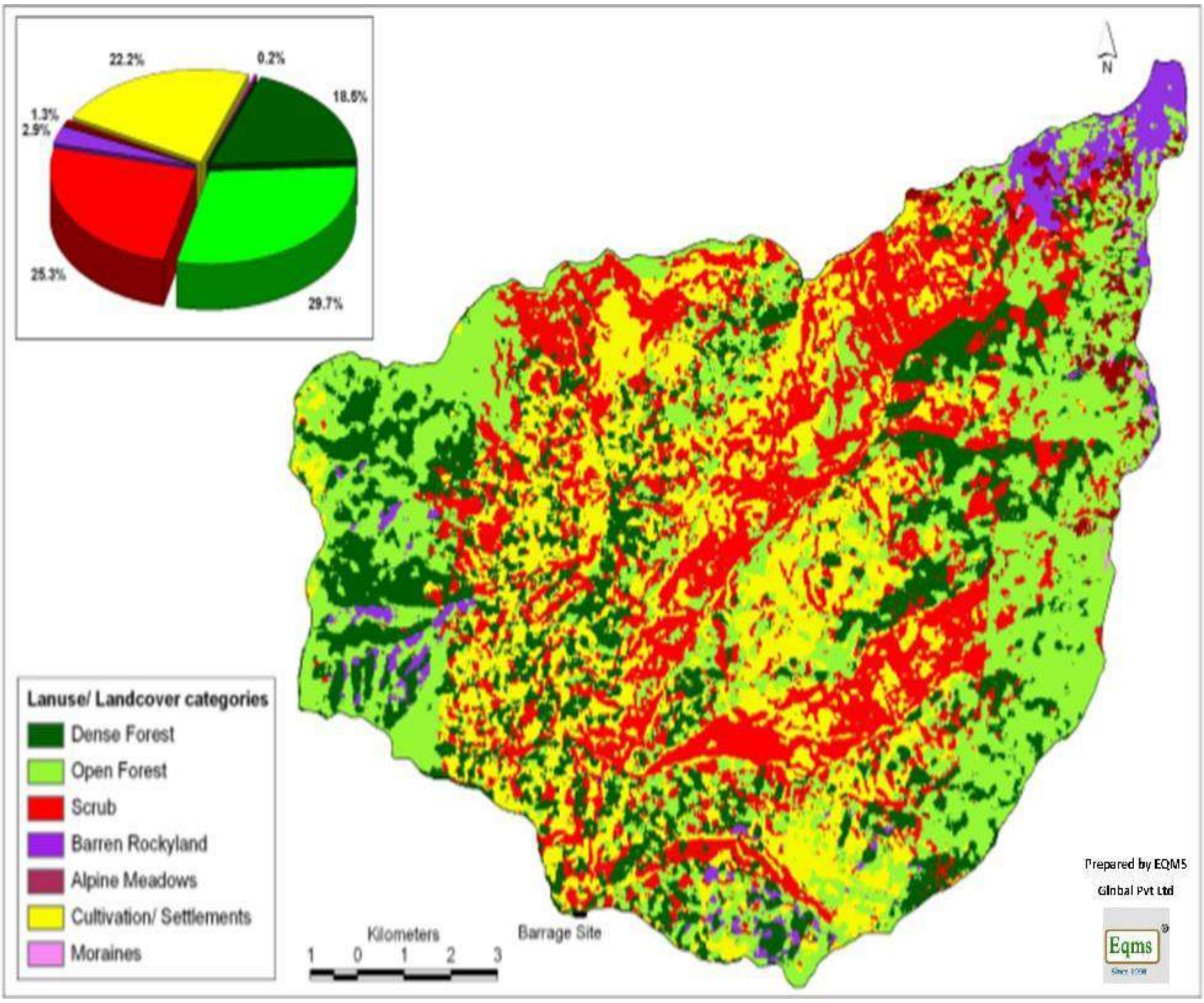


Figure 10.5: Land Use Map of the Free Draining Catchment

10.1.7 Slope

The slope of a watershed plays an important role in controlling the soil and water retention thereby affecting the land-use capability. The percentage of the slope in a watershed determines the soil erosion susceptibility and forms the basis for classifying different of the watershed into suitable classes for formulating effective soil erosion conservation measures. Broadly, the following slope classes and ranges **(Table 10.4)** as per norms of All India Soil & Land Use Survey were adopted to classify the slopes for the present study.However, for the present studies the slope classes A-C were merged into one single class i.e., area under 0-5% slope range has been described as gently sloping as the project area is hilly.

Table 10.4: Slope Ranges and Description

S. No	Slope Range (Degrees)	Description
1	0-2	Gently sloping
2	2-18	Moderately sloping
3	8-15	Strongly sloping
4	15-30	Moderately steep
5	30-50	Steep
6	50-70	Very steep
7	>70	Escarpments

However, for the present studies the slope classes A-C were merged into one single class i.e., area under 0-5% slope range has been described as gently sloping as the project area is hilly.The Slope map of the free draining catchment is presented in **Figure 10.6** and slope details are as presented under **Table 10.5.**

Table 10.5: Area Under Different Slope Categories

S.N.	Slope Category	Area (ha)	Percentage area
1	Gently sloping	450.07	2.37
2	Moderately sloping	328.93	1.73
3	Strongly sloping	1016.43	5.35
4	Moderately steep	7768.23	40.89
5	Steep	8628.63	45.41
6	Very steep	807.53	4.25
7	Escarpments	0.19	0.00
Total		**19000.00**	**100.00**

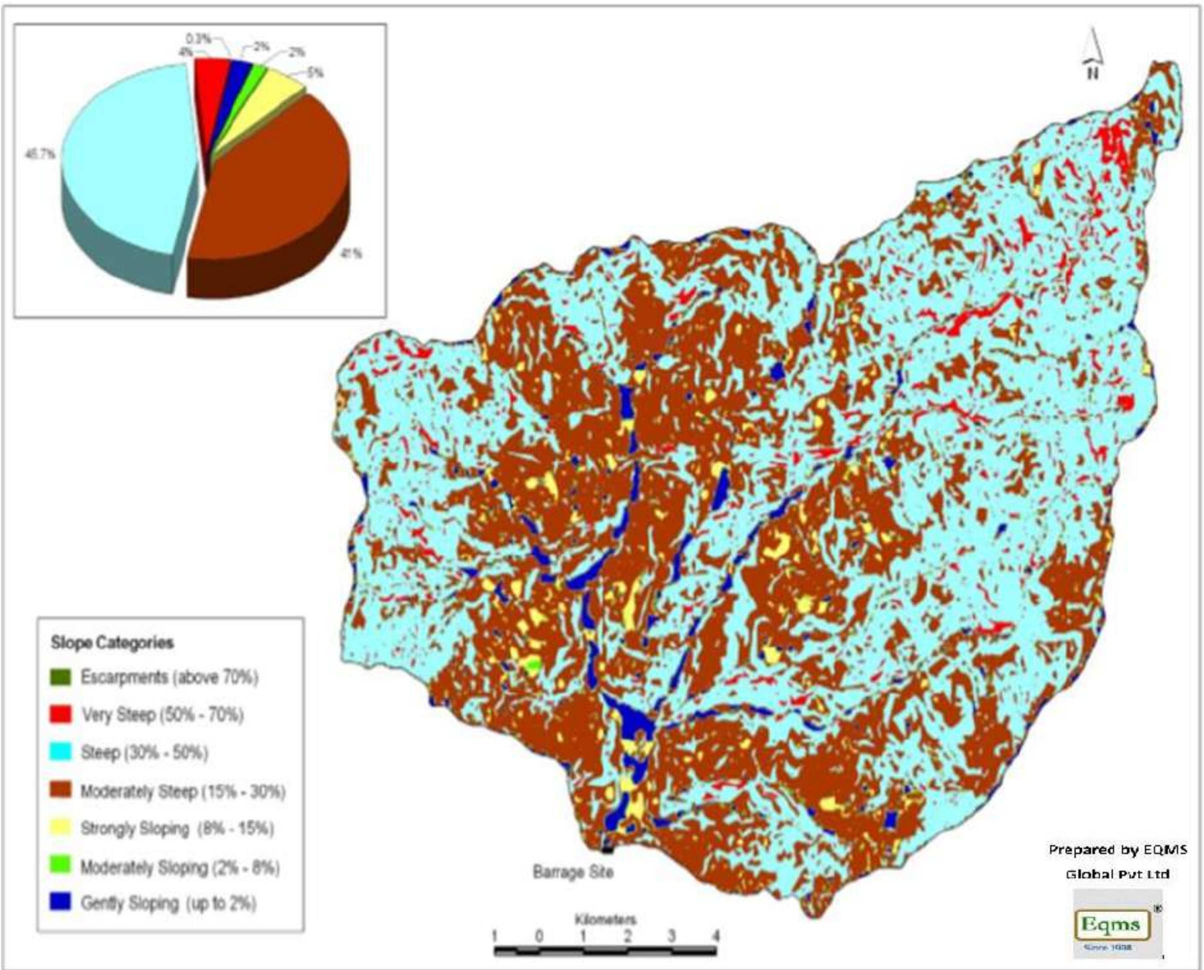


Figure 10.6: Slope Map of Free Draining Catchment

10.1.8 Methodology Used for Study

Superimposing topography, slope, soil and land use data/maps, a tentative estimation of erosion prone areas and landslides area in the catchment were made. The vulnerable and problematic areas were identified in different physiographic zones. These data sets were used for preparation of the thematic maps, calculation of sediment yield index and Erosion Intensity Units.

10.1.9 Soil Erosion

There are mainly five categories of Land uses for which a proper treatment plan should be developed. First is the Agricultural Land, as this activity can never be eliminated, because the faulty practice results in heavy loss of fertile soil. Second, being open forestland for obvious conservation reasons. Third is scrub or degraded land, which contributes heavily to the silt load and possibilities exist to bring this area under pastures and other plantation to meet the local demand of fuel and fodder and thus decreasing the biotic pressure on the forests and leading to environment friendly approach of sustainable development. The fourth and most important category is Barren land because with practically no vegetal cover, the area produces huge amount of silt load. The fifth is dense forest land where in a few places soil conservation measures are required. For treatment of catchment area, the areas that require treatment have been delineated from the Composite Erosion

Intensity Unit Map. The sum of weightages was reclassified as pe **Table 10.6** to further subdivide the area as per the erosion intensity classes. The weightages for Land use, Slope & Soil were summed to get the Erosion Intensity Classes.

Table 10.6: Erosion Intensity & Weightages

Erosion Intensity Class	Sum of weightages
Very severe (E5)	12 to 14
Severe (E4)	9 to 11
Moderate (E3)	6 to 8
Slight (E2)	4 to 5
Negligible (E1)	0 to 3

Considering the topographic factors, soil type, climate, land-use/land-cover in the catchment area following engineering and biological measures have been proposed to be undertaken with the aim to check the soil erosion, prevent/check siltation of reservoir and to maintain its storage capacity in the long run. The Erosion Intensity Map of the free draining catchment has been generated based on SYI data and is presented in **Figure 10.7** and the statistics are presented in **Table 10.7.**

Table 10.7: Area (ha) Under Different Erosion Intensity Categories

Erosion Class	SWS-1	SWS-2	SWS-3	SWS-4	SWS-5	SWS-6	SWS-7	SWS-8	SWS-9	SWS10	SWS11	SWS12	SWS13
V.Severe	10.76	1.10	0.96	0.05	1.06	0.02	0.00	0.00	0.00	0.46	1.14	0.03	0.00
Severe	1492.66	661.3	808.39	836.48	868.5	851.53	357.95	713.27	248.01	553.25	352.56	150.14	558.72
Moderate	901.70	674.15	783.89	176.17	1099.15	656.57	490.93	476.66	346.55	468.26	1166.63	776.11	493.66
Slight	28.46	17.96	45.66	15.29	38.78	35.36	46.16	26.63	14.10	67.45	39.45	36.81	70.63
W.B.	59.42	89.49	104.10	148.01	127.51	95.52	52.96	172.44	31.34	366.58	90.22	50.91	60.99
TOTAL	2494	1444	1746	1180	2140	1645	955	1397	649	1466	1661	1026	1197

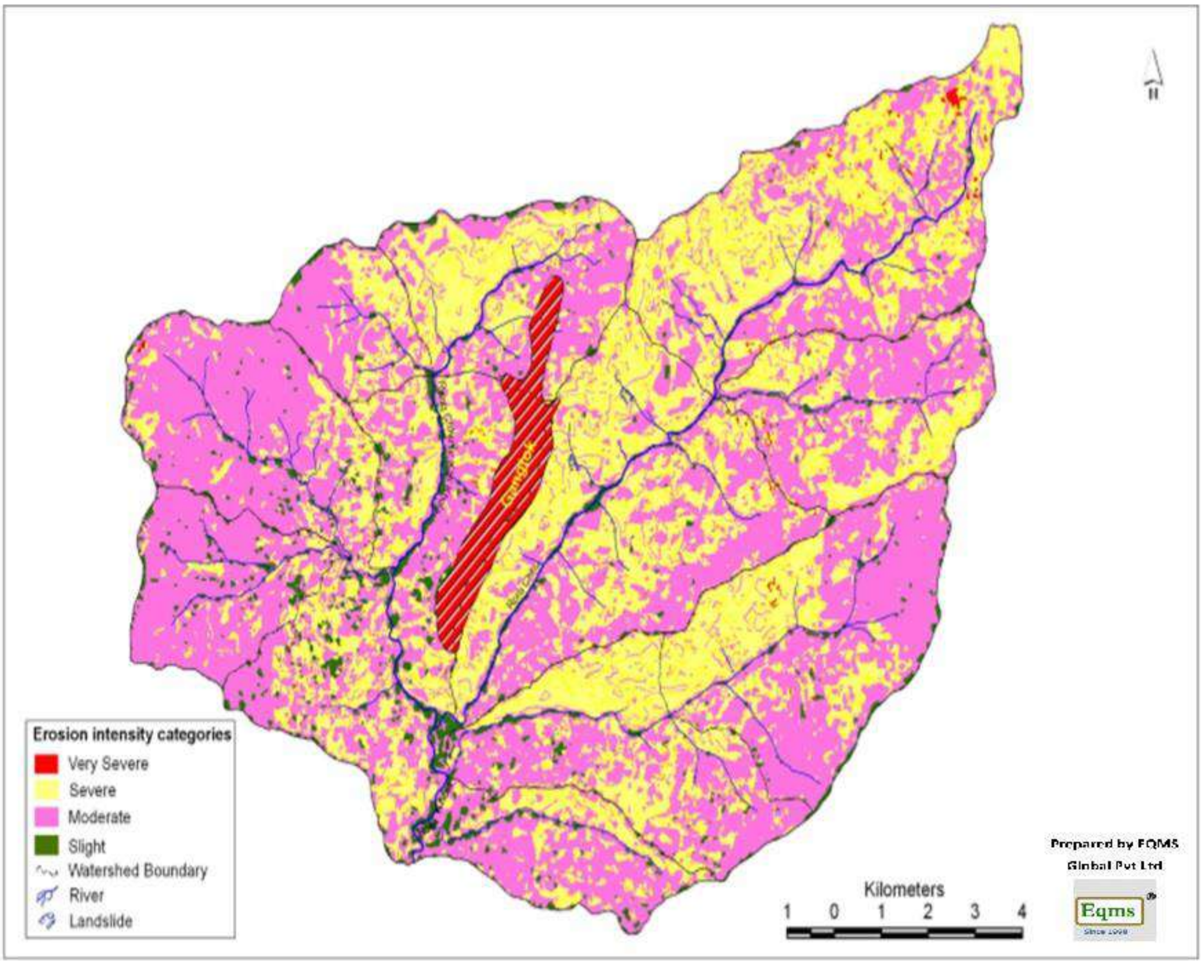


Figure 10.7: Erosion Intensity Map of Free Draining Catchment Area

10.1.10 Prioritization of Micro-Watersheds Using Silt Yield Index Method

`Silt Yield Index' (SYI), method has been used for prioritization of micro watersheds in the catchment for treatment. The Silt Yield Index (SYI) is defined as the Yield per unit area and SYI value for hydrologic unit is obtained by taking the weighted arithmetic mean over the entire area of the hydrologic unit by using suitable empirical equation. The Silt Yield Index Model (SYI) considers sedimentation as product of erosivity, morphometry and delivery ratio of a particular sub-watershed and was conceptualized by Soil and Land Use Survey of India (SLUSI) as early as 1969 and has been operational since then to meet the requirements of prioritization of smaller hydrologic units within river valley project catchment areas. Silt yield index (SYI) was calculated using following empirical formula:

SYI = (Ai x Wi x Di) x 100/Aw; where I = 1 to n

Where

Ai = Area of ith (EIMU)

Wi = Weightage value of ith mapping unit

Di = Delivery ratio

n = No. of mapping units

Aw = Total area of sub-watershed

10.1.10.1 Erosion Intensity Mapping Unit

Erosion Intensity Mapping Units (EIMU) are demarcated and defined as per the soil erosion intensity map prepared above. Various EIMU categories, such as Very Severe, Severe, Moderate, Low, Very Low, and Negligible & Slight (clubbed together), were then used to calculate sub-watershed-wise SYI. Erosion Intensity Mapping Units (EIMU) is a composite expression of physiography, land use, and conservation practices adopted. While computing soil erosion intensity in a catchment all the factors (physiography, land use, and conservation practices) are already taken into consideration. Therefore, EIMUs are assumed as per the soil erosion intensity in the micro-watershed.

10.1.10.2 Weightage Value

Each erosion intensity unit is assigned a weightage value. When considered collectively, the weightage value represents approximately the comparative erosion intensity. A basic factor of K = 10 was used in determining the weightage values. The value of 10 indicates a static condition of equilibrium between erosion and deposition. Any addition to the factor K (10+X) is suggestive of erosion in ascending order whereas subtraction, i.e. (10-X) is indicative of deposition possibilities. The weightage value assigned to erosion mapping unit in a sub-watershed range from 11-20.

10.1.10.3 Delivery Ratio

Delivery ratios were adjusted for each of the erosion intensity unit. The delivery ratio suggests the percentage of eroded material that finally finds entry into reservoir or river/ stream. Delivery ratios are assigned to all erosion intensity units depending upon their distance from the nearest stream. The criteria adopted for assigning the delivery ratio are as in **Table 10.8.**

Table 10.8: Delivery Ratio (DR) Criteria

Nearest Stream	Delivery Ratio (DR)
0-0.9 km	1.00
1.0-2.0 km	0.95
2.1-5.0 km	0.90
5.1-15.0 km	0.80
15.1-30.0 km	0.70

10.1.10.4 SYI Classificationfor Prioritization of Sub-watersheds

The criteria followed for priority categorization of sub-watersheds depending upon their SYI values is given in **Table 10.9.**

Table 10.9: SYI Criteria of Categorization

Priority categories	SYI Values
Very high	> 1300
High	1200-1299

Priority categories	SYI Values
Medium	1100-1199
Low	1000-1099
Very Low	<1000

10.1.10.5 Silt Yield Index

The area of each of the mapping units is computed and silt yield indices of individual micro-watersheds are calculated using the equations mentioned above. The SYI values for classification of various categories of erosion intensity rates are given in **Table 10.10**.

Table 10.10: SYI and Priority Rating as per Erosion Intensity

Sub-watershed code	Erosion intensity	Area (ha)	Weightage	Area x weightage	Delivery ratio	Gross silt yield	Sediment yield index	Priority
3A1B3(1)	V.Severe	10.7	16	171.2	0.9	154.08	1118	Medium
	Severe	1492.66	14	20897.24	0.9	18807.52		
	Moderate	901.7	10	9017	0.9	8115.3		
	Slight	28.46	5	142.3	0.9	128.07		
Total		2433.52		0		27204.97		
3A1B3(2)	V.Severe	1.1	16	17.6	0.9	15.84	1070	Low
	Severe	661.3	14	9258.2	0.9	8332.38		
	Moderate	674.15	10	6741.5	0.9	6067.35		
	Slight	17.96	5	89.8	0.9	80.82		
Total		1354.51		0		14496.39		
3A1B3(3)	V.Severe	0.96	16	15.36	0.9	13.824	1065	Low
	Severe	808.39	14	11317.46	0.9	10185.71		
	Moderate	783.89	10	7838.9	0.9	7055.01		
	Slight	45.66	5	228.3	0.9	205.47		
Total		1638.9		0		17460.02		
3A1B3(4)	V.Severe	0.05	16	0.8	0.9	0.72	1186	Medium
	Severe	836.48	14	11710.72	0.9	10539.65		
	Moderate	176.17	10	1761.7	0.9	1585.53		
	Slight	15.29	5	76.45	0.9	68.805		
Total		1027.99		0		12194.7		
3A1B3(5)	V.Severe	1.06	16	16.96	0.9	15.264	1047	Low
	Severe	868.5	14	12159	0.9	10943.1		
	Moderate	1099.15	10	10991.5	0.9	9892.35		
	Slight	38.78	5	193.9	0.9	174.51		
Total		2007.49		0		21025.22		
3A1B3(6)	V.Severe	0.02	16	0.32	0.9	0.288	1088	Low
	Severe	851.53	14	11921.42	0.9	10729.28		
	Moderate	656.57	10	6565.7	0.9	5909.13		

	Slight	35.36	5	176.8	0.9	159.12		
Total		1543.48		0		16797.82		
3A1B3(7)	V.Severe	0	16	0	0.9	0	1021.	Low
	Severe	357.95	14	5011.3	0.9	4510.17		
	Moderate	490.93	10	4909.3	0.9	4418.37		
	Slight	46.16	5	230.8	0.9	207.72		
Total		895.04		0		9136.26		
3A1B3(8)	V.Severe	0	16	0	0.9	0	1101	Medium
	Severe	713.27	14	9985.78	0.9	8987.202		
	Moderate	476.66	10	4766.6	0.9	4289.94		
	Slight	26.63	5	133.15	0.9	119.835		
Total		1216.56		0		13396.98		
3A1B3(9)	V.Severe	0	16	0	0.9	0	1036	Low
	Severe	248.01	14	3472.14	0.9	3124.926		
	Moderate	346.55	10	3465.5	0.9	3118.95		
	Slight	14.1	5	70.5	0.9	63.45		
Total		608.66		0		6307.326		
3A1B3(10)	V.Severe	0.46	16	7.36	0.9	6.624	1055	Low
	Severe	553.25	14	7745.5	0.9	6970.95		
	Moderate	468.26	10	4682.6	0.9	4214.34		
	Slight	67.45	5	337.25	0.9	303.525		
Total		1089.42		0		11495.44		
3A1B3(11)	V.Severe	1.14	16	18.24	0.9	16.416	970	V.Low
	Severe	352.56	14	4935.84	0.9	4442.256		
	Moderate	1166.63	10	11666.3	0.9	10499.67		
	Slight	39.45	5	197.25	0.9	177.525		
Total		1559.78		0		15135.87		
3A1B3(12)	V.Severe	0.03	16	0.48	0.9	0.432	939	V.Low
	Severe	150.14	14	2101.96	0.9	1891.764		
	Moderate	776.11	10	7761.1	0.9	6984.99		
	Slight	36.81	5	184.05	0.9	165.645		
Total		963.09		0		9042.831		
3A1B3(13)	V.Severe	0	16	0	0.9	0	1051	Low
	Severe	558.72	14	7822.08	0.9	7039.872		
	Moderate	493.66	10	4936.6	0.9	4442.94		
	Slight	70.63	5	353.15	0.9	317.835		
Total		1123.01		0		11800.65		

10.1.11 Treatment of Individual Micro-Watershed

There are mainly five categories of land uses for which a proper treatment plan should be developed. First is the agricultural land as this activity can never be eliminated. And, agriculture activities, if faulty, result in heavy loss of fertile soil. Second, is open forest land for conservation reasons Third is scrub or degraded land, which contributes heavily to silt load. Possibilities exist to bring this area under pastures and plantation to meet local demand of fuel and fodder and thus decreasing the biotic pressure on the forests leading to environment friendly approach of sustainable development. The fourth and most important category is barren land because with practically no vegetal cover the area produces huge amount of silt load. The fifth is dense forest land where at few places soil conservation measures are required.

Areas falling under very severe and severe erosion intensity category would be taken up for conservation treatment measures after excluding the percentage of area above 50^0 slopes from the area coming under very severe and severe erosion intensity class falling under rocks and inaccessible terrain where no treatment is feasible, the rest of area of very severe and severe categories is to be treated with biological, bio-engineering and engineering measures under CAT Plan. In the present case, an area of 2071 ha has been proposed to be treated under biological measures besides engineering measures.

10.1.11.1 Activities to be Undertaken under Biological Measures

Afforestation

In critically degraded areas, plantation of locally useful diverse and indigenous plant species such as timber plantation species, fodder species, fuel wood species, grasses, shrubs and legumes, medicinal and aromatic plants would be undertaken. The forestation will include rising of multi-tier mixed vegetation of suitable local species in the steep and sensitive catchment areas of rivers/streams with the objective of keeping such areas under permanent vegetative cover. Furthermore, degraded areas would also be brought under vegetation cover. Suitable trees of economic value to local people shall be raised in the degraded forest areas near to villages with the objective of supplementing income of the villagers. In critically degraded areas, plantation of locally useful, diverse and indigenous plant species such as *Alnusnepalensis*, *Albiziaodoratissima*, *Schimawallichii, Prunus cerasoides*, etc. would be undertaken.

While effort is to raise a mixture of conifer and broad-leaved species so far as practical however choice of species might change at the time of actual implementation. 1500 plants per hectare will be planted under this scheme. Planting will be done in pits. Earth work should be done well in advance. Plants should be healthy with strong stems. Planting should be done in June when the water supply starts. The plantation will be maintained for subsequent seven years. RCC fence posts with 4 strand barbed wire fencing, interlaced with thorny bushes will be done in the plantation areas. A total of 462 ha area has been identified as available for tackling under this scheme

Natural Regenaration

There are a few locations within forest in the catchment area where the crown density is poor.At such patchesstone wall 120 cm high and 45 cm wide or 4 strand barbed wire fencing would be erected during first year along with soil working. The cooperation of local villagers would be sought for the success of the plantation programmes.

Weeding, hoeing and mulching would be carried out during October-November. Weeding and loosening of soil by hoeing breaks the capillary action in soil and thus reduces the moisture loss. Mulching reduces evaporation and conserves soil moisture and adds humus to soil. Cut and uprooted weeds and grasses used as mulching material would be spread in the `thawla' around the plant.

NTFP Regenaration

Sikkim Forest Divisions are rich in a variety of non-timber forest produce. However, in past uninhibited exploitation of NTFP has led to depletion of this valuable resource. Therefore, in order to augment natural stock of NTFP in the forests, it is proposed to take up planting of NTFP and establishing their nursery. An outlay of Rs.48.30 lacs @ Rs.74,745/- per ha has been made to cover about 68 ha for creation (Rs.33.66 lakh) and its maintenance (Rs.14.64 lakh) for three year

Treatment of Active Landslide

Active landslides and areas prone to landslides require extensive treatment measures to stabilize them. If these landslides are not taken up for treatment they shall contribute to greater siltation of reservoir apart from damaging agricultural lands and human habitation. For the control of landslides, about 1430 running meters (Rmt) of catchwater drains would be constructed in the landslide prone areas in different sub-watersheds. An amount of Rs.25.00 lakh (@ Rs.1,750/- per Rmt) has been proposed for treatment of some of the active landslides under CAT plan.

Assisted Natural Regeneration

In some forest areas, conditions are conducive to natural regeneration provided some sort of assistance is provided. Such area shall be taken up under this component. The areas shall be closed to reduce biotic interference. Forest floor will be cleared of slash, debris and felling refuse to afford a clean seed bed to the falling seed. At certain places some soil raking may also have to be done to facilitate germination of seeds. Where natural regeneration is found deficient. It will be supplemented by artificial planting. Patch sowing in suitable areas may also be done. Bush cutting & cleaning operations are done depending on necessity. Up to 800 plant or patches per hectare will be planted /sown to hasten the process of regeneration in the area uniformly. An outlay of Rs.85.37 lakh @ 25,790/- per ha has been made to cover 335 ha of open forests for creation (Rs.63.01 lakh) and its maintenance (Rs.22.36 lakh) up to 3 years.

Development of Medicinal Plants

One of the major factors impacting the effective conservation of forests is the dependence of rural communities on the forest biomass resources for meeting their fuel, fodder, small timber and other livelihood needs. While schemes to augment availability of fuel wood, fodder, small timber have attracted much attention, the need to address the livelihood issue by encouraging forest-based enterprise has not received the desired attention. Propagation of medicinal plants is an innovative land use strategy to address the livelihood issues of local people on sustainable basis as it provides alternative income generation activity. Moreover, this will help in in-situ conservation of medicinal plants. With this purpose, medicinal herbs will be propagated under this component. 13200 plants per ha will be raised in the selected areas. The plants can be raised as intercrop in the other plantation areas taken for tree plantation. Trees can be planted as intercrop in the areas suggested for assisted natural regeneration. The plantation areas will be fenced with barbed wire fencing on wooden fence posts. The plantation will be maintained for subsequent seven years.

Nursery Management

The catchment area harbors a large variety of medicinal plants, some of these medicinal plants are under rare and threatened category due to large scale unscientific collection. The depletion of such important repource has been a major concern from ethno-herbal treatment as well as biodiversity conservation point of view. Therefore, in situ and ex-situ conservation of various medicinal plants would be undertaken under the CAT plan. For taking up various activities like afforestation, assisted natural regeneration, NTFP/medicinal plants etc., 3 to 4 new nurseries will be created besides existing one. An amount of Rs. 10.00 lakh has been kept for this activit

Forest Infrastructure Development

For an efficient management of forest resources, it is essential that field infrastructure of the Forest Department is adequately developed. The terrain being very tough, there is a need to improve the existing forest roads and paths. However, no jeepable road would be constructed in the catchment area as this would lead to increased siltation. Only bridle paths, inspection paths and footbridges shall be constructed or improved for which an amount of Rs.17.80 lacs has been kept. Similarly, in remote localities of the Forest divisions there are no places for shelter for the staff, people and trekkers. Therefore, following provisions be made under the CAT Plan.

Activities to be Undertaken under Engineering Measures

Engineering measures are more effective in conserving soil and water when they are supplemented by vegetative methods. But in certain situations, only engineering measures can be proposed. Various engineering measures have been suggested for flood prone nalas, landslides/ landslips, treatment of nalas and soil and water conservation in forest area in the free draining catchment area.

- **Brush wood Check Dams and Retaining Walls**

Brushes wood check dams are useful in arresting further erosion of depressions, channels, and gullies on the denuded landslides. In addition, retaining walls of stone masonry and RCC would be constructed to provide support at the base of threatened slopes.

- **Slope Modification by Stepping or Terracing**

The slope stability increases considerably by grading it. The construction of steps or terraces to reduce the slope gradient is one of the measures.

- **Bench Terracing**

The area under moderately steep slope i.e. between 100-150slopes would be subjected to bench terracing. The local people would be convinced to follow this type of terracing for comparatively better yield and with minimum threat to erosion. Moreover, in several habitations in the catchment such practices are already visible. While making bench terraces, care must be taken not to disturb the topsoil by spreading earth from the lower terraces to higher terraces. The vertical intervals between terraces will not be more than 1.5m and cutting depth may be kept at 50 cm. The minimum average width of the terrace would be kept from 4 to 5 m to enable usage of prolong hinge. The shoulder bunds of 30 x 15 cm would also be provided. Staggered channels will drain off the excess water from the terraces.

- **Gully Control-Check Dams**

Gullies are mainly formed because physiographic, soil type, and heavy biotic interference in an area. The scouring of streams at their peak flows and sediment-laden run-off cause gullies. The gullies would be required to be treated with engineering/mechanical as well as vegetative methods. Check dams would be constructed in some of the areas to promote growth of vegetation that will consequently lead to the stabilization of slopes/area and prevention of further deepening of gullies and erosion. Different types of check dams would be required for different conditions comprising of different materials depending upon the site conditions and the easy availability of material (stones) at local level and transport accessibility. Generally, brush wood check dams are recommended to control the erosion in the first order basin/streams in upper reaches and dry random stone masonry check dam shall be provided in the lower reaches where discharge is higher. In such stream where discharge and velocity of flow are still higher gabion structure shall be provided. Lower down the sub-watershed, i.e., in the third order drainage silt retention dams in the form of gabion structure shall be provided.

- **Stream bank Protection**

Stream bank erosion is caused by variety of reasons such as destruction of vegetative cover, mass movement on unstable bank slopes, undermining of top portion of lower bank by turbulent flow and sliding of slopes when saturated with water. The Stream Bank Protection would include wire crate boulder spurs in two to three tiers depending upon the high flood level of the streams.

- **Contour Staggered Trenches**

Contour staggered trenches are mainly provided to trap the silt and runoff. This is also done to prepare a fertile base for plantation, in moderately steep to very, very steep slopes.

- **Landslide Control**

Rainfall pattern of the area and water seepage coupled with geological formation results in landslides. Water plays an important role in triggering of landslides and mass wasting processes along with other factors such as slope and nature of soil/land-cover/land-use. However, most of the landslides are caused by human negligence. Road construction, overgrazing of hill slopes, felling of trees for timber, fuel, and fodder and upslope extension of cultivation are some of main causes of landslides. Gabion structures shall be provided at the base of the land slide zones to control the toe erosion by water.

- **Catch-water Drains**

Among the most effective, practical and least expensive measures of landslide hazard management is construction of catch-water drains for run-off and surface waters in the identified hazard-prone zone so that little or no water can infiltrate into the ground. All the streams and minor watercourses would be diverted around the crown of the slide or the potentially hazardous area through catch water drains with an adequate gradient. The catch water drains when provided avoids runoff to pass over such vulnerable areas and water is guided through these drains provided on foothill or along the katcha/pucca roads. The ground surface of threatened area is leveled out to eliminate all depressions where water can accumulate.

10.1.12 Analysis of Rates for Treatment Measures

The analysis of rates for biological and engineering measures is presented in following sub paragraphs

10.1.12.1 Per Hectare Analysis of Rates for Biological Treatment Measures

Table 10.11: Per Hectare Analysis of Rates for Biological Measures

S.N.	Component	Amount (Rs)
1	**Afforestation**	
(i)	Fencing and Plantation	27000.00
(2)	Maintenance	
(i)	First Year	4400.00
(ii)	Second Year	3400.00
(iii)	Third Year	2600.00
	Sub Total (B)	10400.00
	Total (A)+(B)	**37400.00**
2	**Assited Natural Regenaration**	
(i)	Fencing and Plantation	18810.00
(2)	Maintenance	
(i)	First Year	2900.00
(ii)	Second Year	2270.00
(iii)	Third Year	1770.00
	Sub Total (B)	6980.00
	Total (A)+(B)	**25790.00**
3	**NTFP**	
(i)	Fencing and Plantation	49500.00
(2)	Maintenance	
(i)	First Year	8415.00
(ii)	Second Year	8415.00
(iii)	Third Year	8415.00
	Sub Total (B)	25245.00
	Total (A)+(B)	**74745.00**

10.1.12.2 Analysis of Rates for Engineering Treatment Measures

Table 10.12: Analysis of Rates for Engineering Measures

S.N.	Particular	Unit	Qty.	Rate	Amount
1	Brush Wood Check Dam				
(i)	Supply of brushwood material with 40 bundles in two layers	Nos.	40	15	600.00
(ii)	Cost of wooden poles of 6' length and 15cm diameter	Nos.	12		300.00
(iii)	Labour charges for laying of brushwood in spur and fixing	Man	4	50	200.00
	Total (i)+(ii)+(iii)				1100.00
	Add 25% for hilly areas				275.00
	Cost per Structure				**1375.00**
2	DRSM Check Dams (8mx1.5mx2m),considering 12/5ha				
(i)	Cost of Stone/boulder and labour charges	cum	24	200	4800.00
	Cost for 12 checkdams for 5 ha @ Rs4800 each	Nos	12	4800	57600.00
	Add 25% for hilly areas				14400.00
	Total Cost				72000.00
	Total cost /ha				**14400.00**

3	Wire Crate CheckDam(8mx1.5mx2m),considering 16/10ha				
(i)	Cost of wire	m	1600	55	88000.00
(ii)	Cost of carriage and weaving	cum	384	60	23040.00
(iii)	Cost of Stone/boulder and labour charges	cum	384	200	76800.00
(iv)	Collection and beaking of boulders	cum	384	60	23040.00
	Total (i)+(ii)+(iii)+(iv)				210880.00
	Add 25% for hilly areas				52720.00
	Grand Total				263600.00
	Total cost/ha				**26360.00**

10.1.13 Abstract of Works Under Biological Measures

The cost of biological measures like afforestation,NTFP and assisted natural regenaration under different sub- watersheds has been worked out as **Rs 310.00 lakh** ,inclusive of maintenance for three years,is given at **Table 10.13.**

Table 10.13:Sub watershed wise cost of Biological measures

SWS	Afforestation		NTFP		Assisted NatualRefeneration		Total
	Qty (ha)	Cost @Rs0.374 lakh/ha	Qty (ha)	Cost @ Rs 0.14400 lakh/ha	Qty (ha)	Cost @ Rs0.26360 lakh/ha	
3A1B3(1)	17	6.36	0	0.00	22	5.67	12.03
3A1B3(2)	14	5.24	0	0.00	15	3.87	9.11
3A1B3(3)	15	5.61	22	16.44	11	2.84	24.89
3A1B3(4)	20	7.48	15	11.21	16	4.13	22.82
3A1B3(5)	18	6.73	14	10.46	25	6.45	23.64
3A1B3(6)	15	5.61	10	7.47	23	5.93	19.01
3A1B3(7)	48	17.95	7	5.23	28	7.22	30.40
3A1B3(8)	75	28.05	0	0.00	37	9.54	37.59
3A1B3(9)	59	22.07	0	0.00	28	7.22	29.29
3A1B3(10)	65	24.31	0	0.00	31	7.99	32.30
3A1B3(11)	32	11.97	0	0.00	25	6.45	18.42
3A1B3(12)	22	8.23	0	0.00	32	8.25	16.48
3A1B3(13)	62	23.19	0	0.00	42	10.83	34.02
	462	**172.80**	**68**	**50.81**	**335**	**86.39**	**310.00**

10.1.14 Abstract of Works Under Engineering Measures

The cost ofengineering measures under different sub- watersheds has been worked out as Rs 130.64 lakh is given at **Table 10.14**

Table 10.14: Sub watershed wise cost of Biological measures

SWS	Brushwood Check dams		DRSM		Wire Crate Check dams		Total
	Nos	Cost @Rs0.01 374lakh/ No	Qty (ha)	Cost @ Rs 0.14400 lakh/ha	Qty (ha)	Cost @ Rs0.26360 lakh/ha	
3A1B3(1)	38	0.52	80	11.52	0	0	12.04

3A1B3(2)	14	0.19	33	4.75	0	0	4.94
3A1B3(3)	17	0.23	35	5.04	12	3.16	8.44
3A1B3(4)	17	0.23	36	5.18	19	5.01	10.43
3A1B3(5)	19	0.26	43	6.19	15	3.95	10.41
3A1B3(6)	18	0.25	42	6.05	13	3.43	9.72
3A1B3(7)	8	0.11	19	2.74	25	6.59	9.44
3A1B3(8)	16	0.22	37	5.33	35	9.23	14.77
3A1B3(9)	6	0.08	14	2.02	29	7.64	9.74
3A1B3(10)	9	0.12	21	3.02	32	8.44	11.58
3A1B3(11)	5	0.07	12	1.73	24	6.33	8.12
3A1B3(12)	3	0.04	11	1.58	22	5.80	7.42
3A1B3(13)	15	0.21	38	5.47	30	7.91	13.59
	185	**2.53**	**421**	**60.62**	**256**	**67.49**	**130.64**

10.1.15 Cost of Other Components of Cat Plan

Apart from the forestry works and drainage line treatment in the catchment area there are other aspects of the CAT Plan to be addressed and their cost included in the overall cost estimate of the plan. The infrastructure development, administrative charges, microplanning andmonitoring and evaluation are some of the integral ingredients which must be considered and included while formulating the CAT plans.

10.1.15.1 Infrastructure Development

In order to execute the catchment area treatment plan, the forest department would be requested to establish a catchment area treatment cell for which the executing agency shall need necessary infrastructure support. A summary of budgetary provision kept for infrastructure development is given in **Table 10.15**

Table 10.15: Cost Estimate for Support Infrastructure

S. N.	Items	Quantity	Amount(Rs lakh)
1	Field Vehicles	2	10.00
2	Computers	2	0.80
3	Misc. office furniture	L.S.	2.00
4	R&Mof vehicles @Rs 1.0 lakh /year		5.00
Total			17.80

10.1.15.2 Adminstrative Charges

For an efficient management of forest resources, it is essential that operational support to the Forest Department is adequately developed. Therefore, following provisions for engaging additional staff during plan period have been made under the CAT Plan. Component of proposals are given in **Table 10.16**.

Table 10.16: Cost Estimate for Administrative Charges

S.N.	Post	Salary/month	Number of post	Total annual (Rs lakh)
1	Draftsman/Surveyor	8000.00	1	0.96

2	Junior Assistant	8000.00	2	1.92
3	Driver	7000.00	1	0.84
4	Year wise fund requirement			
(i)	Total for Ist Year			3.72
(ii)	Total for 2nd Year @15% escalation			4.28
(iii)	Total for 3rd Year @15% escalation			4.92
(iv)	Total for 4th Year @15% escalation			5.66
(v)	Total for 5th Year @15% escalation			6.51
5	Totalfund requirement for 5 years			25.09

10.1.15.3 Microplanning

Based on the ground truth reality in each of the village forest department committee or society under different sub-watersheds, comprehensive micro plan for execution of the work has to be prepared as per norms. The micro plan for each beats of sub-watershed shall be prepared in consultation with the members of concerned VFDCs with due regards to the environmental functions and productive potential of the forests and their carrying capacity. For this purpose, a provision of Rs. 5.0 lakh is being made.

10.1.15.4 Provision for Monitoring and Evaluation

The success of implementation of a CAT Plan can be fathomed by increase in vegetal cover on hill slopes and the enhancement. Various engineering and biological measures have been aimed at treating degraded and potential areas of severe to very severe soil erosion by increasing soil holding capacity and thus reducing sediment flow in the water.

A close watch on annual basis shall be maintained in respect of such areas where habitat improvement works have been carried out so as to verify the work executed on site itself and also to ascertain the rate of survival of plants and / or any damage to the new workplan. The work of monitoring of various works under the CAT plan should be entrusted to an external agency which has long experience of carrying out similar work on land use data and evaluating environment impact.

A provision of Rs.10.00 lakh is being made for monitoring and evaluation activities including the expenditure likely to be incurred on conducting meetings / seminar / workshops at the head quarter and outside. Provision for Joint Forest Management & Micro Planning

10.1.16 **Institutional Mechanism**

10.1.16.1 Role of Project Proponent

The forest department would implement the Catchment Area Treatment Plan. A joint inspection group is suggested that would include officers drawn from State Forest Department and officials from the Environment Cell of MBPCL. The management will have liaison with the forest officials. As far as the financial disbursement to undertake activity involvement of various stake holders and collaborative public participation should be encouraged to have transparency in the system.

10.1.16.2 CAT Implementation

The designated Environmental Officer of MBPCL would coordinate with the forest department for the implementation of the proposed Plan. The Environment Officer would evaluate/monitor financial aspects. The modalities of financial disbursement need to be worked out. The implementing agency shall submit completion certificate in the light of guidelines fixed by the Sikkim Forest Department. The implementation of CAT Plan should have enough flexibility and should be subject to changes as per requirements of specific ecosystem and periodic gains. A monitoring committee as per the MoEF guidelines may be constituted for the project for administrative guidance and smooth realization of targets.

10.1.16.3 Project Monitoring and Reporting Procedures

Meetings would be held every three months to resolve problems arising in plan implementation. A Joint committee may be formed with the Environment Cell of MBPCL. and State Forest Department; the team members must ensure implementation and monitoring of the CAT works and review the progress from time to time. Quarterly progress reports and completion certificates would be submitted to MBPCL for evaluation and disbursement of finance. In addition, the work done should be published through public awareness campaigns. Visual and print media may be used to gain maximum benefit by beneficiaries. Such efforts would resolve conflicts which otherwise are potential sources for project delays.

10.1.17 Summary of Cost of Works

The cost of all works proposed in the CAT plan is enumerated in **Table10.17** and annual break-up of cost is shown in **Table 10.18.**

Table 10.17: Summary of Cost Estimate for Works Under CAT Plan

S. N.	Particulars	Amount (Rs. Lakh)
A	**Biological Measures**	
(a)	Afforestation (462 ha @ Rs. 27000 per ha)	161.10
(b)	Maintenance of afforested area for three years	48.12
(c)	Assisted Natural Regeneration (335 ha @ Rs 18810 per ha)	63.01
(d)	Maintenance of Assisted Natural Regenerationfor three years	22.36
(e)	NTFP Regenaration(68 ha @ Rs. 49500 per ha)	33.66
(f)	Maintenance ofNTFPfor three years	14.64
(g)	Nursery support	10.00
	Sub- total (A)	**316.53**
B.	**Engineering measures**	
(a)	DRSM check dam (421ha @ 24000/ha)	60.62
(b)	Vegetative Spurs (185 no. @ 1375 each)	2.54
(c)	Wire Ceate (256 ha @ 26300/ha)	67.48
(d)	Bench Terracing(529 ha @ 7500/ha)	39.68
	Total (a)+(b)+(c)+(d)	170.32
	Add 5% for maintenance	8.52

Sub- total (B)		**178.84**
C.	**Treatment of Landslides**	25.00
Sub- total (C)		**25.00**
D.	**Other Components of CAT Plan**	
(a)	Implementation of Support Infrastructure cost	17.80
(b)	Administrative Charges	25.09
(c)	Provision for Micro Plan	5.00
(d)	Provision for Monitoring and Evaluation Activities	10.00
Sub- total (D)		**57.89**
Grand Total (A+B+C+D)		**578.26**
Say Rs.		**578.00**

Table 10.18: Annual Break up of Cost

S.N.	Particulars	Unit	Rate(Rs)	I-Year		II -Year		III-Year		IV-Year		V-Year		Total	
				Phy	Fin.	Phy	Fin.	Phy	Fin.	Phy	Fin.	Phy	Fin.	Phy	Fin.
A	Biological Measures														
1	Afforestation														
(i)	Creation	ha	27000	182	49.14	164	44.28	116	31.32					462	124.74
(ii)	Maintenance	-				182	8.01	346	13.41	462	15.40	-	-		48.12
2	Assisted Natural Regenaration														
(i)	Creation	ha	18810	185	34.80	92	17.30	58	10.91	-	-	-	-	335	63.01
(ii)	Maintenance	-	-	-	-	185	5.44	277	6.90	335	7.07	-	2.95		22.36
3	NTFP														
(i)	Creation	ha	49500	48	23.76	10	4.95	10	4.95	-	-	-	-	68	33.66
(ii)	Maintenance	-	--	-	-	48	4.04	58	5.72	-	-	-	-	-	14.64
B	Engineering Measures														
1	Gully Control														
(i)	Brushwood	No	1375	67	0.92	48	0.66	45	0.62	25	0.34	-	-	185	2.54
(ii)	DRSM	ha	14400	150	21.60	128	18.43	95	13.68	48	6.91	-	-	421	60.62
(iii)	Wire Crate	ha	26360	115	30.31	75	19.77	40	10.55	26	6.85	-	-	256	67.48
2	Bench Terracing	ha	7500	263	19.73	143	10.73	84	6.30	39	2.92	-	-	529	39.68
	Sub-total (1)+(2)	-	-	-	72.56	-	49.59	-	31.15	-	17.02	-		-	170.32
	Maintenance @5%	-	-	-	3.63		2.48	-	1.56	-	0.85	-	-		8.52
	Total (B)	-	-		76.19	-	52.07	-	32.71	-	17.87	-	-	-	178.84
3	Treatment of Landslides	-	-	-	10.0	-	10.0	-	5.0	-	-	-	-	-	25.00
4 (a)	Forest Infrastructure	-	-	-	13.80	-	2.00	-	1.0	-	1.0-	-	-	-	17.80
4 (b)	Administrative Charges	-	-	-	3.72	-	4.28	-	4.92	-	5.66	-	-	-	25.09
4 (c)	Microplanning	-	-		2.00	-	2.00	-	1.00	-	-	-	-	-	5.0
4 (d)	Monitoring and Evaluation	-	-	-	4.00	-	2.00	-	2.00	-	1.00	-	1.00	-	10.0
	Grand Total	-	-	-	**224.41**		**159.37**		**119.00**	**-**	**53.73**	**-**	**21.75**	**-**	**578.26**

10.2 COMPENSATORY AFFORESTATION SCHEME

10.2.1 General

The compensatory afforestation scheme was implemented through Forest Department of Sikkim by depositing requisite amount in CAMPA Fund. The activities included soil conservation works, fencing, protection, awareness, monitoring and evaluation along with maintenance for a period of five years.

In hills, trees and other vegetation cover have an important role in the conservation of ecosystem. Due to project activities increase in demand of fuel wood, fodder and grazing, the pressure in the project area adds to the loss of forests. Vacant lands devoid of trees exist in the region. It is very essential to create more resources for fuelwood to check further degradation in the area where most of human and livestock population stay. This shall provide vegetal cover to barren slopes to check soil erosion and cater to the increasing demand of fuel wood and fodder. The plan envisages afforestation on the following model of plantation scheme.

The plantation of vacant land would be carried out depending on plant species. Soil binding species were proposed to be planted. Broad-leaved species meant mainly for their fodder and fuel wood utility would be planted. Fuel wood species were planted with fodder species.

10.2.2 Forest Land Requirement of Project

The total forest land required to be diverted for project works other than transmission linewas25.1388ha(23.735 ha surface+2.4963 ha underground)covered under Singtam and Ronglirange under East Sikkim (T) Forest Division.For “Right Of Way” for construction of 220KVD/CTransmission Line from RHEP Power station switch yard at Kumrek to 220/132KV sub stationof PGHCIL at Mamring (Samardong) total forestland requirement is 23.3437ha. Thus, total requirement of forerst land to be diverted is 48.4825 ha.

10.2.3 Status of Forest Land Diversion

Stage-I Forest clearances for diversion of 26.2313 ha forest land has been accorded vide letter No.3-SKC012/2007-SHI/2533-34 dated 17.1.2008 and Stage-II clearance videletter No.3-SKC012/2007-SHI/256-57 dated18.5. 2009. Further diversion of additional 2.5325 ha of forest land for the project and surrender of 3.6250 ha of forest land diverted under 26.2313 ha for the project was approved on 10.2.2012. As such, total forest land in possession at present is 25.1388 ha.

Stage-I Forest clearances for diversion of 23.3437ha forest land ,for “Right Of Way” for construction of 220KVD/C Transmission, has been accordedvide letter No.3-SKC104/2013-SHI/6339-40 dated 20.1.2014.

10.2.4 Compensatory Afforestation

Under Forest (Conservation) Act, 1980, in case of diversion of forest land for non-forestry purpose, the compensatory afforestation shall be done over equivalent area of non -forest land made available to the Forest Department and its ownership transferred and the same is notified as FR.As far as possible, the non-forest land should be identified contiguous to or in proximity of

Reserved Forest or Protected Forest in the same district and in case if it is not available, it should be identified anywhere else in the state, so as to minimize the micro-ecology of the area.

10.2.5 Land for Compensatory Afforestation

Since non-forest land/landswere not available,Compensatory afforestation had to be raised over degraded forestland twice in extent of the forest area being diverted/deserved.The compensatory afforestation had to be carried out over 47.50 ha degraded forest land identified by the Forest Department at four locations under Singtam Range in East Division and 6.50 ha at Tarpin R,F, under RongliRangeof East Division.

In respect of forest land required as “Right Of Way” for construction of 220KVD/C Transmission,the compensatory afforestation had to be carried out over 47.00 ha degraded forest land was identified by the Forest Department at two locations each in East and south Division viz., 20 ha at Sumin(Preckchu) R,F, and 14 ha at LingzeyKhasmai in Singtam Range East District.7 ha at Jhulangi RF(Samardong) and 6ha at Mangrhing RF at Namthang Range South District .

10.2.6 Payment of Net Present Value of Land Transferred

The MoEFCC New Delhi Circular F. No. 5-1 / 98-FC (Pt-II), dated 17/18 September, 2003, issued pursuant to the order of the Hon’ble Supreme Court of India, makes obligatory for the State Government to charge from the user agency the Net Present Value (NPV) of land to be converted for non-forestry purposes under the Forest (Conservation) Act, 1980. Depending upon the forest density the rates of NPV have been finalized. In the present context the value of NPV of the forest land for 25.1388 ha has been assessed as Rs 1,87,03,199.00 and for 23.3437 ha it was assessed as Rs 1,97,25,426.00 . After realizing the amount, the state Government transfered these funds to CAMPA.

10.2.7 Cost Estimate of CompensatoryAfforestation Works

The overall cost estimate for compensatory afforestation works to **Rs. 606.00** lakh as shown in **Table 10.19.**

Table 10.19: Total Cost of Compensatory Afforestation Scheme

S.N.	Particulars	Amount (Rs lakh)
1.	Cost of compensatory afforestation	131.885
2.	NPV of Forest Land to be diverted	384.286
3	Compensation	89.679
Total		**605.85**
Say		**606.00**

10.3 WILDLIFE AND BIODIVERSITY MANAGEMENT PLAN

10.3.1 Introduction

The main objective of Biodiversity Conservation and Management plan is sustainable use of natural resources, which involves scientific management of natural wealth vis-à-vis developmental activities, is likely to affect these resources. The threats to natural terrestrial and aquatic ecosystems generally arise due to by anthropogenic activities that may arise because of construction and associated activities of proposed project. A detailed biodiversity conservation and management plan has been proposed and the main objectives of said plan are as follows:

- Maintenance of ecological balance through preservation and restoration of wherever it has been disturbed due to project developmental activities,
- Conservation and preservation of natural habitats in catchment area
- Rehabilitation of critical species (endangered, rare and threatened species), if any with provisions for *in-situ* or *ex-situ* conservation of critical/ important plant/ animal species,
- Mitigation and control of project induced biotic and/or abiotic pressures/influences that may affect the natural habitats,
- Habitat enhancement in project catchment area by taking up afforestation and soil conservation measures,
- Creating all round awareness regarding conservation and ensuring people's participation in the conservation efforts and minimizing man animal conflict.

10.3.2 Protected Areas

Fambong Lho Wildlife Sanctuary exists within 5.5 km from the project area but no part of the project falls within the ESZ of WLS.

10.3.3 Conservation of Rare, Endangered & Threatened species.

During the course of primary survey, no plant species recorded as threatened in the study area.

10.3.4 Conservation and Cultivation of Medicinal Plants

An Herbal nursery shall be developed at an appropriate location. Farmers shall be trained to make them aware of the use of herbal plants and in animal health care also. East Sikkim Forest Division is rich in a variety of medicinal plants. However, in past uninhibited exploitation of medicinal plants has led to depletion of this valuable resource. Therefore, in order to augment natural stock of medicinal plants in the forests, it is proposed to take up planting of medicinal plants and establishing medicinal plants nurseries. An outlay of Rs.7.48 lakh @ Rs.74,745/- per ha has been made to cover about 10 ha for creation (Rs.4.95 lakh) and its maintenance (Rs.2.53 lakh) for three years

10.3.5 Endemic, Threatened and Endangered Species of Mammals

The catchment area of the proposed project falls under Fambong Lho Wildlife Sanctuary and Schedule-I fauna i.e. Red Panda and Clouded Leopard are reported in the Fambong Lho Wildlife Sanctuary hence, conservation plan is required for the schedule-I species.

The Wildlife Protection Act, 1972,provides for the protection of wild animals, birds and plants; and for matters connected therewith or ancillary or incidental thereto.

10.3.5.1 Conservation Plan:

The people living in the surrounding area and employee of the company would be motivated towards the protection of the animal. Motivation will lead to timely information to the concerned authorities about any threat to wild life or any cases of poaching/hunting. Proper incentive shall be given to such locals who pass on information about the illegal poaching. Water holes should be made away from such places where the local people bring their animals for grazing. The ban on use of plastic bags should be strictly followed. The dangerous chemicals should not be indiscriminately disposed near to the water holes otherwise the water quality shall be impaired to dangerous proportion. The database of natural habitat of wild animals should be prepared and the information disseminated to the gram Panchayat. A great deal of wildlife also inhabits the area outside of the forests which do not fall under jurisdiction of the Forest Department. In context of such areas the revenue department and the NGOs may take joint and concerted efforts for protection of animals.

10.3.5.2 Wildlife Management Plan

Forest areas can be developed as wildlife habitat by resorting to restorative strategies which *inter alia* would into the following:

- Redressing man animal conflict
- Habitat improvement measures
- Anti-poaching operations
- Capturing problematic and aberrant animals
- Staff development and capacity building

10.3.5.3 Redressing Man Animal Conflict

The villages near forest have small chunk of agricultural land and people are mainly depending upon rain fed crops. Wild animals like often damage their crops which is the main man-animal conflict around the area. Though Wildlife (Protection) Act, 1972 authorizes Chief Wildlife Warden and Officers acting on his behest to permit killing of such wild animals causing destruction to life and property, yet the local due to religious sentiments do not opt for animal killings. In such a scenario adequate compensation shall be made to suffering stake holders near the buffer areas. To avoid revenge killing the compensation in case of loss of human life, resulting from man-animal conflict, shall be made @ Rs. 2.0 lakh / victim while for serious injuries Rs. 0.6 lakh / person.

Besides this crop protection structures can be erected at prominent places and cages/traps to catch problematic animals can be deployed.

10.3.5.4 Habitat Improvement Measures

The activities under this sub-head mainly comprises of such initiative which will improve the forage and browse values of the habitat for wild animals. The works like creating water holes, water retaining structures, pasture land reclamation (grass improvement) and eradication of weeds. The improvement in the floral diversity in the buffer area can be partly achieved from plantation under green belt to be carried out under the environment management plan proposed under the EIA/EMP report.

10.3.5.5 Anti-Poaching Operations

Under this sub-head deployment of anti-poaching squads drawn from army personnel and home guard; deployment of special tiger protection force (STPF) shall be the main constituent of the plan. Besides this establishment and maintenance of patrolling camps/ chokies equipped with wireless sets/mobile phones and procurement of field gear, night vision devices shall be the other ingredients.

10.3.5.6 Capturing Problematic and Aberrant Animals

This will involve procurement and deployment of traps, cages to catch aberrant animals besides procurement of tranquilizing equipment's.

10.3.5.7 Staff Development and Capacity Building

Under this sub-head specialized training in the field of management planning, park interpretation through conducting workshops / seminars / study tours for appraisal of good practices followed in other reserves. Apart from this training in the use of GIS systems and anti-poaching operations shall be imparted.

10.3.6 Wildlife Management Plan for Clouded Leopard

To prepare the Wildlife Conservation plan for Clouded Leopard (Neofelisnebulosa). Biological study was conducted along with the Fambong Lho Wildlife Sanctuary officials following official of Fambong Lho Wildlife Sanctuary were present during the site visit:

1. Mr. Karma Lepcha (Block Officer)
2. Mr. Mangal Singh Subba
3. Mr. Justin Jamalag

Survey of the site, Secondary data collection and identification of the place of habitation, werethe first few steps followed. The survey was carried out in four steps:

- Collection of available area specific secondary information by perusal of literature.
- Mapping of land cover/forest and other related parameters.
- The Santuary area was surveyed, both by rapid and intensive protocols.
- Consultation with Sanctuary official

10.3.6.1 Taxonomy of Clouded Leopard

The clouded leopard, named after its distinctive markings - ellipses partially edged in black, with the insides a darker color than the background tawny color, and sometimes dotted with small black spots(**Figure10.8).** The limbs and underbelly are marked with large black ovals, and the back of its neck is conspicuously marked with two thick black lines. The long tail is thick and encircled with black rings, equal to body length (up to 80-90 cm) (Pocock 1939a, Legakul and McNeely 1977, Mehta and Dhewaju 1990). The legs of the clouded leopard are short, but its canines are relatively the longest of any felid (3.8-4.5 cm) and have a very sharp posterior edge. Clouded leopards are intermediate in size between large and small cats: wild adults can weigh between 11-20 kg (Pocock 1939a). Clouded leopards occupy tropical forests at elevations of up to 3000 meters. They are highly arboreal, using trees for resting and hunting. However, they also hunt on the ground. Clouded leopards inhabit primarily evergreen tropical forest but they are also reported from other habitats, such as secondary forest, logged forest, mangrove swamp, grassland, scrub land, dry tropical forest. Their diet consists of birds, primates and small mammals, as well as larger prey, such as porcupines, deer, and wild boar.

The species in free ranging condition may thrive for about 11 years and 14 – 17 years in captivity. The males and females reach sexual maturity by 20 to 30 months of age. No fixed breeding season is known and reports suggest that it may occur round the year. They make dens in dense undergrowth or tree hollows. Efforts in parental care are invested by the mother alone. The mother after a gestation period of 85 – 109 days produces a litter consisting of 1 – 5 cubs (average 2). The inter birth interval has been reported to range from 10 – 16 months

Figure 10.8: Clouded Leopard

10.3.6.2 Behavior

Clouded leopards are mostly nocturnal, very secretive and quick. Large feet, short legs, and a long tail make clouded leopards well-adapted for arboreal living; reports from captive animals suggest that it can descend head first. Their high levels of adaptation to arboreal living enable Clouded leopards to hunt in trees, preying on birds, monkeys, and rodents. They are probably solitary animals. A male and female found together, are probably a mating pair, coming together for breeding. A typical clouded leopard has a territory of 30 to 40 square kilometers, with a heavily used core area of 3 to 5 square kilometers. Male and female home ranges overlap substantially.

10.3.6.3 Distribution

The species range extends from the Himalayan foothills in Nepal through mainland south-east Asia to China. It inhabits mixed evergreen forests in its area of occurrence. The island populations of Sumatra and Borneo have been identified as a separate species Neofelisdiardi by Buckley-Beason et.al. 2006 and Kitchener et.al 2006. In India the species Neofelisnebulosa occurs in the states of Sikkim, West-Bengal, Assam, Arunachal Pradesh and Tripura.

In the sanctury area the clouded leoprd is reported at altitude more than 3000 m. No Clouded leopard were seen during the site visit. Though it was captured on camera trap which are already installed by sanctuary official.

10.3.6.4 Threats

The species prefers closed dense forests which are declining at a rapid rate. Habitat destruction and associated loss of cover and prey base has resulted in a rapid decline in population of clouded leopards in the wild. Besides this the species is extensively hunted for the illicit wildlife trade in skins, bones for medicines and meat for exotic dishes

10.3.6.5 Status

Due to the various threats to the survival of the species in the wild the species has been ranked as Vulnerable [criterion C1+ 2a(i)] of IUCN Red list of Threatened species, version 2009.1 and Schedule I of the Wild Life Protection Act; Govt. of India. It is also protected by legislation in most of its range countries. It is included in CITES Appendix I due to the extensive illicit trade.

10.3.6.6 Conservation Measures

The conflict between animal and human can be reduced by improvement of habitat to augment food and water availability and to minimize the animal movement from the forests to the habitations, besides training the local peopleand creating awarenessin them about the Do's and Don'ts to minimize conflicts.

- **Habitat Improvement**

It is important that sufficient prey/ larger prey, such as porcupines, deer, and wild boar available in the sanctuary forest. Through the study area supports fair number of wild fauna and other herbivores which can be prey for leopard, as part of conservation plan for this predator, habitat protection and improvement, especially the food availability of water and salt licks are of priority. monkey, porcupine, wildboar exist in the area, which is an important prey species for clouded leopard in sanctuary area.

- **Gap Plantation with Woody Shrubs**

Gap plantation can be done in the degraded e forest areas, mainly in the patches that are heavily degraded and lack natural regeneration, covering at least one ha area in each plantation site. The species suggested for gap plantation as part of habitat improvement. As the clouded leopard habitated in upper hill region i.e. hence species of Pinus, Abies, Oak, Rhododendron, Betula and Michilussp.can be planted under gap plantation scheme.

A total of 6 tree species species have been suggested under gap plantation to improve the habitat quality. This in turn will help provide food and desirable habitat for prey species for Clouded Leopard as described below: -

- Improve vegetation cover and provide shelter for small mammals such as porcupine, wild boar, hare, and monkeys.
- Control soil erosion and retain the soil moisture and thereby improve the overall regeneration potential of other tree species of the forest habitat.
- Provide food for prey species like porcupine, wild boar, hare, and monkeys which are main prey species for leopard which is top carnivore of the study area.

- **Development for Grasslands/Patches for Prey species**

In order to improve the prey species, including the rodent population that are also eaten regularly by clouded leopard where prey especially ungulates population is low, the habitat improvement should involve developing grass patches in the area that are open. List of some grass species suitable for the study area suggested for grassland development.

- **Development of Water bodies/Water holes**

These will be developed in habitation zone of Clouded Leopard for drinking purpose. In drought condition, drinking water availability will be maintained in the sanctury area especially in active zone area of clouded leopard.

10.3.6.7 Budget for Conservation of Clouded Leopard

The cost estimate for conservation has been shown in **Table10.20.**

Table 10.20: Cost Estimate for Conservationof Clouded Leopard

Sl. No.	Conservation Measures	Budget (Lakh)
1	Cleanin of unwanted weeds and invasive species	1.5
2	Maintenance of patrolling path inside the santuary	1.0
3	Construction of small water holes, watering facility & availability of water in habitation of clouded Leopard including water availability (@ 50,000 per year for 5 years)	2.5
4	Maintance of Log House/Inspection House	2.5
5	Repair of road leading to the Fambong Lho Wildlife Sanctuary.	10.0
6	**Total**	**17.5**

10.3.7 Wildlife Management Plan for Red Panda

10.3.7.1 Habitat

The red panda is found in the mountains of the Himalayas, western China, northern Myanmar (Burma), and Laos. It is generally found on steep, mountainous slopes that are covered with mixed forests of coniferous (cone-bearing, evergreen) trees, deciduous hardwoods (trees that seasonally drop leaves), bamboo, and rhododendrons. It prefers altitudes between 5,000 and 15,000 feet.

10.3.7.2 Characteristics

Body length: up to 44 inches long, including a 19-inch tail; Weight: 7-13 pounds.The red panda has a round head and large, erect, pointed ears. It has a long, dense, reddish–brown, wooly coat with lighter colored bands on the tail. Its undersides are dark reddish-brown or black. Its face is white, with a reddish-brown stripe extending down from each eye to the lower jaw (similar to a tear mark). It has black legs. The front legs are angled inward, which causes its waddling walk. The soles of its feet are covered with dense hair that gives protection from the cold and hides scent glands. The red panda's forepaws (front paws) have a false "thumb" that enables it to climb and grasp bamboo leaves and poles. The false "thumb" is actually an enlarged wrist bone. The claws are sharp and semi-retractile (partly retractable). It has 36- 38 teeth and strong jaw muscles. Such adaptations enable it to crush and to chew bamboo and to eat meat. It has a life span of 12-14 years in the wild and upto 14 years in captivity.

Figure 10.9: Red Panda

10.3.7.3 Behaviors

The red panda is nocturnal, crepuscular (active at dawn and dusk) and arboreal (much of its time is spent in trees). During the day in cold weather, the red panda is usually found curled up in its nest with its tail wrapped around its head for warmth. When it is warmer, it may stretch out and dangle on a branch. Even though it has a gentle, quiet and curious nature, the red panda is very shy. Adults are generally solitary, except during mating season and throughout the time when a female is rearing its young. It descends trees headfirst and is very agile as it moves from branch to branch. Most feeding is done on the forest floor and its movement is often a slow gait while on the ground. When threatened it is capable of bounding up a tree. It can also strike out with its semi-retractile claws. Whether male or female, the red panda marks its territory with a musky scent from the anal gland, urine and/or feces. Its trails are also automatically marked with scent from glands on the soles of its feet. The usual communication is a series of short whistles and squeaks. However, when provoked or frightened, it stands on its hind legs and hisses and/or emits a series of snorts. Food is held in a forepaw and brought to the mouth while it is sitting, standing and/or lying on its back. After the red panda awakens and/or eats, it tends to lick its whole body and limbs, wash its face with a paw, and stretch or rub its back and abdomen against an available object.

10.3.7.4 Reproduction

Sexual maturity is reached at 18 months for both sexes. Males fight for breeding rights. During such fighting encounters, they will first arch their backs and lower their heads. Then they will stand on their hind legs and use their forepaws to beat each other. Mating season is in winter, usually from early January to mid-March. The gestation period is 90 to 150 days which includes a period of delayed implantation. Birth usually occurs from mid-June to late July. Litters may contain 1-5 young, but usually only a pair is born. Before the female gives birth, she will use nesting materials (sticks, grass, leaves) to prepare her nest site, which may be in a hollow tree or in a rock crevice. At birth, the fully fur-covered cubs are blind and helpless. After 17-18 days, the cubs' eyes open. They leave the nest for the first time at around 90 days of age, usually during the night. They reach adult size at around 12 months of age. Usually the young stay with their mother for one year, or until the next litter is about to be born.

10.3.7.5 Diet

Mainly bamboo, some fruit, grasses, roots, acorns, insects, eggs, young birds, small rodents, lichen are the main diet of the red pands.

10.3.7.6 Distribution

The red panda is endemic to the temperate forests of the Himalayas, and ranges from the foothills of western Nepal, to China in the east. Its easternmost limit is the Qinling Mountains of the Shaanxi Province in China. Its range includes southern Tibet, Sikkim and Assam in India, Bhutan, the northern mountains of Burma, and in south-western China, in the Hengduan Mountains of Sichuan and the Gongshan Mountains in Yunnan. It may also live in south-west Tibet and northern Arunachal Pradesh, but this has not been documented. Locations with the highest density of red pandas include an area in the Himalayas that has been proposed as having been a refuge for a variety of endemic species in the Pleistocene. The distribution range of the red panda should be considered disjunct, rather than continuous. A disjunct population inhabits the Meghalaya Plateau of north-eastern India. The red panda lives between 2,200 and 4,800 m (7,200 and 15,700 ft) altitude, inhabiting areas of moderate temperature between 10 and 25 °C (50 and 77 °F) with little annual change. It prefers mountainous mixed deciduous and conifer forests, especially with old trees and dense understories of bamboo.

10.3.7.7 Threat

A major threat is the loss of habitat due to deforestation for timber, fuel and agriculture. The everincreasing human populations have affected land that once provided trees for nesting sites and areas of bamboo forests. Domestic local livestock are now out-competing red pandas for food and land. Domestic dogs used for livestock threaten nests. The flowering and dying phases of bamboo threatens its survival.

Poaching for the pet and fur trades continues to threaten the red panda. Its fur is used to make hats and clothing worn by local people in China. Its tail is used as a duster. Its skin is used during cultural ceremonies. To help with conservation efforts, make sure that you buy no products made of red panda fur, skin and/or other body parts and contribute to organizations that support red pandas. Predators of the red panda are snow leopards, yellow-necked martens and humans.

10.3.7.8 Status

Due to the various threats to the survival of the species in the wild the species has been ranked as Endangered; and Schedule I of the Wild Life Protection Act; Govt. of India. It is also protected by legislation in most of its range countries. It is included in CITES Appendix I due to the extensive illicit trade.

10.3.7.9 Conservation Measures

- **Habitat Improvement**
  It is important that sufficient prey/ larger prey, such as Mainly bamboo, some fruit, grasses, roots, acorns, insects, eggs, young birds, small rodents and lichen in the sanctuary forest.
- **Bamboo Plantation with Grasses**

Bamboo plantation can be done in the degraded forest areas along with grasses. There are many species of grasses and bamboos that can be planted in degraded areas in sanctury as part of habitatimprovement.The grasses to be planted*interalia* include *Arundinellanepalensis,Chrysopogonaciculatus,Cymbopogon pendulus,Digitariaciliaris,Imperatacylindrica,Oplismenuscompositus,Saccharum spontaneum and Pennisetumorientale.*Awareness programme among local people for not hunting and poaching of the species

10.3.7.10 Budget for Conservation of Red Panda

The cost estimate for conservation has been shown in **Table10.21.**

Table 10.21: Cost Estimate for Conservationof Red Panda

Sl. No.	Conservation Measures	Budget (Lakh)
1	Purchase of equipments/uniforms for forest staff	5.0
2	Awareness programme among local people (Minimum 1 camps per years including signage, printing of brochures and awareness materials) for protection of Wildlife (@ 50,000 per year for 5 years)	2.5
6	**Total**	**7.5 Lakhs**

10.3.8 Financial Projection for Wildlife and Bio-diversityManagement Plan

To implement the plan following works are proposed within forest . More emphasis will be given to soil and water conservation structures and creation of water holes along with the habitat development works. To improve the habitat and conserve the flora and fauna following items of works are proposed and tentative financial allocation for the same is given in **Table 10.22**

Table 10.22: Cost under Conservation Plan

S. N.	Item	Amount (Rs. Lakh)
1	Conservation of Clouded Leopard	17.50
2	Conservation of Red Panda	7.50
3	Medical Plant Conservation	
(i)	Establishment and maintenance of nurseries for medicinal plant	7.48
(ii)	Preparing inventory of medicinal plants and identification of plants requiring conservation	20.00
4	Wildlife survey & research	
(i)	Survey of wildlife & wildlife habitats	10.00
(ii)	Public awareness on conservation, training, etc	5.00
(iii)	Anti-poaching activities like training,reward for informers, etc.	5.00
(iv)	Eco-tourism	5.00
(v)	Rescue operations for affected wildlife,equipments,etc.	10.00
5	Development of habitat improvement measures in degraded areas	
(i)	Normal Plantation	4.50
6	Contingency @10% on total (1)+(2+(3)+(4)+(5)	8.70
Total		**100.68**
Say		**101**

10.4 : FISHERIES MANAGEMENT PLAN

10.4.1 Introduction

Hydroelectric power project may have some negative or positive effects on the fish species found in the river flows at the project site, depending upon the particular situation and the fish fauna inhabiting the concerned river. The construction of barrage leads to the fragmentation of habitat which may have adverse impact on the fishes especially the migratory fishes. Possible fish passage/fish ladder/fish bypass to provide migratory passage have been assessed to evolve effective conservation strategies for sustainable management of aquatic biodiversity. However, these passages have been found more effective in low head barragebut for high barrage passage are not found viable due to immediate loss of habitats.

10.4.2 Fisheries Status

Rongni Chhu was found to have 26 fish species belonging to orders Cyprinidae, Sisoridae, Cobitidae and Channidae. The capture fishery in the Rongni Chhu comprises mainly of *Schizothoraxrichardsonii, Schizothoraicthysprogastus* and *Acrossocheilushexagonolepis*. None of the fish species, found in the Rongni Chhu is categorized as 'threatened'. The fish species found during primary survey and from the secondary data are shown in **Table-10.23** with their conservation status.

Table 10.23: Fish species in the project area

Sl. No.	Species	Local name
Family Cyprinidae		

1	*Acrossocheilus hexagonolepis*	Catli
2	*Schizothorax richardsonii*	Asla
3	*Schizothoraicthys progastus*	Chucheasla
4	*Puntius clavatus*	–
5	*Barilius bendelisis*	Korang, Joia
6	*B. bendelisis chedra*	Korang, Joia
7	*B. vagra*	Chirkay
8	*Danio aequipinnatus*	Vhitti
9	*Garra gotyla gotyla*	Budhna
10	*G. gotyla stenorhynchus*	Budhna
11	*G. annandalei*	Budhna
12	*G. lamta*	Budhna
13	*G. mcclellandi*	Budhna
14	*G. mullya*	Budhna
Family Sisoridae		
15	*Pseudecheneis sulcatus*	Kavrey
16	*Glyptothorax gracilis*	Kahray
17	*G. sinense manipurensis*	Kahray
18	*G. sinense sikkimensis*	Kahray
Family Cobitidae		
18	*Nemacheilus butanensis*	Gadela
19	*N. carletoni*	Gadela
20	*N. corica*	Gadela
21	*N. devdevi*	Gadela
22	*N. sikkimensis*	Gadela
23	*N. kanjupkhulensis*	Gadela
24	*N. multifaciatus*	Gadela
Family Channidae		
25	*Channa gachua*	Hilay

10.4.3 Impact on Fisheries

The possible disturbance to the fishes may be due to siltation and turbidity during construction phase. There may be a possibility of increase in soil erosion due to clearance of vegetation.

About 13 km stretch of the river would be dried up and there will be separation of Rongni Chhu from river Teesta, from where these species move into river Rongni Chhu. Not only the fish but fishermen of the vicinity would also suffer. Thus, not only the conservation of indigenous fish but protection of fishermen’s interest should be given priority. The conservatory measures and fisheries development can be achieved through establishment of fish farms, reservoir fishery and hatchery development.

Project may affect changes in the river ecosystem, as the river transforms from a fast-flowing water system to slow moving and less water stream. The aquatic animals affected most may be fishes due to disturbances and alterations to their habitat.

The barrage shall act as a barrier between the upstream and downstream habitat of migratory fishes because neither any fish ladder / pass has been providedin orinal layout nor constructed.Since all barrage bays and u/s and d/s wing/walls and piers have been completed,nor it is now feasible to construct any fish pass.

The migratory fish species that are likely to be adversely affected due to obstruction created by the proposed barrage are. *Schizothoraicthys progastus, Schizothorax richardsonii* and *Acrossocheilus hexagonolepis* which are known to perform local migration.

10.4.4 Objectives

The main objective of Fishery Management Plan is creation of infrastructure for the production of fish seed to affected / culturable species so as to make it available for stocking in open water and prospective fish farmers who will be affected by the project. Therefore, the Fishery Management Plan has been taken up with the following objectives:

- To develop sustainable fishery in Rongni Chhu
- To provide source of livelihood to the affected fishermen/ local unemployed youth
- Assistance to reservoir fishers on the purchase of gill nets and boats etc. for fishing in upcoming reservoir
- Training to reservoir fishers

10.4.5 Fisheries Development Plan

Small reservoirs are predominantly culture-based fisheries systems and the management norms are based on the principle of stock manipulation, adjustment in fishing effort, observation of conservation measures and gear selectivity. The reservoir is expected to retain water throughout the year and offers an opportunity for fishery development to help in the increasing employment potential and provide alternate employment to poor and to produce protein rich food improve human dietary standards in rural area and raising the net income of rural community. Fisheries are a dynamic source which when exploited replenishes the loss and hence a maximum sustainable yield from this resource is possible.

10.4.5.1 Stock Management

The Management of fish stocks in reservoir entails maintenance of enough quality stocks in adequate number in order to sustain the fishery. This involves several steps such as; stocking, conservation of fish habitat including breeding, dwelling and feeding grounds, fishing gear and effort regulation, mesh regulation, observance of dose season, regulation on exotic fishes.

10.4.5.2 Stocking

It is well known that a reservoir passes through period of trophic burst during the first few years after its impoundment. During this period, there is a sudden surge in plankton and benthic communities due to high level of nutrients derived from the submerged organic material in the reservoir bed. This is the right time to stock desirable species in to the reservoir. Heavy stocking with fast growing fishes on a short food chain is essential during trophic burst along with the protection of breeding ground. This will facilitate establishment of desirable species, which convert primary energy in to fish flesh at more economic rate of the reservoir. Any lapse in this management measure may cause proliferation of trash fishes, which in turn provide forage base for catfishes (predominantly predators).

10.4.5.3 Development Strategy

The following fish species has been selected by the State Fishery Department, for culture in the reservoir area based on its commercial importance and are culturable in captivity in the project stretch of RongiChhu:

- *Acrossocheilus hexagonolepis* (Catli)
- *Schizothorax* (Snow trout)

10.4.6 Fisheries Development Plan

A hatchery is the main centre of seed production of different fish species. From these centers the seeds can be propagated in the proposed reservoir and lower reaches of various rivers in Sikkim. The hatchery for catli and two fish farms for snow trout and catli are proposed in the vicinity of Rongni Chhu. Initially all the running and maintenance of expenditure would be borne by the project authorities for a period of at least 2 years. Thereafter, it is assumed that it will be taken over by the Sikkim State Fishery Directorate.Department of Fisheries, Government of Sikkim, will be solely responsible for the monitoring, maintenance and overall management of the plan including fish release to downstream of barrage site, training to fisherman/ unemployed youth, further assistance to them. Cost Estimate for Fisheries Management Plan

The cost estimate as prepared by the Department of Fisheries, Government of Sikkim, under various head is enumerated in **Table 10.24**. The funding (100%) will be done by MBPCL.

Table 10.24: Cost Estimate of Fisheries Management Plan

S.N.	Particular	Qtty	Unit	Rate	Amount (Rs lakh)
A	Cost of estabilishing Hatchery				
(i)	Acquisition of land and its development	3	ha	4.0	12.00
(ii)	Construction of Hatchery House and provision of equipments like troughs (40 No.) and trays (150-200 No.)	1	Job	L.S.	10.00
(iii)	Construction of Feed Store	1	Job	L.S.	4.00
(iv)	Construction of nurseryponds (3mx0.75mx0.5m)	20	Nos.	0.30	6.00
(v)	Construction of rearingponds (10mx1.5mx0.5m)	8	Nos.	1.00	8.00
(v)	Construction of stockiong ponds (30mx6.0mx1.5m)	4	Nos.	5.00	20.00
(vi)	Construction of office	1	No.	5.00	5.00
(vii)	Construction of Chawkidar hut	1	No.	4.00	4.00
(viii)	Construction of Water Intake Channel/pipe line	1	Job	L.S.	4.00
(ix)	Construction of Laboratory and Cost of Equipment	1	No.	6.00	7.00
(x)	Cost of Vehicles for transportation of seed alongwith requisite gadget	1	Job	L.S.	5.00
(xi)	Construction of fish landing centre	1	Job	L.S.	10.00
(xii)	Cost of boats and motor boat	10	Nos.	0.40	4.00
(xiii)	Cost of one motor boat	1	No.	5.0	5.00
	Sub Tota;l (A)				**104.00**
B	Construction of fish farm	2	Nos.	3.00	6.00

C	Salary,TA of one inspector,1Assistant,1Clerk,1 peon and 2 Chawkidars@ Rs2.50lakh/month for 24 months	24	Month	2.50	60.00
	Grand Total (A+B+C)				**170.00**

10.5 RESETTLEMENT& REHABILITATION PLAN

10.5.1 Introduction

For execution of the project permanent acquisition of private land 11.3859 ha land was carried out in five revenue blocks falling in two sub divisions viz., Gangtok and Pakyong Sub division. There are three project affected rvenue blocks (project affected villages) in Gangtok Sub division, viz., Sumen, Namli and Central Pendam.Besides this there are two project affected rvenue blocks (project affected villages) in Pakyong Sub division, viz.,Namcheybung and Yangtam.

The project was conceived with the sole objective of minimal or no displacement of people, compulsory acquisition of small extent of private land for the public purpose had become necessary. The acquisition of the land was carried out in consonance with principles enshrined in NRRP,2007,which was applicable at the time of acquisition of land under section -4 of Land Acquisition ACT, 1894. Now no further acquisition of private land is involved, therefore provisions of "The Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement Act, 2013", are not invoked.

10.5.2 Social Impact Assessment of Project

Chapter -IV Section 4.1 of the NRRP, 2007 mandates that whenever it is desired to undertake a new project or expansion of an existing project, which involves involuntary displacement of four hundred or more families *en massein* plain areas, or two hundred or more families *en masse* in tribal or hilly areas, DDP blocks or areas mentioned in the Schedule V or Schedule VIto the Constitution, the appropriate Government shall ensure that a Social Impact Assessment (SIA) study is carried out in the Proposed affected areas in such manner asmay be prescribed.

In so far as there was no involuntary or voluntary displacement of any family was involved ,there was no case for conducting SIA studies.Furthermore,now no further acquisition of private land is involved, therefore provisions under section 4 of "The Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement Act, 2013", are not invoked.

10.5.2.1 Village-wise Project Affected Families

The village-wise details of total private land to be acquired and its intended use for the project and number of title holders is shown in **Table 10.25.** It is evident that there shall be 62 affected families (whose land shall be acquired) of which none shall be displaced families (who on account of acquisition of land has to be re-located and resettled from the affected area to the resettlement area).

Table 10.25:Village-wise Details of Land to be Acquired and PAF

S.N.	Name of Village	Land To be Acquired (ha)	No. of PAF	No. of D.F.

S.N.	Name of Village	Land To be Acquired (ha)	No. of PAF	No. of D.F.
1	Sumen	0.8510	19	0
2	Central Pendam	5.013	15	0
3	Namli	3.2860	11	0
4	Namcheybung	0.9005	12	0
5	Yangtam	1.3390	5	0
Total		**11.3895**	**62**	**0**

10.5.2.2 Extent of Private land and Other Assets Likely to be Affected

Details of affected private structures and other assets is shown in **Table 10.26.**

Table 10.26: Details of Affected Private structures and Assets

S.N.	Village	HOUSES	CATTLE SHED
1	Sumen	0	0
2	Central Pendam	0	0
3	Namli	0	0
4	Namcheybung	0	0
5	Yangtam	0	0
Total		0	0

10.5.2.3 Extent of Public Assets Impacted due to project

No public assets were lost under the proposed acquisition

10.5.2.4 Feasibility of Acquisition at an Alternative Place.

The siting and alignment of the project components is mainly based on the geological condition of the rocks. During investigation and planning stage and also at the time of preparation of DPR, detailed surface and sub-surface investigations are carried out at different alternative sites and balance is struck in favor of the best alternative. Before and fixation of the size and dimensions.

Initially,the NHPC carried out preliminary survey in respect of the project . and during February,2005,submitted PFR. As per PFR, NHPC had recommended development by conceiving 170m high concrete gravity dam on Rongni chhu and diversion of water through HRT to a proposed surface powerhouse(195 MW) on right bank of Rangpo Chhu. The later studies conducted by M/s SMECIndia Pvt.Ltd. found that PFR was over estimated in terms of height of dam.

The alternative scheme conceived by M/s SMECIndiaPvt.Ltd encompassed construction of barrage about 80m upstream of an existing low head weir near village Namli and u/s of confluence of RongniChhueith Andheri Khola and surface powerhouse on right bank of Rangpo Chhu, but downstream of location of powerhouse in the earlier PFR of NHPC.The advantage of new powerhouse site was that sufficient flat land was available andgaining of additional head for power generation. Alternative-2 has been found most suitable and hence selected.

10.5.2.5 Assessment of bare minimum extent of land needed for the project.

The land requirement for various components of the project i.e.barrage, intake structure and underground works have been in sync with the dimensions determined on the basis of detailed hydraulic as well as structural design. The land required for various components of barrage i.e. waterway to pass the design flood discharge, u/s and d/s floor length, is based on as per standard designed practices, IS:6966(Part-I). likewise, the tunnel diameter has been finalized on the basis of economical diameter. Some quantity of the muck generated has been proposed for consumptive use for construction material thereby implying minimization of land required for muck disposal site as well as quarry sites. Thus, to keep the land requirement to the minimum, an all-out effort has been made.

10.5.3 Resettlement & Rehabilitation Principles

The provisions of the National Rehabilitation and Resettlement Policy, 2007(NRRP-2007) provide for the basic minimum requirements, and all projects leading to involuntary displacement of people must address the rehabilitation and resettlement issues comprehensively. The principles of this policy may also apply to the rehabilitation and resettlement of persons involuntarily displaced permanently due to any other reason.

Besides this meeting the mandatory requirement, certain works relating to social welfare and community development are also considered in consultation with local authorities and representatives of affected families to make the R&R Plan for the proposed project so that a greater degree of acceptability for implementation of the plan is achieved.

10.5.3.1 Definitions Followed in the R& R Plan

For this project, procedure and compensationhad been asper NRRP-2007 and following key definitions will be followed:

(i) “Agricultural family” means a family whose primary mode of livelihood is agriculture and includes family owners as well as sub-tenants of agricultural land, agricultural labourers, and occupiers of forest lands and of collectors of minor forest produce;

(ii) “Agricultural land” includes lands used or capable of being used for the purpose of-

(a) Agriculture or horticulture;

(b) Dairy farming, poultry farming, pisciculture, breeding or livestock and nursery growing medical herbs;

(c) Raising of crops, grass or garden produce; and

(d) Land used by an agriculturist for the gazing of cattle, but does not include land used for cutting of wood only;

(iii) “Displaced family” means any tenure holder, tenant, Government lessee or owner of other property, who on account of acquisition of his land including plot in the ‘abadi’ or other property in the affected zone for the purpose of the project, has been displaced from such land or other property;

(iv) "Family" means Project Affected Family consisting of such persons, his or her spouse, minor sons, unmarried daughters, minor brothers or unmarried sisters, father, mother and other members residing with him dependent on him for their livelihood.

(v) "Holding" means the total land held by a person as an occupant or tenant or as both.

(vi) "Marginal farmer" means a cultivator with an unirrigated land holding up to one hectare or irrigated land holding up to half hectare.

(vii) "small farmer" means a cultivator with an unirrigated land holding up to two hectares or with an irrigated land holding up to one hectare.

(viii) "Project affected family" means a family/person whose place of residence or other properties or sources of livelihood are substantially affected by the process of acquisition of land for the project and who has been residing continuously for a period of not less then three years preceding the date of declaration of the affected zone or practicing any trade, occupation or vocation continuously for a period of not less than three years in the affected zone, preceding the date of declaration of the affected zone.

(ix) Houseless person means a person who is rendered houseless as a result of acquisition of house under the Land Acquisition Act.

(x) Landless person/Oustees means a person who is holding no land after acquisition, for agriculture purposes whether as an owner or a tenant.

(xi) Eligible person means a person who after acquisition holds less than 5 bighas of land as a land owner or as a tenant.

10.5.4 Compensation for Land Owners

The acquisition of land for the proposed activity shall be in accordance with the provisions of the Land Acquisition Act, 1894 and the compensation shall be paid as per the circle rate approved by the District Magistrate or mutually agreed between project authority, administration and the people and shall be disbursed by land acquisition officer appointed for the purpose. The total private land falling under this category is 11.3895 ha and the compensation is worked out to be Rs-148.61 lakh as shown in **Table 10.27.**

Table 10.27: Details of Affected Private structures and Assets

S.N.	Name of Village	Land To be Acquired (ha)	Cost of land (Rs)
1	Sumen	0.8510	0.30
2	Central Pendam	5.013	1.70
3	Namli	3.2860	78.00
4	Namcheybung	0.9005	39.03
5	Yangtam	1.3390	29.58
Total		**11.3895**	**148.61**

10.5.5 Compensation for Other Assets

Table 10.28: Details of Affected Private structures and Assets

S.N.	Village	Houses		Cattle shed		Total cost
		No.	Cost	No.	Cost	
1	Sumen	0	0	0	0	0.00
2	Central Pendam	0	0	0	0	0.00
3	Namli	0	0	0	0	0.00
4	Namcheybung	0	0	0	0	0.00
5	Yangtam	0	0	0	0	0.00
Total		0	0	0	0	0.00

10.5.6 Elements of Landless Grant for Affected /Eligible persons

In addition to the compensation of land, landless grant be paid to those who are Non-Agricultural Labourer (NAL). Landless grant is basically provided to compensate those who lose land and to enable them financially. The amount of landless grant to be provided for different categories shall be as provided in **Table 10.29.**

Table 10.29: Details ofLandless Grant for Affected /Eligible persons

S.N.	Particular	Grant/family
1	Family with more than 5 bighas of land and rendered landless	50000.00
2	Family with land holding less than 5 bighas rendered landless	45000.00
3	Families who are left with land up to 2.5 bighas	40000.00
4	Families who are left with > 2.5 bighas but < 5 bighas of land	35000.00

10.5.6.1 Grant Disbursement

The Deputy Commissioner, East Sikkim will be the sanctioning authority for rehabilitation grant which shall be provided by the Project Authorities and placed at the disposal of the Deputy Commissioner, East Sikkim for disbursement to eligible persons.

10.5.6.2 Procedure for Applying for Grant

Every head of family will submit his application on the prescribed performa in the office of Land Acquisition Officer, Rongni Chhu H.E.P along with required affidavit, duly attested. Dates within which such applications are to be filed shall be fixed by the Land Acquisition Officer with prior approval of the Deputy Commissioner, East Sikkim (Sikkim).Form of application along with specimen of affidavit shall be supplied to each head of family by the Land Acquisition Officer, Rongni Chhu H.E.P, free of cost.

10.5.6.3 Dispute Mechanism

In case of any dispute of interpretation of the plan, head of the affected family shall file an application before Deputy Commissioner, East Sikkim, whose decision shall be binding and final on both the parties.

10.5.7 Summery of Compensation of Assets Acquired and Grants

As elucidated in Table 10.25, the total private land requirement for the project 212.86 ha. Village wise land acquisition cost in respect of land as per collector's circle rate prevalent for these villages, has been worked out in Table 10.27. Cost of other assets attached to land to be acquired is shown in Table 10.28. The total financial package for 62 PAF loosing land but left with land up to 2.5 bighas and loosing no structures has been summarized in **Table10.30.**

Table 10.30: Summary of Compensation and Grants

S.N.	Particular	Amount(Rs lakh)
1	Compensation for **11.3895**ha land	148.61
2	Compensation for houses	0.00
3	Compensation for Cattle sheds	0.00
4	Compensation for trees	0.00
5	Eligible Person Family Grant for 62 PAF @ Rs 40000/each	24.80
	Total	**173.41**

10.5.8 Local Area Development Plan

In addition to the rightful compensation and R & R package for the project affected families, the project authorities will undertake a plan of infrastructural development in the area which will result in better quality of life for the entire human population of the area. Several such facilities like creation of employment oppurtunities,development of education facilities including strengthening of existing facilities,development of recreation facilities, would be created for the benefit and use of general public residing in the vicinity of the project area.

An amount of Rs.100.00 lakhwas originally kept for development activities for the affected villages in the vicinity of project area. This amount would cover upgradation and strengthening of existing facilities like schools, water and power supply, health care, vocational training centres, recreational/ community centres, etc.Under this head various development works had been carried out and an expenditure of Rs111.00 lakh has been incurred as enumerated in **Table 10.31**.

Table 10.31: Summary of Works Executed Under LADP

Year	Particulars	Amount (Rs.lakh)
2011	Construction of Monastery at Rumtek	2.00
2011	Construction of Nepali Museum at AhoYangtham	0.70
2011	Sponsorship for Football Tournament, Ranipool	0.10
2011	Computer Training Programme to local youth	0.09
2011	Computer Training to local youth, Assam Lingchey	0.07
2011	Renovation of Mandir at Samsing	0.18
2011	Promotion of Sports (Basket Ball) Gangtok	2.00
2011	Promotion of Sports (Table Tennis)	0.20
2011	Promotion of Sports (Volleyball)	0.25
2011	Donation for publishing the Annual School Magazine of Duga	0.30
2011	Connecting road for villagers	1.72
2011	Purchase of furniture for Kalyan Samaj at Sumin	0. 43
2012	Celebrating Cultural Programme for orphans and old age people	0.06
2012	Social welfare for youths of Namli village	0.20
2012	Construction of Mandir at Takchang	0.25

2012	Development of super football tournament Gangtok	0. 30
2012	Donated Cement & Steel for construction of Shiva Mandir at Linchey	0.82
2012	Social Welfare to Sikkim Police – Renovation of SDPO's Office	2.11
2012	Donation of Household items for Surya Development Sangh, Namli.	0.23
2012	Purchase of Furniture Items for Surya Development Sangh, Namli	0.11
2012	Construction of Temple at Zitlang	0.70
2012	Sposorship for anti-Drug abuse musical concert at Rangpo	0.20
2012	Drinking water supply at Nimtar	3.75
2012	Donation towards Construction of Community Centre at Duga	8.00
2012	Drinking water supply at Sumin	12.89
2012	Promotion of Sports at Namli (Barrage Area)	0.10
2012	Construction of Auditorium At Rangpo	1.00
2012	Supply poly pipe at Nimtar for Drinking Water	0.13
2012	Promotion of Table Tennis	0.50
2012	Promotion of Football	0.10
2013	Musical & culture event at SingtamBazar by Frozen Band	0.05
2013	Promotion of Marathon Race	0.05
2013	Provided CGI Sheet for BDO Office, Duga	0.58
2013	Mid Day Meal Shed constructed at Sumin	5.43
2013	GI Pipes Supply at Nimtar for Drinking water	0.92
2013	Encouragement to Brilliiant Student for Sumin	0.25
2013	Donated chairs to SagarmathYuva Pratibha Club	0.26
2013	Construction/maintenance of Mandir at Namli	4.14
2013	Construction of Water Tank at Mangthang	1.35
2013	Furniture and Stationary supply for Samdur Primary School	0.70
2014	Construction of Rural Water Supply for Kalikhola, West Pendam	8.92
2014	Maintenance of approach road for BDO Office, Duga	0.26
2016	Donation for purchasing furniture at Lower Sumin School	0.50
2016	Donation towards construcionof wall at Panchayat Bhavan, Duga	1.00
2016	Donation for BethalChristan Fellowship church, Duga	0.50
2016	Donation for Renovation of Shiva Mandir at Lower Sumin	1.24
2016	Renovation of Sassi Devi Nag Mandir at Lower Sumin	0. 24
2017	School Ground Fencing at Rongneck Jr. High School	3.92
2017	Contribution for National Bedminton Tournament event at Sikkim	0.40
2017	Construction of 10 Unit Toilet at Tika LallNiroula Govt. Sr. Sec School, Central Pendam	4.03
2017	Donation for STNM Hospital for Centenary Celebration	0. 30
2017	Construction of Cremation Shed and CC footpath at Mazitar, Rangpo	6.81
2017	Renovation of School Building and Midday meal shed of Govt. Sec. School, Lower Sumin	1.93
2017	Construction of stage at Govt. Sec. School Duga	3.45
2018	Ten Minutes to Earth Programme	0.10
2018	Award of MBPCL Student Scholorship for 24 months for Class-X & XI	2.40
2018	Construction of three unit toilet at Govt. Jr. High School, Sumin	2.76
2018	Construction of CC footpath at Namli	6.56
2018	Contribution for Durga Puja Celebration at Mazitar	0.20
2018	Contribution for Duga Residential Winter Coaching Camp	1.00
2018	Construction of CC footpath at Samsing	2.50
2018	Construction of waiting shed at Sangkhola	1.50
2018	Contribution for Rabong Cho-Dzo-fest	1.00
2018	Financial Aid for Arithang Social Welfare Association -Destitute Home	2.00
2019	Contribution for Winter Coaching Camp at Duga Secondary School	0. 50
2019	Construction of Garden in IRB complex, Pangthang	0. 20
2019	Support for purchase furnitures at Govt. School, Adampool	0. 25
2019	Contribution to DC/East Account for social works	1.00

2019	Contribution for Pilgrimage tour for Kamarey Villagers	0.25
2019	Construction of Church at Upper Mangthang	3.61
2019	Renovation SDPO Office at Rangpo	0.50
	Total	**110.83**

10.5.9 Summary of Cost

The cost because of implementing Rehabilitation and Resettlement Plan including the cost of land acquisitionand the cost of infra-structure Development works out to Rs 284.00 lakh and is presented in **Table 10.32**

Table 10.32: Total Cost under R&R Plan

S.No.	Particular	Amount (Rs lakh)
1	Land Acquisition Cost	148.61
2	Eligible Family Grants	24.80
3	Tribal Plans	0.00
4	Cost of Infra-Structure Development in R&R site	110.83
Total		**284.24**
Say		**284.00**

10.6 GREEN BELT DEVELOPMENT PLAN

10.6.1 Introduction

While improving the aesthetic of the area the greenbelt though functioning as pollutant sinks while scavenging pollutants, also incidentally help in developing habitats for birds and animals. The plants in their function as scavenger of pollutants are also prone to suffer toxicity of air pollutants like any other living organism. In order to mitigate and minimize environmental impacts from air pollution, noise pollution, soil erosion etc. arising due to construction of project, greenbelt development around the project sites is a good option. Green canopy not only absorbs some of these pollutants but also improves the environment. Therefore, a "Green Belt Development Plan" by using the local species has been proposed around the project area, colonies and the project roads

10.6.1.1 Development of Greenbelt

The green belt is proposed to be developed within the project area around reservoir periphery, along the network of new roads/approach roads, residential areas and other working areas like crushing and aggregate processing plant, batching plant and workshops.

Green belt around the reservoir would be created to avoid erosion of soil and prevention of land slips from the banks. The green belt will start from the immediate vicinity of the reservoir rim on both the banks, where moderate slopes are available for plantation. The average width of the green belt will be around 20 m varying depending upon the physiographic and land features and the area shall be about 5 ha. In areas wherever, private land falls along the periphery of the project area the plantation will be done by distributing saplings free of cost to villagers, so that they are motivated to take up plantation in their land.There would be at least 3 layers of plantation. Water loving speciespreferably *Salix alba, S. acmophylla,Populus alba* and *P. ciliata* will be planted in the row nearest to the reservoir rim. The soil present at this level and the air moisture are favourable for the survival and growth of these species. Species like *Terminalia myriocarpa, Punicagranatum, Grovelliarobusta, Juglans regia*will occupy the middle portions of the green belt. These species have been observed to thrive well in this area. In the outermost layer of the green belt, *Grevelliarobusta, Ficus sp., Amomum subulatum* and *Dendrocalamusstrictus*will be planted.

The area for green belt development around reservoir rim shall be about 5 ha over which 5500 saplings would be planted. Along the new roads and approach roadsplantation will be done on both sides where ever feasible as such plantation of about 1500 saplings will be done. Plantation along roads must consider visibility aspects on curves so as to ensure safe driving. Plantation (200plants) around the colony and office complexes is proposed to be done so that greenery is developed. Precaution should be exercised by not planting large size trees around buildings and other similar structures as during winter the sun rays are obstructed by them invariably and much wanted sunshine is impaired.

The schematic arrangement of greenbelt development proposed along the roads and office/colony is presented in **Figure 10.10**.

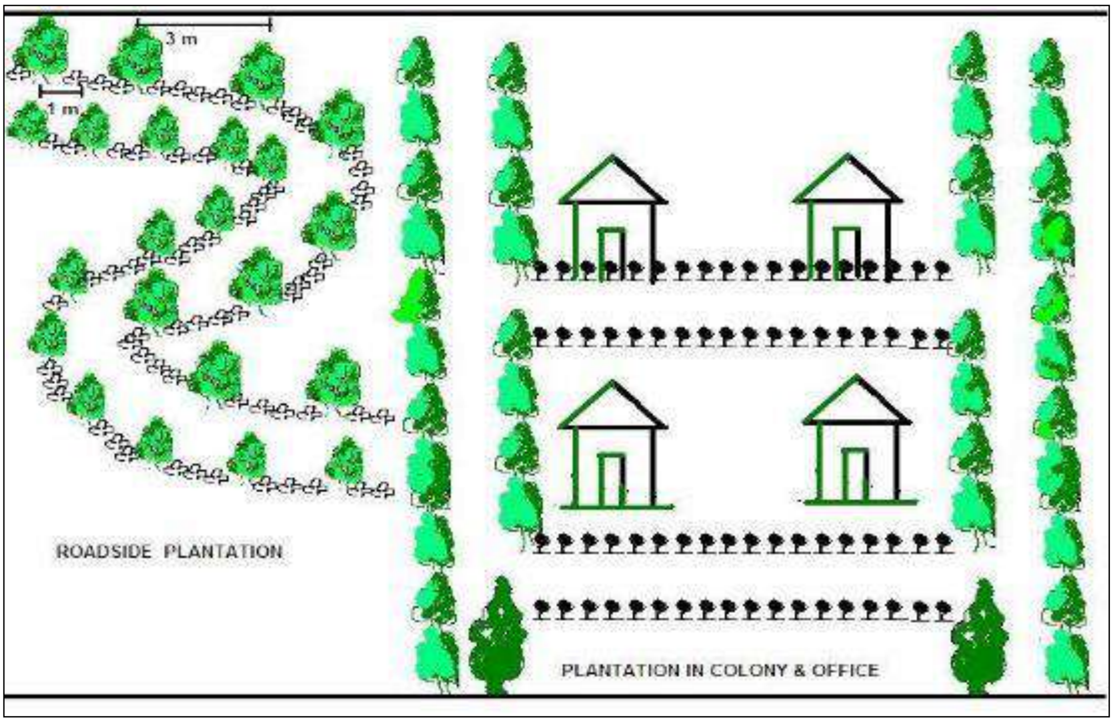


Figure 10.10: Schematic Arrangement of Greenbelt Plantation

10.6.1.2 Strategy for Greenbelt

The green belt is proposed to be developed within the project area around reservoir periphery, along the network of approach roads, residential areas and other working areas like crushing and aggregate processing plant, batching plant and workshops. The strategy worked out for development of green belt consists of the following:

- The species selected should be capable of growing fast,
- The species should be wind firm and long lived.
- Broad leaf trees growing above 10 m in height should be planted along the roads, offices and infrastructure facilities.
- The species should form a dense crown cover.
- The species should form a litter in abundance on the plantation flow.
- Generally local/indigenous fast-growing trees shrubs should be planted.
- The trees should be protected by plantation of non-palatable shrub species to avoid browsing by animals.
- Placement of tree guards (metal tree guard, pre-fab RCC tree guard, Fiber tree guard etc.), should be provided to save avenue plantation.
- For protection against biotic interference thorn fencing around the plantation, circular trench around the planting pit and sown with fast growing thorny shrubs on the ridge should be followed'

10.6.1.3 Size of Nursery

The total requirement of saplings shall be approx. 8000.To produce and maintain plants a nursery of about 0.1 ha area would be required. Keeping in view the small requirement of saplings it is proposed to be purchase them from nearby Forest Nursery over the complete duration of the plan

10.6.1.4 Nursery Site Selection

A well-drained site near the areas where plantation is to be carried out is always preferred. Light shading site for the nursery is important for protection of the seedlings against sun, frost, hailstorms or heavy rains. Sites shall be selected in consultation with Forest Department preferably near the existing one and such sites which are prone to water logging, should not be selected sites. Modernization of existing nursery may also be explored.

10.6.1.5 Transportation

The nursery should be readily accessible all the year round in order to facilitate transportation of materials required in the nursery and dispatch of seedlings from the nursery.

10.6.1.6 Fertilizer Application

The organic fertilizer produced through domestic organic waste coupled with vermin-compost can be utilized for the nursery. Farmyard manure (FYM) can also be used but chemical fertilizer should be avoided. The compost / vermin-compost, proposed to be developed through solid waste management, shall be used.

10.6.1.7 Soil and Soil Fertility

The best site for raising the nursery is the area, which has got a thick layer of humus. The fertile and well-drained soil with sandy loam to loamy texture, pH varying from 6.5-7.5 should always the preferred for nursery sites.

10.6.1.8 Water Supply and Drainage

The site should have perennial water supply. The drainage of soil has important bearing on the health of seedlings.

10.6.1.9 Precautions during Plantation

Some important precautions should be taken during the plantation, which are as under:

- Open grazing is practiced in general in the area; therefore, protection should be provided in advance.
- Polyculture should be practiced. Mixture by group should be preferred over intimate mixture.
- The species mentioned should be planted in sufficient numbers so as to increase their population size in the area.
- Multipurpose species should be planted in large numbers, so as to provide direct benefit to people living around.

10.6.1.10Species to Be Planted

To maintain the scenic beauty of the Reservoir/ pond, the most basic would be Planting Zone B for shorter plants in the middle of the greenbelt and Zone A for taller plants on the edges. Zone C, immediate vicinity of the reservoir comprised with water-loving plants. The development of water dependent vegetation along the shoreline is beneficial for water birds and mammals. Plant species which are economically important, perfect soil binder, sustained in high humid and flood conditions will be chosen for plantation. Fruit bearing species would also be encouraged to plant in order to provide food for birds and other animals.

- ZoneA (Outermost strip of Greenbelt): *Salix alba, S. acmophylla, Populus alba* and *P. ciliata*
- Zone B (Middle strip of Greenbelt):Terminalia myriocarpa, Punicagranatum, Grovelliarobusta, Juglans regia
- Zone C (Immediate vicinity if reservoir): *Grevelliarobusta, Ficus sp., Amomum subulatum*and *Dendrocalamusstrictus*

10.6.2 Green Belt Development

In order to raise the green belt around project area and roads, the total requirement of different species of plants will be 8000 saplings. Since the green belt is to be created over a period of five years the maintenance for a period of five years of nursery and plantation works will be required. The beating up of mortality may be done with the plant stocks proposed to be purchased from nearby Forest Nursery over the complete duration of the plan.

10.6.2.1 Road side plantation

Cost of the plantation has been calculated as per the existing schedule of rate, material cost (plants, FYM, tree guard, etc.) and the total area of treatment. One row each for tree, shrub and bio-fencing has been proposed with a spacing of 3 m x 3 m for trees and 2 m x 2 m for shrubs (to take care of the mortality in the next season). The pit size has been recommended as 45 x 45 x 45 cm for trees and 30 x 30 x 30 cm for shrubs. For the protection of trees from the cattle and other losses, tree guards are required. Along the approach roads plantation will be done on both sides whereverfeasible. Plantation along roads must take into account visibility aspects on curves so as to ensure safe driving. The view of avenue plantation carried out is shown in **Figure10.11**.

Figure 10.11: Photographic View of Avenue Plantation

10.6.2.2 Green Belt around Residential Area and Office Complex

Plantation around the office complexes is proposed to be done so that greenery is developed. Precaution should be exercised by not planting large size trees around buildings and other similar structures as during winter the sun rays are obstructed by them invariably and much wanted sunshine is impaired. Besides this, it is also proposed to develop green belt around the working areas for trapping the dust and noise. Plantation of avenue, ornamental and fruit trees is proposed in these areas along with the area around office complex. The ornamental, fruit plants will be procured from the local market while the avenue plants will be raised in the project nursery.

10.6.3 Cost Estimate of Green Belt Development

The itemized summery of cost for green belt development is presented in **Table 10.33**

Table 10.33: Summary of Cost for Green Belt Development

S. N.	Component	Cost (Rs lakh)
1.	Plantation around reservoir rim area over 5 ha @ Rs. 1.50 lakh/ha	7.50
2.	Cost of planting 1500 saplings along road side @ Rs.250/No	3.75
3.	Plantation of 200 saplings@ Rs.250/No around colonies and office complex	0.50
4.	Maintenance cost for 3 years – 1 chowkidar @ Rs. 8000/- per month	2.88
Total		**14.63**
Say		**15.00**

10.7 RESERVOIR RIM TREATMENT PLAN

10.7.1 Introduction

The reservoir behind the proposed 14 m high barrage shall also extend to about 1.0 km into Rongni Chhu.Due to the project, a sudden change shall be brought about in the existing riverine scenario to lacustrine condition. The toe of hills towering over the river bed shall be subjected to elevated water surface level, due to the reservoir. The rock mass which had not experienced the flow of river before shall be subjected to hydraulic conditions apart from many other direct and indirect factors responsible for instability of land masses. All such factors that facilitate sliding in one way or the other can be grouped into two headings i.e. internal and external factors.

The internal factors include those which tends to reduce the shearing strength of the rocks, the water content of the rock masses, their mineralogical composition and metrological character, structural features and the state of stress are important internal factors. External factors include mainly vibrations naturally by either an earthquake or artificial due to heavy traffic and rock blasting. Besides these, removal of support at the foot of the slope i.e. toe failure by high velocity of flow is another cause. Water charging of soil strata due to water storage reduces coefficient of friction causing landslide or slope failures.

The main objective underlining the plan is to adequately check the debris flow into the reservoir, to carry out the toe and surface treatment of the active and potential landslides besides providing protection to the foundation of the house / structures near to the FRL.

10.7.2 Treatment Measures for Landslide Prone Zone

Rongni Chhu during its course through the proposed reservoir area flows through a u-shaped valley, which has agricultural fields on either bankThe project reservoir is neither prone to landslides nor any active slide is present in the project area and thus, landslide/landslip treatment is not warranted.

10.7.3 Treatment Measures for Reservoir Rim

Green belt around the reservoir would improve the stability of banks, provides protection against water waves, converts the water area into landscape, protects against soil erosion, enhances the quality of water for aquatic animals, and provide would and timbre. The area for green belt development around reservoir rim shall be about 5 ha for which a provision of Rs 7.50 lakh @ Rs 1.50 lakh/ha has been earmarked in chapter captioned as green belt development.

10.7.4 Protection of Houses / Fields

The human settlements and agricultural fields at some villages are very close to FRL of reservoir. Therefore, such places need protection for their land and houses for which it is proposed to construct retaining wall along the stretch of reservoir at potentially vulnerable places having a combined length of about 0.200 km as depicted in Table 10.44. The cost of protection walls (R.R. Stone masonry in C.M.1:5) of 3m height has been assessed as Rs. 11.00 lakh and is shown in Table **10.34.**

Table 10.34: Cost of Protection Walls

S. No	Particulars	Quantity	Unit	Rate	Amount (Rs lakh)
1.	R.R. Stone Masonry in Cement Mortar 1:5 with 0.3 m thick M-10 grade c.c.in foundation CC M-10 grade 200 x2 x0.3	120	cum	2500	3.00
	R.R. Stone Masonry in C.M. 1:5 200 X 0.5 (0.6+1.6) X 3.0 =660 cum	660	cum	1200	7.92
Total					**10.92**
				Say	**11.00**

10.8 MUCK MANAGEMENT PLAN

10.8.1 General

The excavation shall result in large quantity of excavated material i.e. muck which shall have to be evacuated, disposed of and roller compacted or laid on mild slopes *pari-passu* with the excavation work, to such designated areas where the muck piles do not substantially interfere with either environment / ecology or the river flow regime and cause turbidity impairing the quality of water. In the present case, the total quantity of muck / debris, to be generated due to the project, shall be 5.16 lakh cumof which 1.90lakh cum shall be consumed on project work leaving 3.26 lakh cum, which with 45% swell factor shall amount to 4.72 lakh cum, to be disposed-off away from sites so as to make available the clear site for construction activities. Component wise details of the muck generated is given in **Table-10.35**.

Table 10.35: Component Wise Details of the Muck Generated and its Management

S. N.	Project Component	Soil (cum)	Rock (cum)	Total (cum)	Muck to be utilized (cum)	Balance Quantity ofMuck (cum)
1	Barrage	20298	1015	21313	7890	13423
2	Desilting Chamber	0	57809	57809	21390	36419
3	HRT	0	211336	211336	78195	133141
4	Adits	0	40200	40200	14875	25325
5	Surge shaft	1598	9448	11046	4090	6956
6	Pressure Shaft/Penstock	0	4747	4747	1757	2990

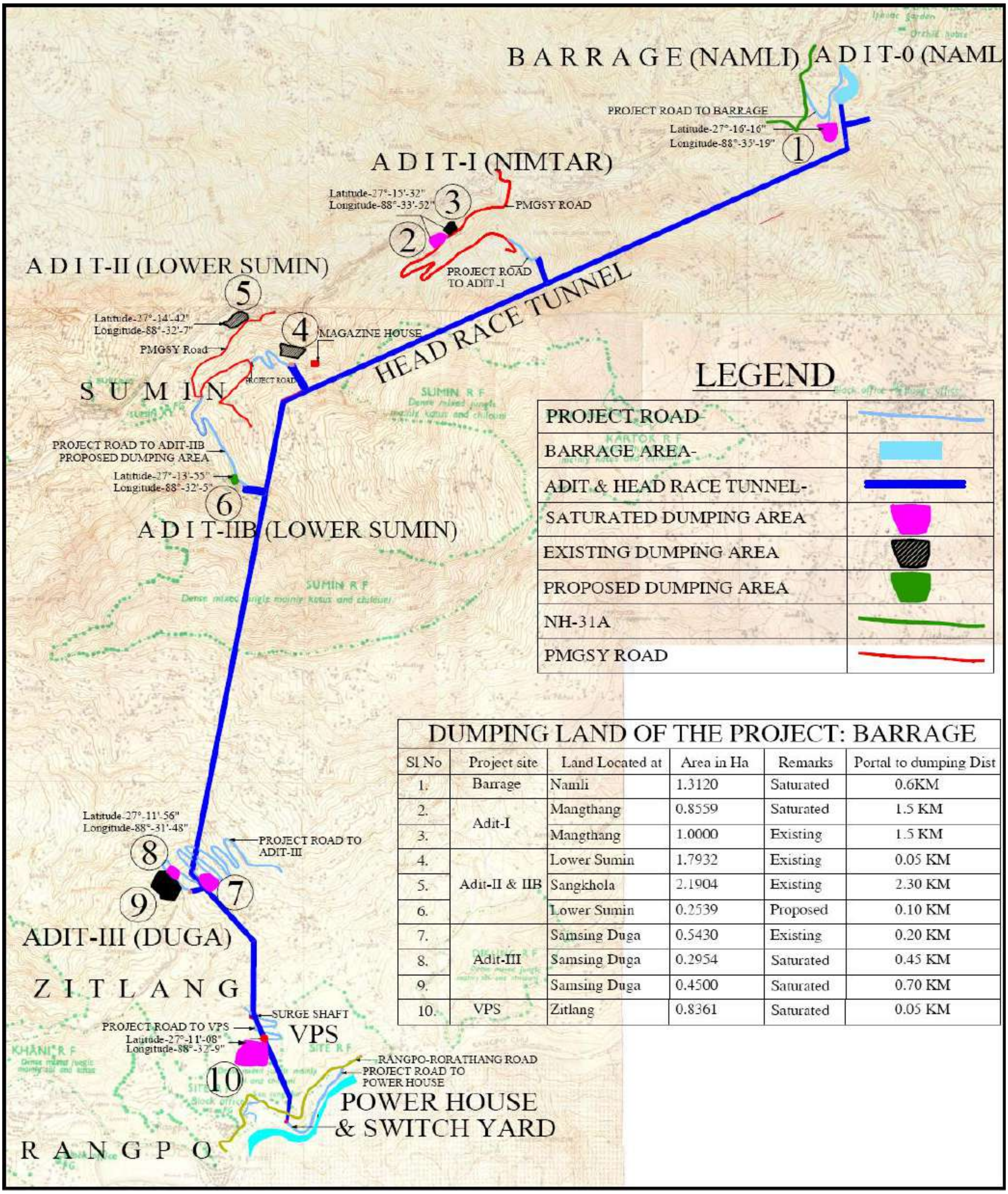
7	Powerhouse	8000	40800	48800	17533	31267
8	TRC	2500	300	2800	1036	1764
9	Switchyard	0	118000	118000	43660	74340
Total		**32396**	**483655**	**516051**	**190426**	**325625**

10.8.2 Details of Muck Disposal Sites

The details of ten muck disposal sites with their total capacity and quantity of muck disposed is given in **Table 10.36** and layout map showing muck sites is shown in **Figure 10.12.**

Table 10.36: Details of the Muck Dumping Site and Muck Management

Sl. No	Project Site	Muck disposal site	Status	Area (ha)	Capacity of dumping (Cum)	Quantity of muck dumped
1	Barrage	Namli	Saturated	1.3120	160000	142000
2	Adit-I	Mangthang	Saturated	0.8559	56000	48000
3		Mangthang	Saturated	1.0000	65000	50420
4	Adit-II	Lower Sumin	Saturated	1.7932	96531	68320
5		Sangkhola	Saturated	2.1904	56946	52216
6	Adit-IIB	Lower Sumin	Saturated	0.2539	11306	7090
7	Adit-III	SamsingDuga	Saturated	0.5430	27000	25479
8		SamsingDuga	Saturated	0.2954	26800	26800
9		SamsingDuga	Saturated	0.4500	35000	25032
10	VPS	Zitlang	Saturated	0.8361	26800	26800
Total				9.5299	561383	472157



DUMPING LAND OF THE PROJECT: BARRAGE

Sl No	Project site	Land Located at	Area in Ha	Remarks	Portal to dumping Dist
1.	Barrage	Namli	1.3120	Saturated	0.6KM
2.	Adit-I	Mangthang	0.8559	Saturated	1.5 KM
3.		Mangthang	1.0000	Existing	1.5 KM
4.	Adit-II & IIB	Lower Sumin	1.7932	Existing	0.05 KM
5.		Sangkhola	2.1904	Existing	2.30 KM
6.		Lower Sumin	0.2539	Proposed	0.10 KM
7.	Adit-III	Samsing Duga	0.5430	Existing	0.20 KM
8.		Samsing Duga	0.2954	Saturated	0.45 KM
9.		Samsing Duga	0.4500	Saturated	0.70 KM
10.	VPS	Zitlang	0.8361	Saturated	0.05 KM

Figure 10.12: Location of Muck Disposal Sites

10.8.3 Description of Muck Disposal Sites

10.8.3.1 Muck Disposal Site D-1

The muck disposal sites D-1 is located near village on left bank of Rongni Chhu, about 0.2km d/s of barrage. It is approachable from barrage through project road. The area of muck disposal site is 1.312 ha It has capacity to store 1.60 lakh cum of muck against which 1.42 lakh cum has been dumped and the site has been stabilized by vegetation.The general view of the site is shown in **Figure 10.13.**

Figure 10.13: Photographic View of Muck Disposal Site-1

10.8.3.2 Muck Disposal Site D-2

The muck disposal sites D-2 near Adit -I is located near Mangthang village about 1.5km from portal. It is approachable through project road. The area of muck disposal site is 0.8559 ha It has capacity to store 0.56 lakh cum of muck against which 0.48 lakh cum has been dumped and the site has been stabilized by vegetation .The general view of the site is shown in **Figure 10.14.**

Figure 10.14: Photographic View of Muck Disposal Site-2

10.8.3.3 Muck Disposal Site D-3

The muck disposal sites D-3 near Adit -I is located near Mangthang village about 1.5km from portal. It is approachable through project road. The area of muck disposal site is 1.0 ha It has capacity to store 0.65 lakh cum of muck against which 0.50420 lakh cum has been dumped and the site has been stabilized by vegetation .The general view of the site is shown in **Figure 10.15.**

Figure 10.15: Photographic View of Muck Disposal Site-3

10.8.3.4 Muck Disposal Site D-4

The muck disposal sites D-4 near Adit -II is located near Lower Sumin village about 0.05km from portal. The area of muck disposal site is 1.7932 ha It has capacity to store 0.96531 lakh cum of muck against which 0.68320 lakh cum has been dumped and the site has been stabilized by vegetation .The general view of the site is shown in **Figure 10.16.**

Figure 10.16: Photographic View of Muck Disposal Site-4

10.8.3.5 Muck Disposal Site D-5

The muck disposal sites D-5near Adit -II is located near Sangkhola village about 2.30 km from portal. The area of muck disposal site is 2.1904 ha It has capacity to store 0.56946 lakh cum of muck against which 0.52216 lakh cum has been dumped and the site has been stabilized by vegetation .The general view of the site is shown in **Figure 10.17.**

Figure 10.17: Photographic View of Muck Disposal Site-5

10.8.3.6 Muck Disposal Site D-6

The muck disposal sites D-6 near Adit -II B is located near Lower Sumin village about 0.10 km from portal. The area of muck disposal site is 0.2539 ha It has capacity to store 0.11306 lakh cum of muck against which 0.0709 lakh cum has been dumped and the site has been stabilized by vegetation .Thelocation of the site is shown in **Figure 10.18.**

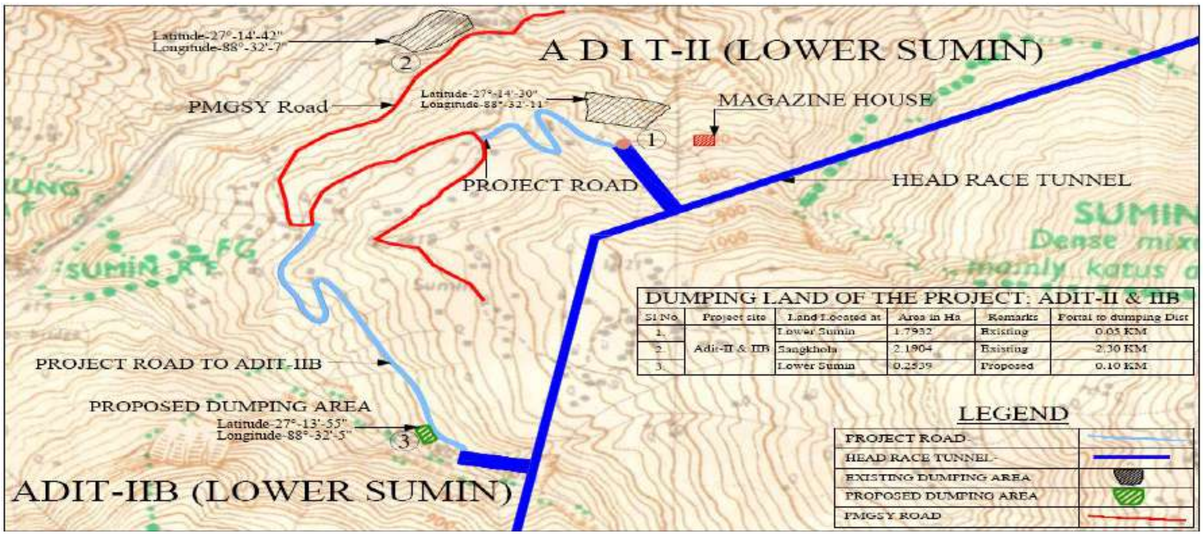


Figure 10.18: Location of Muck Disposal Site-6

10.8.3.7 Muck Disposal Site D-7

The muck disposal sites D-7 near Adit -III is located near SamsingDuga village about 0.20 km from portal. The area of muck disposal site is 0.543 ha It has capacity to store 0.270 lakh cum of muck against which 0.25479 lakh cum has been dumped and the site has been stabilized by vegetation .The general view of the site is shown in **Figure 10.19.**

Figure 10.19: Photographic View of Muck Disposal Site-7

10.8.3.8 Muck Disposal Site D-8

The muck disposal sites D-8 near Adit -III is located near SamsingDuga village about 0.40 km from portal. The area of muck disposal site is 0.2954 ha It has capacity to store 0.268 lakh cum of muck against which 0.268 lakh cum has been dumped and the site has been stabilized by vegetation .The general view of the site is shown in **Figure 10.20.**

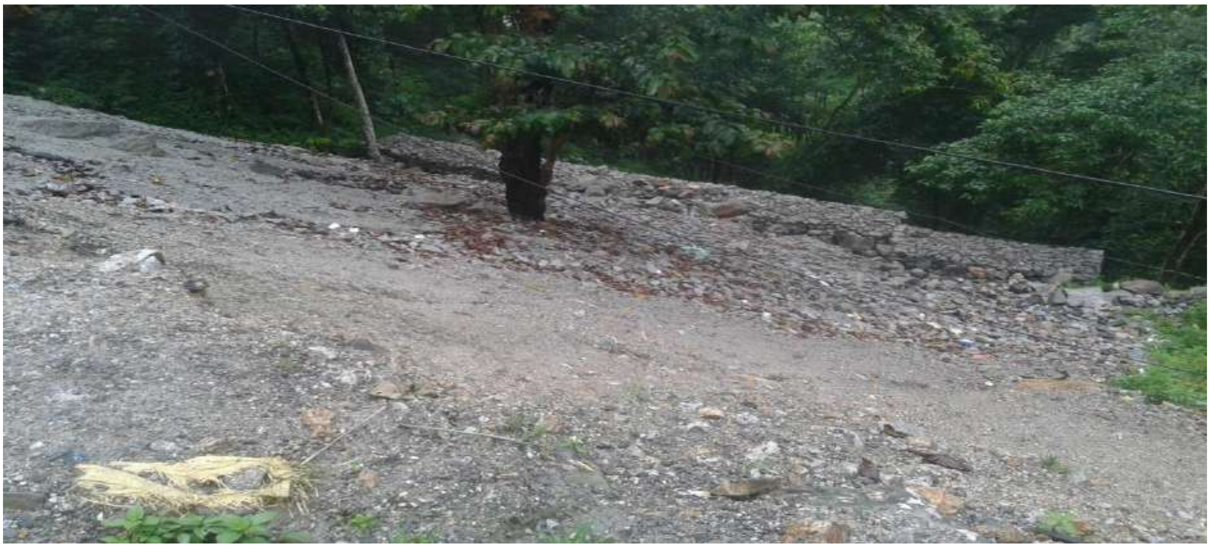


Figure 10.20: Photographic View of Muck Disposal Site-8

10.8.3.9 Muck Disposal Site D-9

The muck disposal sites D-9 near Adit -III is located near SamsingDuga village about 0.70 km from portal. The area of muck disposal site is 0.45 ha It has capacity to store 0.35 lakh cum of muck against which 0.25 lakh cum has been dumped.The general view of the site is shown in **Figure 10.21.**

Figure 10.21: Photographic View of Muck Disposal Site-9

10.8.3.10 Muck Disposal Site D-10

The muck disposal sites D-10 near VPS is located near Zitlang village. The area of muck disposal site is 0.8361 ha It has capacity to store 0.268 lakh cum of muck against which 0.268 lakh cum has been dumped.The general view of the site is shown in **Figure 10.22.**

Figure 10.22: Photographic View of Muck Disposal Site-10

10.8.4 Implementation of Engineering & Biological Measures

As already explained engineering measures like providing retaining walls and compaction of muck will provide stability to the profile of muck piles. Later on, suitable top soil amended with bio-fertilizers shall be laid on top of muck piles and vegetated.

10.8.4.1 Engineering Measures

It has been observed that after excavation the disposal of muck creates problem as it is susceptible to scattering unless the muck disposal yards are supported with engineering measures such as retaining structures, crate walls and gabions. All the dumping sites need proper handling to avoid spilling of muck either on the adjoining and or into the river water while dumping and in the post dumping stages.

The muck disposal sites shall have to be developed from below the ground level by providing boulder wire crates of 5 SWG wire with 10 cm x 10 cm mesh size and in dimension 2.5m x 2.25 m x 3.0 m. It is proposed to provide three tiers of boulder wire crates with 2.5 m berm width. After placing of first tier of crates at the toe of muck disposal site, the muck brought in dumpers shall be dumped and manually spread behind the crates in such a manner that rock mass is properly stacked behind the crates with minimum of voids.The slope surface shall be developed by turfing. Intermediately wire crates shall also be erected to support dump material at different elevations in case of increased dump height.After construction of retaining wall, the muck brought in dumpers shall be dumped and manually spread behind the wall. The muck shall be laid with vertical angle not exceeding 40^0 in such a manner that rock mass is properly stacked behind the wall with minimum of voids. The typical cross section of gabion structure is shown in **Figure10.22.**

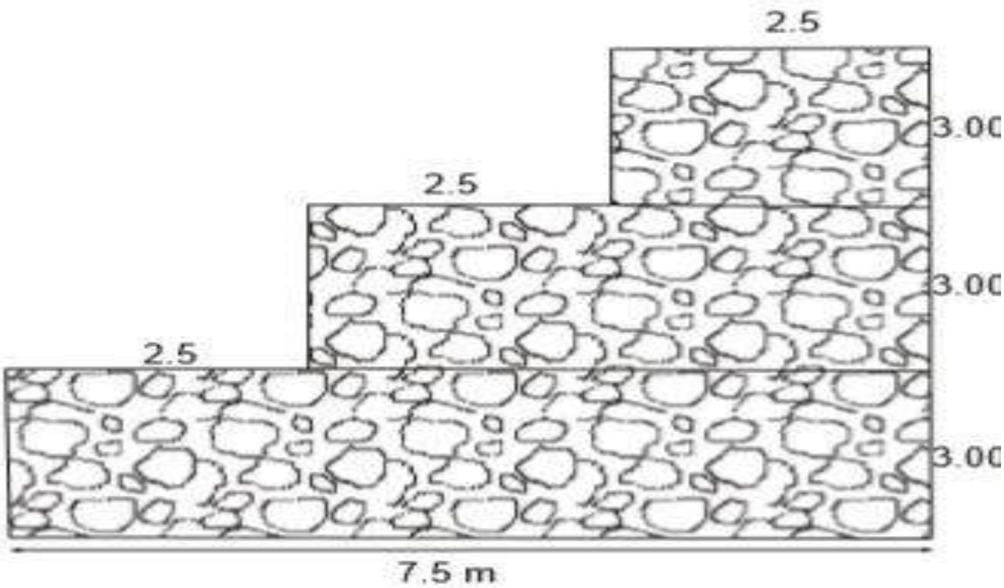


Figure 10.23: Typical Cross Section of Gabion Structure Provided at Toe

10.8.4.2 Biological Measures

Biological measures, however, require special efforts as the muck disposed in disposal yards will in general be devoid of nutrients and soil contents to support vegetation. The selection of soil for spreading over such an area would require nutrient profiling of soil for different base elements. The work plan formulated for revegetation of the dumping sites, through 'Integrated Biotechnological Approach', is based on following parameters: i) Evaluation of dumped material for their physical and chemical properties to assess the nutrient status to support vegetation. ii) Formulation of appropriate blends of organic waste and soil to enhance the nutrient status of rhizosphere. iii) Isolation and screening of specialized strains of mycorrhizal fungi, rhizobium, azotobacter and phosphate solubilizers (bio-fertilizers inoculum) suitable for the dumped material. iv) Mass culture of plant specific biofertilizer and mycorrhizal fungi to be procured from different institutions/organisations which are engaged in the phyto-remediation activity of degraded areas. v) Plantation of dumping sites/areas using identified blend and biofertilizer inoculum. Suitable ad mixture of nutrients would be done before placing the soil on the top surface of muck disposal areas to have administered growth of forest canopy.

10.8.4.3 Plantation Technique

In view of the peculiar site conditions particularly the soil conditions, the planting technique for all the categories of the plants has to be very site specific and suited to the stress conditions as anticipated and discussed above. The planting substrates would need to be considerably improved to support the plants in their initial stages of establishment. The moisture retention capability, availability of nutrients and soil aeration, permeability and porosity would require intervention and assistance.

Multistoried and multipurpose plantations are proposed to be raised on the muck dumping sites as also in road side strips using grasses, shrubs and bushes in the under story and trees in the upper story. Nursery raised grass slips, seedlings of shrubs & bushes and tree species would be planted in the area combined with grass sowing in patches. In addition, cuttings of bushes and shrubs can also be planted to supplement the nursery raised stock but this would substitute requirement of raising the nursery of these species. Intimate mixture of species would be avoided right at the planning stage and would be strictly followed during planting. Each patch should contain maximum of two species. Grasses would be mixed by groups in rows, shrubs and bushes by group again in rows.

Grass slip planting and grass seed sowing would be done in strips at 0.10 m x 0.10 m spacing in the prepared staggered patches of 1 m x 0.5 m with a depth of 0.30 m. Soil mixture would be used while filling the patches. Balance dug up soil/muck will be stacked along the patch on the downhill side for rain water tapping and enhanced percolation in the patch. Number of such patches in each hectare is proposed at 500.

Shrubs and bushes would be planted in elongated strips of 1.5 m x 0.5 m with a depth of 0.45m. Soil mixture would be used while filling the patches. Balance dug up soil/muck will be stacked along the patch on the downhill side for water tapping and better percolation in the patch. These would be staggered throughout the area numbering 500 per hectare. Each patch would have two rows of planting with staggered spacing between plants in a row as 15 cm and distance between rows as 15 cm.

Planting of trees would be done in contour staggered pits of 0.60 m x 0.60 m x 0.60 m size numbering 800 per hectare. Out of these 800 plants, about 200 plants per hectare are meant for planting along the periphery of the area. If the periphery gets filled up with lesser numbers, the remainder would be planted in the core/main area. Soil mixture would be used while filling the pits. Balance dug up soil/muck will be stacked on downhill side of the pit for trapping the rain water and allowing it to percolate in the pit.

It is proposed to use soil mixture in the pits & patches consisting of soil imported from nearby areas mixed with compost or human or vermin-compost or all of these. The ratio for the mix would be 5 parts: Compost/manure 2 parts: Sand 2 part: and humus or vermin-compost 1 part. This will make nutrients really available for the plants in the preliminary stages and also help increase soil aeration, porosity & permeability and improved moisture available for the plants.

The stabilization sites from the time of execution of biological measures would be protected with barbed wire fencing on 2m high RCC posts and provided with inspection paths. Since the muck dumping sites are being provided with either RCC walls or the wire crate (gabion) wall on the valley side (towards river) which is not negotiable by animals and human beings, fencing would not be required along the entire perimeter. Hence, it would be done on the vulnerable sections i.e. towards the hillside only.

The proposed costs include nursery costs for initial planting and also for mortality replacement.

The biological measures shall be taken up towards the end of construction. The plantations would be maintained for a period of 5 years by irrigating the plantation during dry seasons, mortality replacement and repair of fencing & inspection paths within the area. The task of irrigation would be performed by the watch & ward (chowkidar) provided in the cost estimate.

10.8.5 Species for Plantation

The afforestation with suitable plant species of high ecological and economic value and which can adapt to local habitat will be undertaken at the rate of 1100 plants per ha depending upon the canopy cover required. Major tree species which would be planted *are Schimawallichii, Castanopsishystrix, Alnus nepalensis, Terminalia myriocarpa, Prunus sp.* and *Grevillea robusta.* The shrubs would include *Rosa moschata, R. brunonii, Berberis aristata, Cotoneaster bacillaris, Mahonia napaulensis* etc. The perennial grasses layer would comprise of *Dendrocalamushamiltonii, D. strictus and Thysanolaenalatifolia.* These perennials show good growth on rocks and on open slopes. The leguminous species would include *Robiniapsuedoacacia, Leucaena leucocephala, Trifoliumrepens*, etc

10.8.6 Cost Model for Plantation

The cost model for plantation on muck dumping sites is given in **Table-10.37**.

Table 10.37: Cost Model for Plantation on Muck Dumping Sites (For One-hectare Area)

S. No.	Particular	Qty.	Unit	Rate (Rs.)	Amount (Rs.)
A.	PALANTATION:				
(1)	GRASS SLIP PLANTING AND GRASS SEED SOWING:				

S. No.	Particular	Qty.	Unit	Rate (Rs.)	Amount (Rs.)
1	Preparation of soil mixture (soil, sand, humus & compost) including digging, purchase, carriage to the site of work and mixing at site.	75.00	Cum.	850.00	63750
2	Digging of staggered patches 1 m x 0.50 m x 0.30 m @ 500 patches/ha.	75.00	Cum.	50.00	3750
3	Filling of staggered patches with imported soil mixture.	75.00	Cum.	15.00	1125
4	Extraction of grass slips from nursery beds @ 50 slips per patch.	25000	Per Slip	0.12	3000
5	Carriage of grass slips from nursery to work site.	25000	Per Slip	0.15	3750
6	Planting of the extracted grass slips in above patches @ 50 slips per patch.	25000	Per Slip	0.18	4500
7	Cost of grass slips (in nursery).	25000	Per Slip	0.5	12500
8	Purchase of grass seeds @ 5 gm. Per patch.	2.50	Kg.	115.00	288
9	Sowing of grass seeds in furrows in each patch.	500	Patch.	2.50	1250
TOTAL					**93913**
(II)	**SHRUBS AND BUSHES PLANTATION:**				
1	Preparation of soil mixture (soil, sand, humus & compost) including digging, purchase, carriage to the site of work and mixing at site.	168.75	Cum.	850.00	143438
2	Digging of elongated patches 1.5 x 0.50 m x 0.45 m @ 500 patches/ha.	168.75	Cum.	50.00	8438
3	Filling of elongated patches with imported soil mixture.	168.75	Cum.	15.00	2531
4	Extraction of shrubs & bushes from nursery beds @ 50 per patch.	25000	Per plant	0.15	3750
5	Carriage of shrubs & bushes from nursery to work site.	25000	Per plant	0.15	3750
6	Planting of the extracted shrubs & bushes un above patches @ 50 per patch.	25000	Per plant	0.20	5000
7	Cost of shrubs & bushes (in nursery).	25000	Per plant	1.00	25000
	TOATL				191906
(III)	**FOUR LINE STRIP PLANTATION (TREE SPECIES):**				
1	Preparation of soil mixture (soil, sand, humus & compost) including digging, purchase, carriage to the site of work and mixing at site.	18.225	Cum.	850.00	15491
2	Digging of pits (45cm x 45cm x 45cm) in periphery of area.	200	No.	4.45	890
3	Filling of pits (45cm x 45cm x 45 cm) with imported soil mixture.	200	No.	1.27	254
4	Extracted of plants from nursery beds.	200	No.	0.25	50
5	Carriage of plants from nursery to the work site over average distance of 10 km uphill carriage.	200	Nos. per Km.	0.17	340
6	Planting of extracted plants in above pits including	200	No.	0.86	172

S. No.	Particular	Qty.	Unit	Rate (Rs.)	Amount (Rs.)
	ramming.				
7	Mulching of plants with grass.	200	No.	0.28	56
8	Cost of plants (in nursery).	200	No.	1.00	200
TOTAL					**17453**
(IV)	**PLANTATION OF TREE SPECIES IN BLANK AREA:**				
1	Preparation of soil mixture (soil, sand, humus & compost) including digging, purchase, carriage to the site of work and mixing at site	54.675.	Cum.	850.00	46474
2	Digging of pits (45cm x 45cm x 45cm) for B/L plantation.	600	No.	4.45	2670
3	Filling of pits (45cm x 45cm x 45cm) for B/L plantation with imported soil mixture.	600	No.	1.27	762
4	Extraction of plants from nursery beds.	600	No.	0.25	150
5	Carriage of plants from nursery to the work site over an average distance of 10 Km uphill carriage.	600	No. per Km.	0.17	1020
6	Planting of B/L plants in pits including ramming.	600	No.	0.86	516
7	Mulching of B/L plants with grass.	600	No.	0.28	168
8	Cost of plants (in nursery).	600	No.	4.00	2400
TOTAL					**54160**
(V)	**MAINTENANCE:**				
1	1st year maintenance.	1	Ha.	4000	4000
2	2nd year maintenance.	1	Ha.	3600	3600
3	3rd year maintenance.	1	Ha.	3200	3200
4	4th year maintenance.	1	Ha.	2800	2800
5	5th year maintenance.	1	Ha.	2000	2000
6	Watch and ward of plantation for 5 years (60 months @ 1000/=) including irrigation during lean seasons.	1	Ha.	1000	60000
TOTAL					**78000**
B.	**SOIL CONSERVATION:**				
1.	Construction of gulley plugs, small check walls/dams etc.			LUMP-SUM	**50000**
TOTAL (A) + (B)					
GRAND TOTAL					**4,85,432**

10.8.7 Cost Estimate for Muck Management Plan

The cost estimate for muck management plan indicating engineering, biological, bio-technological measures and maintenance is provided in **Table-10.38.**

Table 10.38:Cost Estimate for Muck Management Plan

Sl. No.	Particulars	Qtty	Unit	Rate (Rs.)	Amount (Rs. lakh)
A. Engineering Measures					

Sl. No.	Particulars	Qtty	Unit	Rate (Rs.)	Amount (Rs. lakh)
1	Gabion structuresi/c cost of all materials ,wire mesh and placing complete in 580 m length(140+50+55+55+35+25+50+50+70+500)x5 1.25=29725	29725	cum	300	95.12
Sub-total (A)					**95.12**
B. Biological Measures					
1.	Plantation of muck disposal sites	5.0	ha	485432	24.27
2.	Barbed wire fencing on 2m high RCC posts	5.0	ha	50000	2.50
3.	Watch&ward 1 no. @ Rs. 10000 p.m. for 5 years	60	month	10000	6.00
Subtotal (B)					**32.77**
Grand Total (A) + (B)					**127.89**
Say Rs.					**128.00**

10.9 RESTORATION PLAN FOR QUARRY SITES

10.9.1 General

The Rongnichu HEP mainly involves construction of barrage, intake, underground water conductor system,surface powerhouse, transformer hall, tail race channel and adits. For the construction of these components construction materials like coarse and fine aggregates and stone are required besides cement, structural steel and reinforcement steel. The quantities of construction material like fine aggregate and coarse aggregate etc., and their potential quarry/mining sites are mentioned in **Table 10.39**.

Table 10.39: Quantity of Various Materials (cum)

S. No	Material	Estimated Quantity(lakh cum)	Net Quantity with 38% losses	Quantity retrieved from excavated muck	Balance quantity to be obtained	QuarrySites for Balance Quantity
1	Coarse aggregate	350000	483000	155000	328000	River bed quarry u/s reservoir on RongniChhu.MartemKhola, DicklingChhu and RonpoChhu
2	Fine aggregate	175000	241500	0.00	241500	
3	Stone	125000	172500	35426	137074	
Total		650000	897000	190426	706574	

Assuming the total losses (38%) for in the quantity estimation of raw material from quarry site to aggregate processing plant for producing aggregates.The total quantity of raw materiallokely to be obtained from crushed muck, works out to be 1.55 lakh cum for coarse aggregate and 0.35lakh stone. Thus, the total raw material requirement for aggregate comes to 8.97lakh cum, which shall be met from utilization of 1.90 lakh cum of muck and balance 7.07 lakh cum from four river bed quarry sites, the location of which is depicted in **Figure 10.24**.

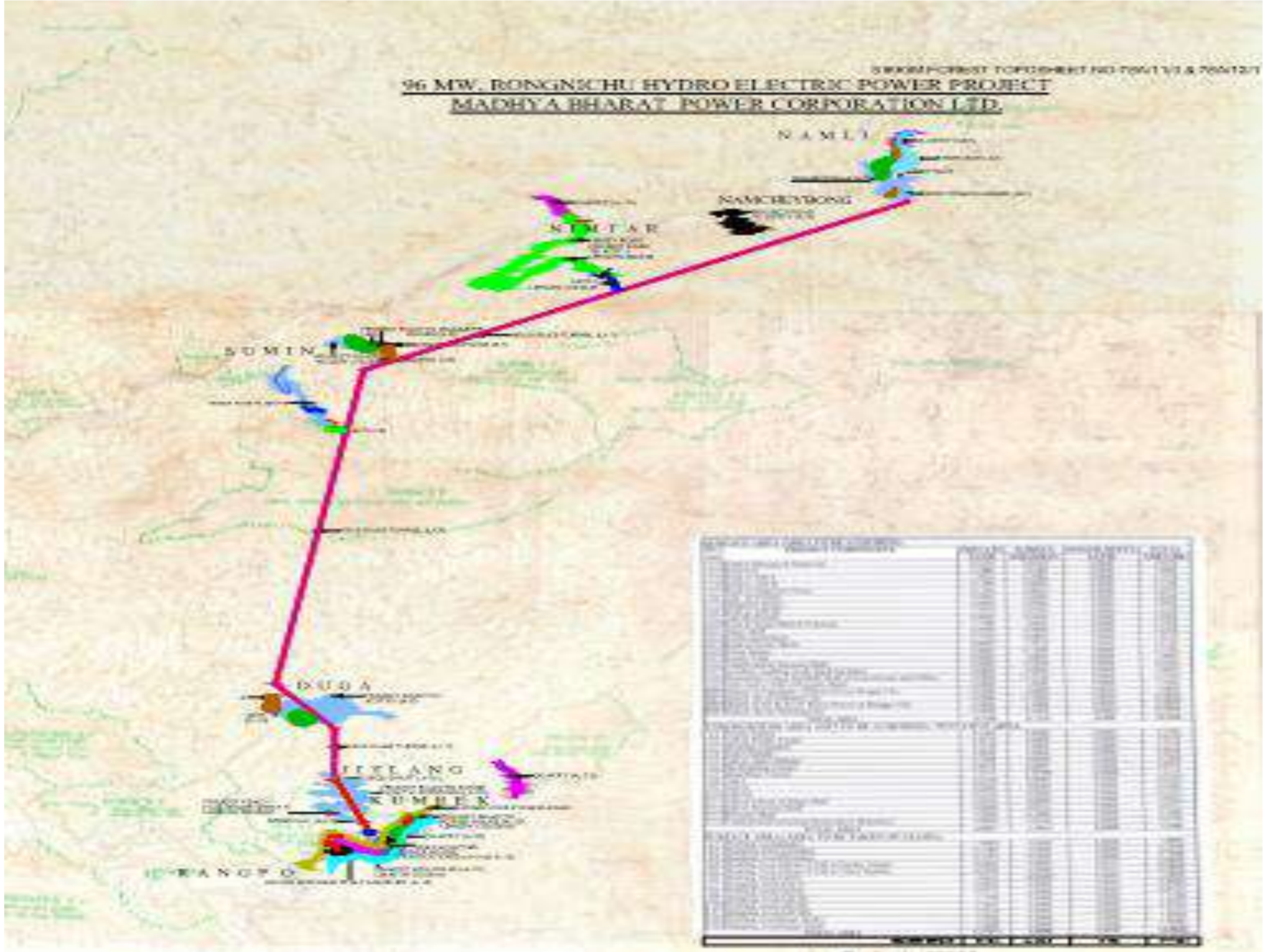


Figure 10.24: Location Plan of Quarry Sites

10.9.2 Details of Quarry Sites

For Rongnichu HEP, the balance requirement of coarse aggregate and fine aggregate for wearing and non-wearing concrete surface shall be met from river bed quarry sites. Samples from these sites has been investigated to find out the suitability as coarse aggregate material. The details of river bed quarry sites is shown in **Table 10.40.**

Table 10.40: Details of River bed Quarry

S.N.	Quarry	Location	Forest Land (ha)
1	Q-1	U/s reservoir on RongniChhu	1.00
2	Q-2	U/s & d/s of powerhouse on RangpoChhu	2.50
3	Q-3	Dickling Khola	0.50
4	Q-4	Martam Khola	0.50
		Total	**5.00**

10.9.3 Environmental Impacts

The river bed quarry does not require any major restoration measures in the light of the fact that the quarried area gets replenished during monsoon and backfilling or reclamation of mined out area is not involved. The quarrying operation in the river bed shall be manual and the quarry pits shall not be dug more than 1.0-meter-deep and the hill side edge of the quarry line shall be at-least 5m away from the foot of the hill. Blasting shall not be allowed in the stream bed. Copious use of sprinkler shall be resorted to stock piles of aggregate and the washing of the aggregate shall be first allowed to settle in the setting tanks before disposing into river. As a dust arrester G.C sheet shield of adequate height shall be erected.

10.9.4 Treatment Measures for Restoration

The environment management plan for mining activity shall be prepared on the basis of impacts and shall be compatible with the eco-friendly management plan in case of the minor mineral.

10.9.5 Cost Estimate for Restoration of Borrow Areas

The details of the expenditure likely to be incurred on the implementation of biological and engineering measures to be adopted are placed in **Table-10.41**.

Table 10.41: Cost estimates for restoration of borrow areas

S.N.	Item of Work	Qty.	Unit	Rate (Rs.)	Amount (Rs. lakh)
1	Construction of drains	300	m	500	1.50
2	Stone masonry retaining wall of 4 m height in 100 m	290	cum	500	1.45
3	Plantation in 2 ha. Including maintenance	2.0	ha	120000	2.40
4	Watch and ward 2 No Chowkidars @ Rs 5000 p.m.	96	months	5000	4.80
5	Provision for Settling Tanks	Job		LS	0.25
6	Removing, storing&spreading top soil for plantation	2000	cum	120	2.40
7	For execution of eco-friendly management plan	Job		LS	3.20
	Total				**16.00**

10.10 LANDSCAPE AND RESTORATION PLAN

Rongnichu HEP encompassing barrage, intake structure, underground water conductor system and surface powerhouse is located in the East Sikkim Distt. The barrage location is about 2 Km downstream of Namli village and 16 Km south of Gangtok along NH-31A. The powerhouse is proposed on the right bank of Rangpo River 2.5 km from Rangpo Town on Rangpo-Rongli State Highway.Thus,the barrage site provides a great opportunity for landscaping for being aesthetically attractive. The water conductor system and appurtenant works are all underground structures and thus their landscaping is not warranted. Considering this the landscape plan is restrictive in nature being limited to barrage and power house site, residential, and office complex areas.

The present landscape on either flank of river at barrage site shall be impacted due to bank excavation and visible scars may develop on rock surface where the rock mass is already fissured. In present case as most of the works are underground except at barrage and powerhouse, the landscape shall not be much impaired. However, at the portal of MAT/Adits, surface excavation shall be involved, there are chances of the damage to landscape, at such place proper measures like slope protection and stabilization of hill slopes shall be required. Besides this in post-construction period, when job facilities, steel fabrication yards, rib-bending yard, crushing plant and batching plant shall be dismantled, these are need to be restored to previous configuration

It is proposed to provide for landscaping the area around project complex. The financial provision of landscape works is presented in **Table 10.42.**

Table 10.42: Cost Estimate for Landscaping Plan

S.N.	Particular	Quantity	Amount (Rs lakh)
1	Providing Channel fencing along approach road to barrage	LS	1.00
2	Providing ornamental, avenue and flowering plants at barrage	LS	1.50
3	Providing rest benches	LS	0.50
4	Watch and ward	LS	1.60
5	Land scape restoration works by resorting to engineering and biological measures	LS	7.00
6	Contingencies	LS	0.40
Total			**12.00**

10.11 STUDY OF DESIGN EARTHQUAKE PARAMETERS

10.11.1 Introduction

The study for site-specific Design Earthquake Parameters was entrusted to IIT, Roorkee, which has submitted the report No, EQD-6005/2012-13(October -2012). The Project site lies in seismic Zone-IV as per the seismic zoning map of India incorporated in Indian Standard Criteria for Earthquake Resistant Design of Structures (IS: 1893 (Part 1): 2002). The recommendations for the site-specific earthquake design parameters for the site are based on the studies carried out related to the tectonics, regional geology, local geology around the site, earthquake occurrences in the region around the site and the seismotectonic setup of the area. Both approaches namely, Probabilistic seismic hazard assessment and deterministic approach for seismic hazard assessment were considered as per the “Guidelines for the preparation and submission of site-specific study report of River Valley project to National Committee on Seismic Design Parameters (NCSDP)” for arriving at the site-specific design earthquake parameters for the site (CWC, 2012).The site specific design earthquake parameters forMCEand DBEconditions are recommended as 0.65g and 0.34g for horizontal and vertical ground motion. The design seismic coefficient for preliminary design of barrage are evaluated as $\alpha h=0.26$ and $\alpha v=0.25$ respectively.

10.12 DISASTER MANAGEMENT PLAN

10.12.1 Introduction

A disaster is an unwarranted, untoward and emergent situation that culminates into heavy toll of life and property and is a calamity sometimes caused by “force majeure” and by human error. The identification of all types of disaster in any proposed project scenario involves the critical review of the project vis-à-vis the study of historical past incidents/disasters in the similar situations. Keeping in view the grievous affects a disaster can cause on human or animal population, loss of property and environment in and around the areas of impact. Therefore, it is essential to assess the possibility of such failures in context to the present project and formulate a contingent plan.

10.12.2 Project Brief

The 14m high barrage has 3 bays of free flow spillway with sill crest level at 728.00 masl, with 3 gates of size 12.2mx 6.5m and FRL of 740 masl with Top level of 742.5masl. The spillway has been designed to pass design flood corresponding to Probable Maximum Flood of 1195 cumec.

10.12.3 Dam Break Inundation Analysis

The outflow flood hydrograph from failure of a hydraulic structure is dependent upon many factors such as physical characteristics of the structure, volume of reservoir and the mode of failure. The parameters which control the magnitude of the peak discharge and the shape of outflow hydrograph include: the breach dimensions, the manner and length of time for the breach to develop, the depth and volume of water stored in the reservoir, and the inflow to the reservoir at the time of failure. The shape and size of the breach and the elapsed time of development of the breach are in turn dependent upon the construction materials and the causal agent for failure. Moreover, in case of hilly terrain, the outflow volume is generally confined within the valley and the elevation of the resulting flow after attenuation of the flood waves is near to the observed historical HFL at the point under consideration.

10.12.4 Model for Dam Break Analysis

For reasons of simplicity, generality, wide applicability and the uncertainty in the actual mechanism, the BOSS DAMBRK model has been used. The model uses failure time interval, terminal size and shape of the breach as the inputs. The possible shapes of the breach that can be accomplished by the model are rectangular, triangular and trapezoidal. The model can adopt either storage routing or dynamic routing methods for routing floods through reservoirs depending on the nature of flood wave movement in reservoirs at the time of failure.

The dynamic wave method based on the complete equations of unsteady flow is the appropriate technique to route the flood hydrograph through the downstream valley. The method is derived from the original equations developed by St. Venant. The model uses St. Venant's equations for routing dam break floods in channels.

10.12.5 Methodology

The U.S. National Weather Service's DAMBRK model developed by Dr. L. Fread has been used in the study. This model simulates the failure of dam, computes the resultant outflow hydrograph and simulates movement of the dam break flood wave through the downstream river valley. The model is built around three major capabilities, which are reservoir routing, breach simulation and river routing. However, it does no rainfall-runoff analysis and storm inflow hydrographs to the upstream of reservoir must be developed external to the model. A brief description of the capabilities of the model is described in the following paragraphs.

10.12.5.1 Reservoir Routing

The storage routing is based on the law of conservation given as:

$I - Q = dS/dt$ …………………… ….. (1)

in which, I is reservoir inflow. Q is the total reservoir outflow which includes the flow spillway, breach, overtopping flow and head independent discharge, and rate of change of reservoir storage volume. Equation (1) can be expressed in finite difference form as:

$(1 + I') 2 - (Q + Q')/2 = \Delta S/\Delta t$ -. -----(2)

in which the prime (') superscript denotes the values at the time t - Δt and the notation approximates the differential. The term ΔS may be expressed as:

$\Delta S = (As + A's)(h-h')/2$ ……………… (3)

in which, As is the reservoir surface area coincidental with the elevation (h) and is a function of h. The discharge Q which is to be evaluated from equation (2) is a function of h and this known h is evaluated using Newton–Raphson iteration technique and thus the estimation of discharge corresponding to h.

10.12.5.2 Dynamic Routing

The hydrologic storage routing technique expressed by equation (2) implies that the water surface elevation within the reservoir is horizontal. This assumption is quite adequate for gradually occurring breaches with no substantial reservoir inflow hydrographs. However, when the breach is specified to form almost instantaneously so as to produce a negative wave within the reservoir, and/or the reservoir inflow hydrograph is significant enough to produce a positive wave progressing through the reservoir, a routing option which simulates the negative and /or positive wave occurring within the reservoir may be used in DAMBRK model. Such a technique is referred to as dynamic routing. The routing principle is same as dynamic routing in river reaches and it is performed using St. Venant's equation. The movement of the dam break flood wave through the downstream river channel is simulated using the complete unsteady flow equations for one dimensional open channel flow, alternatively known as St. Venant's equations. These equations consist of the continuity equation

$$\frac{\partial Q}{\partial x} + \frac{\partial s(A + A0)}{\partial t} = q \qquad \text{...............} (4)$$

And a conservation of momentum equation:

$$\frac{\partial (sQ)}{\partial t} + \frac{\partial (A2/ + A)}{\partial t} + g A \left(\frac{\partial h}{\partial t} + Sf + Se \right) + Lc = 0 \text{ ......}(5)$$

where,

A = active cross – sectional flow area

A0 = inactive (off-channel storage) cross – sectional area

s = a sinuosity factor which varies with h

x = distance the channel

t = time

q = lateral inflow or outflow per lineal distance along the channel

g = acceleration due to gravity

β = the momentum coefficient for velocity distribution

Q = discharge h = water surface elevation

Sf = boundary friction slope

Se = expansion – contraction slope

Lc = lateral inflow/outflow momentum effect due to assumed flow path of inflow being perpendicular to the main flow

The friction slope and expansion – contraction loss slope is evaluated by the following equation

$$Sf = \frac{n3\ Q2}{2.21\ A2\ R¾} \qquad \text{..................................} (6)$$

and,

$$Se = \frac{K\Delta(Q/A)2}{2g\ \Delta X} \qquad \text{.....................................} (7)$$

Where,

n = Manning's roughness coefficient

R = A/B where B is the top width of the active portion of the channel

K = Expansion – contraction coefficient varying from 0.1 to 0.3 for contraction and -0.1 to 1.0 expansion

Δ(Q/A)2 = Difference in (Q/A)2 for cross sections at their end of a reach

The non-linear partial differential equations (4) and (5) are represented by a corresponding set of non-linear finite difference algebraic equations and they are solved by the Newton – Raphson method using weighted four-point implicit scheme to evaluate Q and h. The initial conditions are given by known steady discharge at the barrage, for which steady state non-uniform boundary flow equations are used. The outflow hydrograph from the reservoir is dependent upon the downstream boundary condition for the channel routing and the model can deal with fully subcritical flow or fully supercritical flow in the reach or the upstream reach having supercritical flow and downstream reach having subcritical flow. There is a choice of downstream boundary conditions such as internally calculated loop rating curve, user provided single valued rating curve, user provided time dependent water surface elevation, critical depth and discharge which may pass flow via spillways, overtopping and/ or breaching.

10.12.5.3 Statement of the problem

The computation of flood wave resulting from a dam breach basically involves two scenarios which can be considered jointly or separately: (1) the outflow hydrograph from the pond (2) the routing of the flood wave downstream from the breached barrage along the river valley and the flood plain. If breach outflow is independent of downstream conditions, or if their effect can be neglected, the reservoir outflow hydrograph is referred to as the free outflow hydrograph. In this case, the computation of the flood characteristics is divided into two distinct phases: (a) the determination of outflow hydrograph with or without the routing of the negative wave in the reservoir, and (b) the routing of flood wave downstream from the breached barrage. In this study the problem of simulating the failure of "Dam" and computing the free outflow hydrograph from the breached section using storage routing technique' with the aim of reproducing the maximum water level marks reached during the passage of flood wave is considered. The information regarding inflow hydrograph into the pond due to the storm at the time of failure, the structural and the hydraulic characteristics details of the barrage, the time of failure, the channel cross sections details, the maximum water level marks reached in the reservoir at the time of failure and those observed in the downstream reach of the barrage to the passage of flood wave etc. are available for the study.

10.12.5.4 Availability of Data

The input data required for the U.S. National Weather Service's BOSS DAMBRK model can be categorized into two groups. The first data group pertains to the barrage and inflow hydrograph into the reservoir and the second group pertains to the routing of the outflow hydrograph through the downstream valley. These are described in the following paragraphs.

10.12.5.5 First Data Group

With reference to the data group pertaining to the barrage, the information on reservoir elevation-volume relationship, spillway details, elevation of bottom and top of barrage, elevation of water surface in the pond at the beginning of analysis and at the time of failure, breach description data are required. Breach of two bays of spillway at drainage gallery level at EL 653masl has been considered for simulation of dam break.

10.12.5.6Second Data Group

The second group of data pertaining to the routing of the outflow hydrograph through the downstream valley consists of a description of cross-sections, hydraulic resistance coefficients of the reach, steady state flow in the river at the beginning of the simulation and downstream boundary condition. The cross section is specified by location mileage, and tables of top width and corresponding elevation. In this study, eight cross sectionals have been used. Seven cross-sections are located at 0,0.2,1.0, 5, 10and 13.3 km respectively from the barrage. The breach time has been taken as 0.25 hour.

10.12.6 Result and Conclusions

The maximum stage elevation and maximum flow at different cross-section at various distances downstream of the barrage is shown in **Table 10.43**. It can be inferred from the result that maximum flow 3278 cumecs corresponding to maximum stage elevation 743.09 masl has been achieved at RD 0.00 km due to breach of barrage and thereafter the maximum flow has gradually attenuated to 2941 cumec corresponding to stage elevation 344.72 at RD13.30 km (**Table 10.43**). This is because for reaches further downstream, the flow wave characteristics may be predominantly influenced by channel geometry. The combined stage and discharge hydrograph are depicted in **Figure 10.25** and **Figure 10.26and** inundation plot in **Figure10.27** respectively.

The barrage break study has been carried out assuming that the barrage gets washed away in the entire length and height from riverbed level to the top. The failure is also assumed to occur when the barrage receives the PMF of 1195 cumecs. The study involves determination of the flood flow from the barrage due to its breach and routing the same along the river valley on the downstream, to estimate the maximum flood levels at various locations on the downstream.

Table 10.43: Flood Crest Summary

Cross Section Location (km)	Maximum Stage Elevation (masl)	Maximum Flow (cumecs)	Time to Maximum Stage (hr)	Maximum Flow Velocity (m/sec)	Flood Wave Arrival time (hr)
0.00	743.09	3278	0.163	5.1	0.03
0.20	734.61	3278	0.25	31.42	0.03
0.50	724.71	3199	0.275	8.39	0.03
1.00	708.27	3156	0.312	8.17	0.03
2.00	681.24	3108	0.362	7.8	0.08
3.00	654.20	3079	0.412	7.50	0.10
4.00	627.15	3056	0.456	7.32	0.18
5.00	600.09	3039	0.492	7.45	0.15
6.00	566.73	3023	0.53	7.24	0.25
8.00	500.23	2996	0.605	7.41	0.25
10.0	433.96	2972	0.68	7.35	0.35
11.1	403.56	2962	0.717	6.91	0.40

Cross Section Location (km)	Maximum Stage Elevation (masl)	Maximum Flow (cumecs)	Time to Maximum Stage (hr)	Maximum Flow Velocity (m/sec)	Flood Wave Arrival time (hr)
12.2	373.98	2952	0.755	6.34	0.47
13.3	344.72	2941	0.78	6.23	0.57

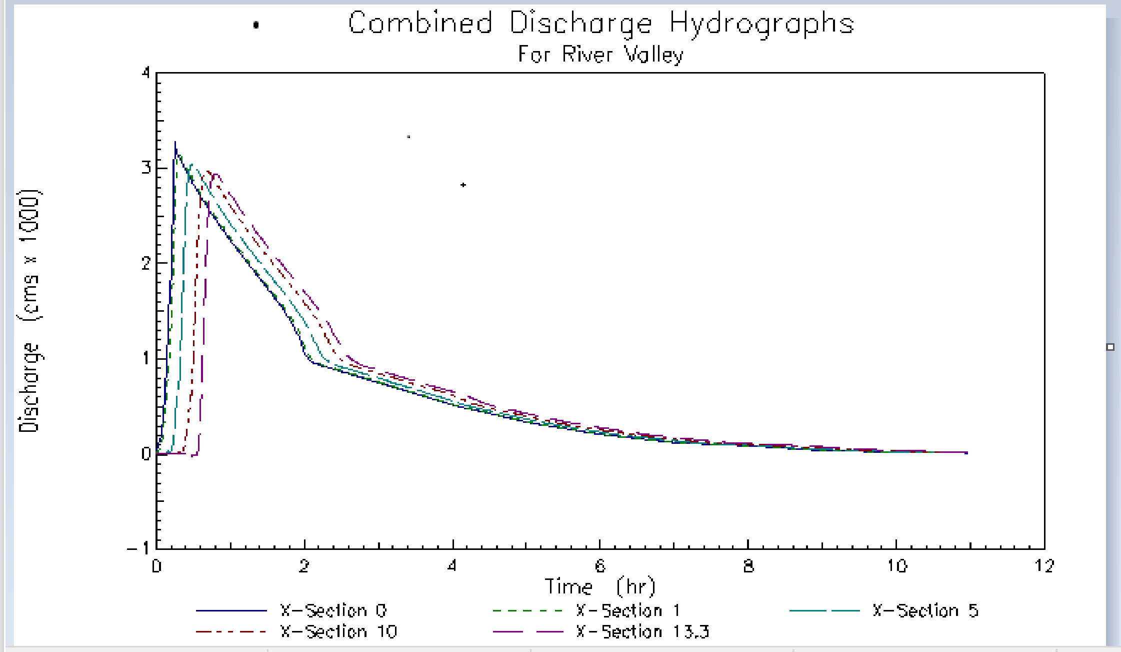


Figure 10.25: Combined Stage Hydrographs

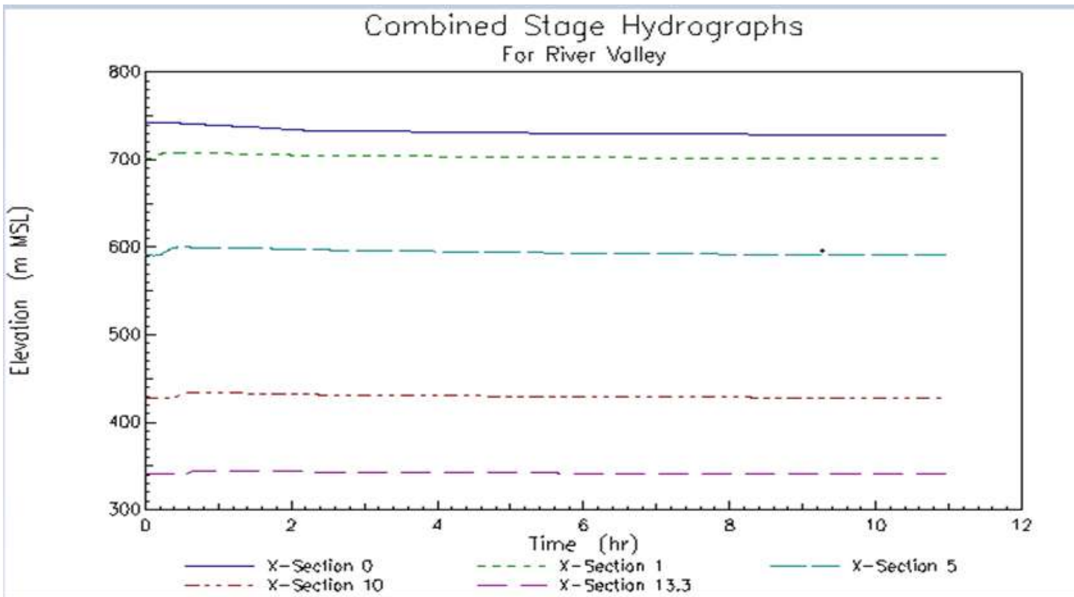


Figure 10.26: Combined Stage Hydrographs

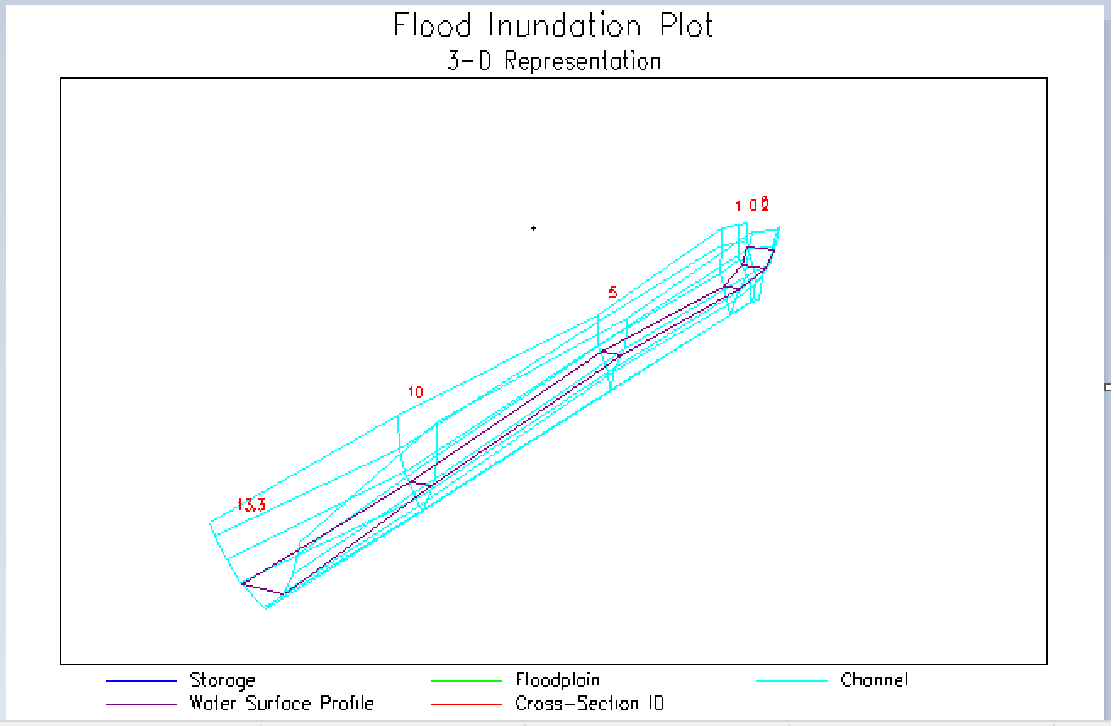


Figure 10.27: Inundation Plot

The following conclusions could be drawn:

1. Failure of the barrage, which is designed to the present technical standards and built with adequate quality control, is a very-very remote possibility.
2. The assumed condition that the whole barrage gets washed away is only hypothetical.

10.12.7 Disaster Management Plan

The emergency planning for barrage break scenario is devised on the basis of results of break analysis mainly the travel time of flood wave to various locations in the downstream stretch of the river. It is inferred from the analysis that in case of barrage break the flood peak discharge as it propagates through valley shall inundate downstream stretch of first km within 2.0 minutes. Owing to the breaking of the barrage the major risk shall be to the persons who have for some reason or the other has entered the riverbed / plain. The plan is, therefore, based on such measures, which are purely preventive in nature.

The flood period during monsoon generally is reckoned from June with the onset of monsoon and ends with withdrawal of south-west monsoon by the end of September. Before the onset of monsoon all hydro-mechanical equipment, electrical gadgets, captive power plant and public announcement and communication system should be kept in perfect readiness. The degree of alertness has to enhance during high stage of river manifested with sharp increase in discharge. Though there cannot be very sharp edge demarcation between different levels of emergency yet the following flood conditions have been contemplated and the preventive measures suggested against each as given in **Table 10.44.**

Table 10.44: Status of Emergency

S. N.	Status of Emergency	Water Level	Preventive measures
1.	Normal Flood	Below FRL i.e. EL 740 masl and flood discharge below 1195 Cumec	Utmost vigil observed in regulation of spillway gates
2.	Level –1 Emergency	Rises above EL 740.00 masl but below EL 741.00 masl and flood discharge below 1195 Cumec	(1) All gates fully operational (2) All the official should attend barrage site. Local officials informed and warning system be kept on alert. Communication & public announcement system should be put into operation and flood warning issued to people
3.	Level –3 Emergency	Top of barrage (742.50 masl) but discharge below 1195 cumec	(1) All staff from barrage site, powerhouse & TRT outlets alerted to move to safer places (2) Possibility of barrage failure should be flashed to District Administration.
4.	Disaster	Rising above EL 742.50 masl and the breach appears in any form rises above	District Administration and Project authorities be intimated and only life saving measures should be resorted too

10.12.7.1 Barrage Safety and Maintenance Manual

Based on standard recommended guidelines for the safety inspection of barrage a manual should be prepared by the project proponents in respect of barrage safety surveillance and monitoring aspects. This should be updated with the availability of instrumentation data and observation data with periodical review. The need for greater vigil must be emphasized during first reservoir impoundment and first few years of operation. The manual should also delve on the routine maintenance schedule of all hydro-mechanical and electrical instruments. It should be eloquent in respect of quantum of specific construction material needed for emergency repair along with delineation of the suitable locations for its stocking and identify the much-needed machinery and equipment for executing emergency repair work and for accomplishing the evacuation plan.

10.12.7.2 Emergency Action Plan (EAP)

Barrage safety programme as indicated above includes the formation of an Emergency Action Plan for the barrage. An emergency is defined as a condition of serious nature which develops unexpectedly and endangers downstream property and human life and required immediate attention. Emergency Action Plan should include all potential indicators of likely failure of the barrage, since the primary concern is for timely and reliable identification and evaluation of existing of potential emergency.

This EAP presents warning and notification procedures to follow during the monsoon season in case of failure or potential failure of the barrage. The objective is to provide timely warning to nearby residents and alert key personnel responsible for acting in case of emergency.

10.12.7.3 Administration and Procedural Aspects

The administrative and procedural aspects of the Emergency Action Plan consist of flow chart depicting the names and addresses of the responsible officials. In order of hierarchy, the following system will usually be appropriate. In the event that the failure is imminent or the failure has occurred or a potential emergency conditions is developing, the observer at the site is required to report it to the Junior Engineer / Assistant Engineer who will report to the Executive Engineer / Superintending Engineer for their reporting to the Chief Engineer through a wireless system or by any available fastest communication system. The Engineer-in-Charge is usually responsible for making cognizant with the developing situation to the Civil Administration viz. District Magistrate. Each personnel are to acknowledge his/her responsibilities under the EAP in an appropriate format at a priority.

The technical aspects of the EAP consist of preventive action to be taken with regards to the structural safety of the barrage. The EAP is drawn at a priority for the regular inspection of the barrage. For this purpose, providing an adequate and easy access to the dam site is a necessity. The barrage, its sluices, overflows and non-overflow sections should be properly illuminated for effective operations during nighttime. Whenever sinkholes, boils, increased leakages, movement of masonry rock, gate failure, rapid rise or fall of the level in the reservoir, rise in the level of reservoir beyond the maximum working level, or wave overrun of thecrest are observed, the personnel on patrol is required to inform immediately to the Junior Engineer (JE)/Assistant Engineer (AE) for initiation of the execution of EAP. They are required to inform the Engineer-in-Charge and the local administrative authorities. It is desirable if the downstream inhabitants are warned using siren, if available, to make them aware the likely imminent danger.

The other preventive measures may include availability of enough sandbags at several selected downstream locations and logs (for holding and sandbags) and at the barrage site, one tractor, two motorboats, gas lanterns, Manila ropes and life jackets. Areas from where the labor can be mobilized should be chalked out at a priority. In addition to these, public participation in the process of execution of the EAP may further help in amelioration of the adverse impacts of the likely disaster. For this, it is necessary that the public should be made aware of its responsibilities.

10.12.7.4 Reserve Stock

For meeting emergent situation reserve stock materials shall always remain at disposal at location mentioned in **Table 10.45.**

Table 10.45: Details of Reserve Stock

S. N.	Location	Material	Quantity
1.	Left Bank	Boulder	200 cum
		Shingle	50 cum
		Sand	50 cum
2.	Right Bank	Boulder	200 cum
		Shingle	50 cum
		Sand	50 cum
3	Central Store at Head Works	Wire crates (3m x 1.5m x 1m.)	50 No.
		Wire crates (1.5m x 1.5m x 1m)	50 No.

		G.I. Wire 8 SWG	5 Ton
		Ballies 6m long	200 No.
		EC Bags	2000 No.

10.12.7.5 Preventive Action

Once the likelihood of an emergency is suspected, action must be initiated to prevent a failure. The point at which each situation reaches an emergency status shall be specified and at that stage the vigilance and surveillance shall be upgraded both in respect of time and level. At this stage a thorough inspection of the barrage should be carried out to locate any visible sign(s) of distress.

Engineers responsible for preventive action should identify sources of equipment needed for repair, materials, labour and expertise for use during an emergency. The amount and type of material required for emergency repairs should be determined for barrage, depending upon its characteristics, design, construction history and past behavior. It is desirable to stockpile suitable construction materials at appropriate sites. The anticipated need of equipment should be evaluated and if these are not available at the site, the exact location and availability of these equipment should be determined and specified. The sources/agencies must have necessary instructions for assistance during emergency. Due to the inherent uncertainties about their effectiveness, preventive actions should usually be carried out simultaneously with the appropriate notification on alert situation or a warning situation. The flow chart of the responsibilities of Project Proponent and Civil Administration is shown in **Figure-10.28.**

10.12.7.6 Communication System

An effective communication system and a downstream warning system are essential for the success of an emergency preparedness plan. The difference between a high flood and dam-break situation must be made lucidly clear to the downstream population.

10.12.7.7 Evacuations Plans

Emergency Action Plan includes evacuation plans and procedures for implementation based on local needs. These could be:

- Demarcation / prioritization of areas to be evacuated.
- Notification procedures and evacuation instructions.
- Safe routes, transport and traffic control.
- Safe areas/shelters.
- Functions and responsibilities of members of evacuation team.

Any precarious situation during floods will be communicated either by an alert situation or by an alert situation followed by a warning situation. An alert situation would indicate that although failure of flooding is not imminent, a more serious situation could occur unless conditions improve. A warning situation would indicate that flooding is imminent as a result of an impending failure of the barrage. It would normally include an order for evacuation of delineated inundation areas

10.12.7.8 Evacuation Team

- It will comprise of following official / Representative:

- District Magistrate (D. M.)/his Nominated officer (To peacefully relocate the people to places at higher elevation with state administration).
- Engineer in charge of the project (Team Leader)
- Superintendent of Police (S. P.)/Nominated Police Officer (To maintain law and order)
- Chief Medical Officer (C. M. O.) of the area (To tackle morbidity of affected people)
- Sarpanch/Affected village Representative to execute the resettlement operation with the aid of state machinery and project proponents.
- Sub committees at village level

The Engineer-in-Charge will be responsible for the entire operation including prompt determination of the flood situation time to time. Once the red alert is declared the whole state machinery will come into swing and will start evacuating people in the inundation areas delineated in the inundation maps. For successful execution, annually demo exercise will be done. D. M. is to monitor the entire operation.

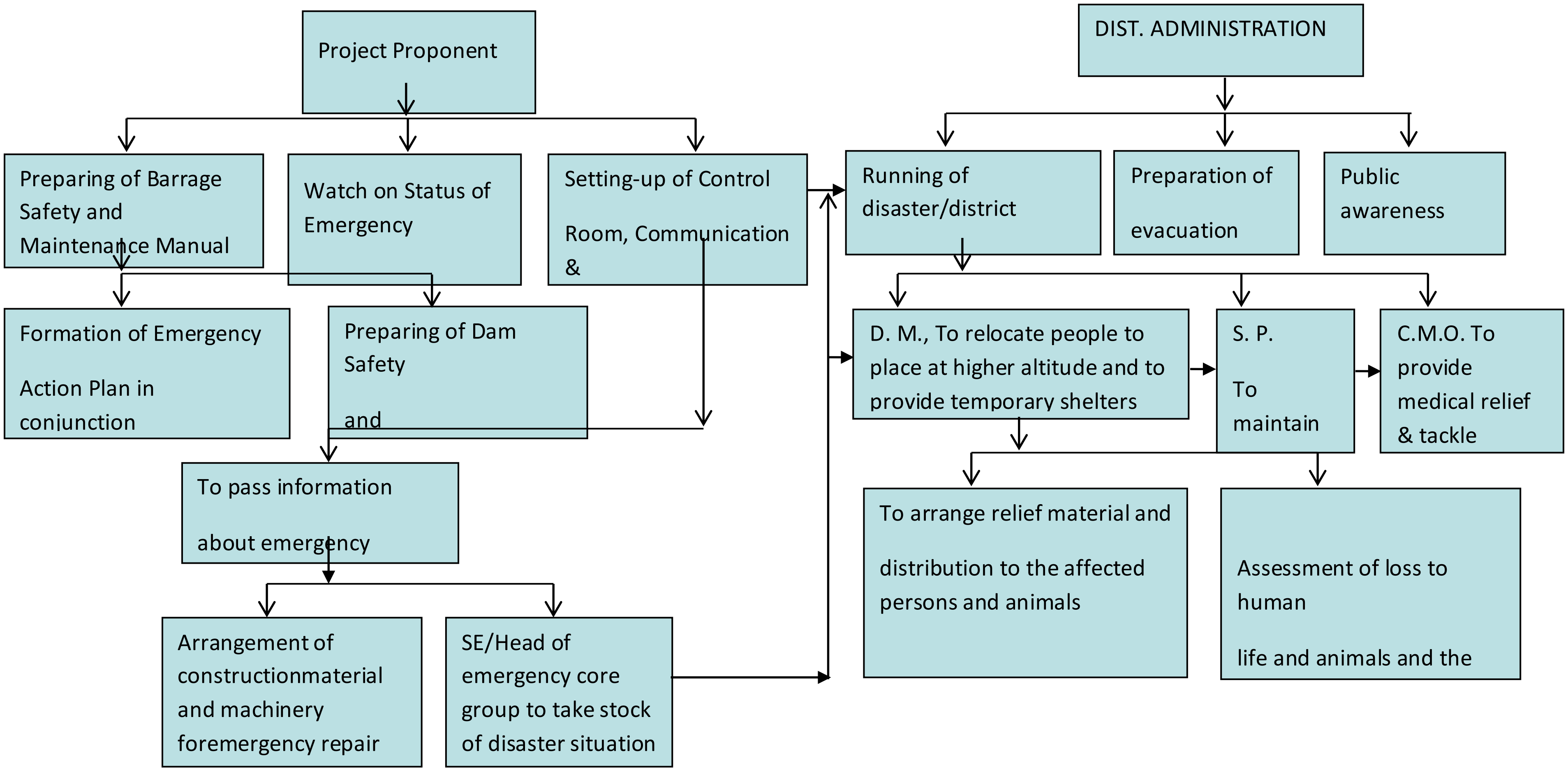


Figure 10.28: Flow Chart of Responsibility

10.12.7.9 Public Awareness for Disaster Mitigation

In addition, guidelines that must be followed by the inhabitants of flood prone areas, in the event of flood resulting frombarrage failure, which form part of public awareness for disaster mitigation may also include following:

1. Listen to the radio for advance information and advice.
2. Disconnect all electrical appliances and move all valuable personal and household goods beyond the reach of floodwater, if one is warned or if one suspects that flood waters may enter the house.
3. Move vehicles, farm animals and movables goods to the higher place nearby.
4. Keep sources of water pollution i.e. insecticides out of the reach of water.
5. Turn off electricity and LPG gas before one has to leave the house.
6. Lock all outside doors and windows if one has to leave the house.
7. Do not enter floodwaters.
8. Never wander around a flood area.

10.12.7.10 Notifications

Notification procedures are an integral part of any emergency action plan. Separate procedures should be established for slowly and rapidly developing situations and failure. Notifications would include communication of either an alert situation or an alert situation followed by a warning situation. An alert situation would indicate that although failure or flooding is not imminent, a more serious situation could occur unless conditions improve. A warning situation would indicate that flooding is imminent as a result of an impending failure of the barrage. It would normally include an order for evacuation of delineated inundation areas.

10.12.7.11 Notification Procedures

Copies of the EAP that also include the above described inundation map are displayed at prominent locations, in the rooms and locations of the personnel named in the notification chart. For a regular watch on the flood level situation, it is necessary that the flood cells be manned by two or more people so that an alternative person is always available for notification round the clock. For speedy and unhindered communication, a wireless system is a preferable mode of communication. Telephones may be kept for back up, wherever available. It is also preferred that the entire flood cells, if more than one, are tuned in the same wireless channel. It will ensure communication from the site to the control rooms. The communication can be established by messenger service in the absence of such modes of communication.

10.12.7.12 Management after receding of Flood Water

It is to be accepted that in the event of barrage break, even with maximum efforts, the loss of human lives, livestock and property would be inevitable. Under such a scenario, a massive effort would be used by various government agencies to provide various relief measures to the evacuees. Formulation of a plan delineating such measures is beyond the scope of work of this document. However, some of the measures which need to be implemented are listed as below: -

10.12.7.13 Provision of various food items and shelter to the evacuees.

- Provision of fuel for various evacuees.
- Provision of adequate fodder supply.
- Arrangements for potable water supply.
- Commissioning of low-cost sewage treatment and sanitation facilities, and disposal of treatment sewage.
- Expeditious disposal of dead bodies human and livestock.
- Immunization programmes for prevention of outbreak of epidemics of various water related diseases.
- Adequate stocks of medicines of various diseases, especially water-related diseases.

10.12.8 **Reservoir Induced Seismicity**

The incidence of reservoir induced seismicity (RIS) or some time referred as reservoir triggered seismicity (RTS) is usually confined in both time and space. It has been observed that in some reservoir's seismicity begins immediately after the first filling while at others it is not observed until several years of filling cycles. The differential behaviour in spatial and temporal pattern of RIS is attributed to two fundamental mechanisms – one related to rapid increase in the elastic stress due to loading of the reservoir and the other to the more gradual diffusion of water from the reservoir to hypo central depths. Until recently it was surmised that RIS was triggered by the loading of the reservoir and/or by the effect of pore pressure (Pp) in lowering the strength of rocks at hypo central depths. The analysis of case histories accumulated suggest that the latter, i.e., pore-pressure is the prime factor and a small perturbation in the in-situ stress field due to Pp changes triggers the RIS. Pore pressure can play a twofold role in the seismic process, the first, a mechanical effect as pore pressure, and second, a chemical effect in reducing the co-efficient of friction between the clays in the pre-existing fractures and the rocks that enclose these fractures. This underlineneeds for routine monitoring of seismic data on dense and local networks. The seismic data so collected shall help to study the mechanism of RIS in particular and the physics of the earthquake process in general.

For mitigation of the seismic hazard, the only option available is to upgrade our knowledge about on the co-dynamics of earthquakes and to utilize the state-of-the-art technology to constraint the motion characteristics. This would help in seismic designing of the components of the project. The reservoir induced seismic concerns; however, require a special emphasis for judging the effect of impoundment of the reservoir on seismic status of the area. With this background, it is proposed that a seismic observatory may be made compatible with IMD National Grid for recording and analyzing the nation-wide seismic activity. This would not only help the project authorities to plan the disaster management scheme related to the project, but will also be helpful for the other projects in the area.

10.12.9 **Flood Forecasting**

The importance of flood forecasting is paramount in abarrage break scenario, by overtopping, when little or no reaction time is left for the people to evacuate to safe places. Effective and accurate flood warning can facilitate the evacuation of people living in flood zone, their property and livestock, opportune maintenance and early alerting of emergency services besides exercising legitimate control by adjusting downstream releases from reservoir / ponds or achieving the balance reservoir. An advance warning of approaching flood allows suitable reservoir operation for moderating its intensity / peak and also helps in ensuring full storage and for flood relief purposes.

The catchment of the Rongni Chhu, up to the proposed barrage site, extends approximately 190sq. km in area. River flows are constituted of two main natural components viz., run-off resulting from precipitation and base flow derived from spring flows. Due to mountains topography, the excessive bed slope causes rapid run-off from the contributing hill torrents to the main river. There is a no network of meteorological station, rain gauge; snow-gauge; gauge and discharge sites in the catchment area. All sub-watersheds within the catchment are un-gauged. Currently flood warning relies on issuing of alerts when the river level at a few location reaches are within a few meters below the high flood levels observed in the past. Sometime these warnings may be accurate but due to very little lead time between the HFL being very fast approached and the commencement of flooding. Due to the existence of fertile agricultural land and its expansion along the river banks and concentration of population in the region of submergence area and downstream of barrage, there is a need for developing an operational flood forecasting system as a part of preparedness strategies for disastrous flood events by providing advance warning several days ahead such that the public and the district authorities have adequate time at their disposal without being panicky.

Due to morphological characteristics, the flood plains and the area near to the river / stream banks, classified under land use class agriculture and settlement, are more prone to the flood hazards. In such areas delineation of flood zone and its height besides detecting the characteristics of floods in different return periods is most significant. Thus, flood zonation is not only essential in respect of various development activities in the likely inundation area, but also for study of ecological and environment impacts. For the study of flood zonation, within the likely inundation area, for different time periods of 2, 5, 10, 25, 50 and 100 years, topography maps at 1:1000 scale shall have to be developed.

All forms of flood forecasting use some type of trigger mechanism to anticipate when the water level of the river at the flood risk area shall exceed the threshold. When the trigger reaches a predetermined level that is less than the threshold, a warning is triggered. In case of a small river, a rainfall-runoff based model may be adequate within reasonable limits of accuracy. In case of small riverslike Rongni Chhu, forecasting of discharge by upstream stages, with a reasonable degree of sophistication is involved. The main aim is to assess the future output at different time as accurately as possible, i.e. within narrow error bonds, starting with measurements of present and past input quantities. Interaction between a comprehensive hydrological model and geographical information system (GIS) technique provides a better forecasting tool. The main requirement of a hydrological model is description of flow channel characteristics and land surface as input data to the watershed model. The flood zonation is actualize, development and perfection of the applied engineering hydrology and its aim is to acquire a real time rainfall data and river flow by short wave, radio and satellite network, and using them tin rainfall runoff models to forecast.

For enabling GIS based flood forecasting using hydrological model, a network of meteorological station, rainfall and snowfall gauges, gauge and discharge sites equipped with latest state-of-the-art gadgets, meteorological radar shall have to be established. Survey of inundation area at 1:1000 scales with 1.0 meter shall have to be conducted. For the current project a sum of Rs. 10 Lakh is being earmarked.

10.12.10 District Disaster Management Plan, Shimla

Under the mandate given as per Disaster Management (DM) Act 2005, the DDMP Shimla (2017) has been prepared to facilitate actions by different stakeholders to prevent / mitigate disaster, climate risk, to enhance preparedness and to develop capacities for effective disaster management in the district. Therefore, the management plan for these tehsils should form a guideline and blue book for the project proponent to strictly follow during the exigency of emergency resulting from disaster from different causes mentioned in the management plan.

10.12.10.1 Village Level Incidence Response Team

The project proponent in consultation with the Deputy Commissioner shall cause to form village level incident response team (VLIRT) for carrying out standard operating procedure for different villages in the project area. The standard operating procedure shall include the following:

- Incident Response Teams i.e. official as notified will assemble at Patwar office concerned as soon as possible after the receipt of information of the disaster but not later than an hour
- VLIRT will rush to the site of occurrence of disaster immediately.
- Will start Search & Rescue Operation
- VLIRT will report the matter at Tehsil Level and to the nodal officer of Sub-Divisional Disaster Management Authority (SDDMA)
- Incident Response System will be activated at Sub-Divisional Level
- Tehsildar/Naib – Tehsildar will rush to the concerned Patwari office/site.
- Will setup relief camp at Patwari office immediately after 2 hrs. of occurrence of disaster.
- Incident Response Team will submit the report from the site where incident occurred to SDDMA.
- SDDMA will activate the resources which can be used for disaster mitigation, Resources of PWD, Irrigation Department, Veterinary Department, Forest, Health & Family Welfare, Police, Fire & Civil Defense will be activated.
- SDDMA will report the matter to DDMA.
- DDMA will coordinate the matter with SDDMA.

The following resources (**Table 10.46**) shall be procured and maintained by the Project proponent:

Table 10.46: Machinery and Equipment Required

S. No	Equipment/Resources/Value	No/Specifications
1	Concrete Cutter	To Cut Angle Iron and Steel
2	Generator	Diesel
3	Search Light 2 Km Range	2km 10 Hrs. Battery Backup

S. No	Equipment/Resources/Value	No/Specifications
4	Public Announcement System with Battery	Speaker and Mike
5	Public Announcement System 16 Amp	Cordless System
6	Breaker Accessories	Different Sizes
7	Ladder	5 Number (10 Feet)
8	Driller	2
9	Tarpaulin	20 No
10	JCB	1
11	Recovery Vehicle	1
12	Trucks	1
13	Tata 407/Pick Up	1
14	Manilla Ropes	10 X 100 Ft
15	Manual Digging Equipment	30
16	Tree Cutter	2

10.12.11 Cost Estimate

The budget for different activities required to be carried out for mitigation and prevention of barrage break hazard exclusively from the barrage is given in **Table 10.47**.

Table 10.47: Cost Estimate for Implementing DMP

S. N.	Particular	Cost (Rs. Lakh)
1.	Installation of alert system in control room	2.50
2.	Setting up of communication system between barrage and d/s settlements	5.00
3.	Setting up of seismic laboratory	15.00
4.	Public information system	1.00
5.	Flood forecasting	10.00
6.	Training and miscellaneous	5.00
7	Machinery and Equipment	26.50
	Total	**65.00**

10.13 WATER & AIR QUALITY MANAGEMENT PLAN

10.13.1 Control of Air Pollution

10.13.1.1 Impacts on Air Quality

In a water resources project, air pollution occurs mainly during project construction phase. The major sources of air pollution during construction phase are:

- Fuel combustion in various construction equipment, e.g. heavy earth movers, loaders, drillers, rock bolters, diesel generating sets, compressors etc.
- Fugitive emissions from stone aggregate crushers.
- Drilling and blasting
- Impacts due to vehicular movement

a) Pollution due to fuel combustion in various equipment's

The running operation of various construction equipment's involves combustion of fossil fuel for running the engine. Normally, diesel is used in such equipment. The major pollutant, which gets emitted as a result of diesel combustion, is SO2. The PM10 emissions are minimal due to low ash content. Based on experience in similar projects, PM10 and SO2 are not expected to increase significantly. Thus, in the proposed project, no significant impact on ambient air quality is expected as a result of operation of various construction equipment's.

b) Emissions from various crushers

The operation of aggregate crushing plant during the construction phase is likely to generate fugitive emissions, which can move even up to 1 km in predominant wind direction. During crushing operations, fugitive emissions comprising of the suspended particulate matter will be generated. There could be marginal impacts to settlements close to the site at which crushers are commissioned. However, based on experience, adverse impacts on this account are not anticipated. The labour camps, colonies, etc. shall be located outside the impact zone (about 1.5 to 2 km) of the crusher plant.

c) Impacts due to vehicular movement

During construction phase, there will be increased vehicular movement for transportation of various construction materials to the project site. Large quantity of dust is likely to be entrained due to the movement of trucks and other heavy vehicles. However, such ground level emissions do not travel for long distances. Thus, no major adverse impacts are anticipated on this account.

10.13.1.2 Mitigation Measures

a) Control of Emissions

Minor air quality impacts will be caused by emissions from construction vehicles, equipment and DG sets, and emissions from transportation traffic. Frequent truck trips will be required during the construction period for removal of excavated material and delivery of concrete mix and other equipment and materials. The following measures are recommended to control air pollution:

- The contractor will be responsible for maintaining properly functioning construction equipment to minimize exhaust.
- Construction equipment and vehicles will be switched off when not used for extended periods of time.
- Unnecessary idle running of construction vehicles to be prohibited.
- Effective traffic management to be undertaken to avoid significant delays in and around the project area.
- Road damage caused by sub-project activities will be promptly attended to with proper road repair and maintenance work.

b) Air Pollution control due to DG sets

DG sets should be located from the consideration of prominent and first prominent wind direction so that on the downwind direction the human habitats are least impacted by the flue gas emissions. The norms prescribed by the CPCB in respect of fixing the minimum stack height for generator, should be strictly complied with. In no case, it should be lesser than the 20% of the under root of generator capacity in KVA added to the height of the building where it is installed. The emission norms in India cover CO, NOx, PM, and HC and are specified based on the number of grams of these compounds present in diesel exhaust when one kilowatt-hour of electricity is generated. These norms have been revised in December 2013 (G.S.R. 771 (E) / 11th Dec 2013 notification), its amendment vide GSR 232(E) dated 31st March,2014 and GSR(E) dated 7th March ,2016 and have come in force from 1st July 2016. These norms are presented in **Table 10.48.**

Table 10.48: Emission limits for DG sets prescribed by CPCB

Power Category	Emission Limits (g/kWh)			Smoke Limit (Light absorption co-efficient per meter)
	NOx+THC or NOx+NMHC or RHC	CO	PM	
Up to 19 kW	≤ 7.5	≤ 3.5	≤ 0.3	≤ 0.7
More than 19 kW up to 75 kW	≤ 4.7	≤ 3.5	≤ 0.3	≤ 0.7
More than 75 kW up to 800 kW	≤ 4.0	≤ 3.5	≤ 0.2	≤ 0.7

c) Dust Control

The project authorities will work in close association with representatives from the community living in the vicinity of project area to identify areas of concern and to mitigate dust-related impacts effectively (e.g., through direct meetings, utilization of construction management and inspection program, and/or through the complaint response program). To minimize issues related to the generation of dust during the construction phase of the project, the following measures have been identified:

- Identification of construction limits (minimal area required for construction activities).
- When practical, excavated spoils will be removed as the contractor proceeds along the length of the activity.
- When necessary, stockpiling of excavated material will be covered or staged offsite location with muck being delivered as needed during construction.
- Excessive soil on paved areas will be sprayed (wet) and/or swept and unpaved areas will be sprayed and/or mulched. The use of petroleum products or similar products for such activities will be strictly prohibited.
- Contractors will be required to cover stockpiled soils and trucks hauling soil, sand, and other loose materials (or require trucks to maintain at least two feet of freeboard).
- Contractor shall ensure that there is effective traffic management at site. The number of trucks/vehicles to move at various construction sites to be fixed.
- Dust sweeping - The construction area and vicinity (access roads and working areas) shall be swept daily or as necessary to ensure there is no visible dust. Kutcha surface / earthen roads shall be sprinkled with water twice a day.
- Dust mufflers shall be provided at batching plants and stone aggregate crushers.

10.13.1.3 Implementing Agency

Various management measures required for control of air pollution need to be included in the Tender Document for the Contractor involved in construction activities. The same shall be monitored on a regular basis by the project proponents. Considering an expenditure of Rs. 400/day for 240 working days annually (excluding rainy season of 4 months), a sum of Rs. 9.60 lakh must be earmarked under air pollution control measures for copious sprinkling on roads for dust suppression.

10.13.2 **Impacts on Noise Levels**

In a water resource project, the impacts on ambient air noise levels are expected only during the project construction phase, due to operation of heavy earth moving machinery, etc. Likewise, noise due to quarrying, blasting, vehicular movement will have some adverse impact on the ambient noise levels in the area.

10.13.2.1 Mitigation Measures

The contractors will be required to maintain proper functioning of equipment and comply with occupational safety and health standards. The construction equipment will be equipped with noise suppression devices and properly maintained mufflers.

- Vehicles to be equipped with mufflers recommended by the vehicle manufacturer.
- Staging of construction equipment and unnecessary idling of equipment within noise sensitive areas to be strictly avoided.
- Use of temporary sound fences or barriers with acoustic material at sensitive locations
- Notification shall be provided at a conspicuous place close to residential areas within 100 meter of major noise generating activities. The notification will describe the noise abatement measures that will be implemented.
- Monitoring of noise levels will be conducted during the construction phase of the project. In case of exceeding of pre-determined acceptable noise levels by the machinery will require the contractor(s) to halt work and remedy the situation prior to continuing construction.

The following Noise Standards for DG sets are recommended for the running of DG sets during the construction:

- The maximum permissible sound pressure level for new diesel generator sets with rated capacity up to 1000 KVA shall be 75 dB(A) at 1 m from the enclosure surface.
- Noise from the DG set should be controlled by providing an acoustic enclosure or by treating the enclosure acoustically
- The Acoustic Enclosure should be made of CRCA sheets of appropriate thickness and structural/ sheet metal base. The walls of the enclosure should be insulated with fire retardant foam to comply with the 75 dB(A) at 1m sound levels specified by CPCB, Ministry of Environment & Forests.

- The acoustic enclosure/acoustic treatment of the room should be designed for minimum 25 dB(A) insertion loss or for meeting the ambient noise standards, whichever is on the higher side.
- The DG set should also be provided with proper exhaust muffler with insertion loss of minimum 25 dB(A).
- Proper efforts to be made to bring down the noise levels due to the DG set, outside its premises, within the ambient air noise requirements by proper placing and control measures.
- A proper routine and preventive maintenance procedure for the DG set should be set and followed in consultation with the DG set manufacturer which would help prevent noise levels of the DG set from deteriorating with use.

10.13.2.2 Mitigation Measures of Noise from Crushers

Based on literature review, noise generated by crushers is in the range of 79-80 dB(A) at 80 m from the crusher. Thus, noise level at 160 m from the crusher shall be of the order of 74 dB(A). The exposure to labor operating in such high noise areas shall be restricted up to 30 minutes daily. Alternatively, the workers need to be provided with earmuffs or plugs, to attenuate the noise level near the crusher by at least 15 dB(A). The exposure to noise level in such a scenario is limited up to 4 hours per day.

It is known that continuous exposure to noise levels above 90 dB(A) affects the hearing of the workers/operators and hence must be avoided. Other physiological and psychological effects have also been reported in literature, but the effect on hearing has been specially stressed. To prevent these effects, under OSHA Noise Exposure Standards vide Table G-16, has provided a 90 dB(A) criterion for an eight-hour time weighted average PEL and is measured using a 90 dB(A) threshold (i.e. noise below 90 dB(A) is not integrated into the TWA. The table reproduced as **Table 10.49** limits short- term noise exposure to a level not greater than 115 dB (A) for up to 15 minutes

Table 10.49: Maximum Exposure Periods specified by OSHA

Maximumequivalent continuous noise level dB(A)	Unprotected exposure period/day for 8hrs/day and 5 days/week
90	8
95	4
100	2
105	1
110	0.5
115	0.25 No exposure permitted at or above this level

The workers deployed at such locations where the noise levels are high shall be provided with earplugs. The cost of earplugs including its replacement shall be Rs.0.40 lakh.

10.13.3 Control of Water Pollution During Construction

During project construction phase, enough measures need to be implemented to control the problem of water pollution from various sources. The sewage generated from various labour camps is proposed to be treated in an oxidation ditch, prior to its disposal. However, efforts shall be made to discharge the treated effluent only in these water bodies, which are not used for meeting domestic water requirements. It is proposed to provide adequate capacity STP for project colony and labour colony for which an amount of Rs 10 lakh has been earmarked.

The construction activities would require a crusher to crush large lumps of rocks to the requisite size for coarse as well as fine aggregates. The effluent generated from these crushers will have high-suspended solids. The effluent needs to be treated before disposal. Settling tanks of appropriate size for treatment of effluent from various crushers should be provided.

During tunneling work the ground water flows into the tunnel along with construction water, which is used for various works like drilling, shotcrete, etc. The effluent thus generated in the tunnel contains high suspended solids. Normally, water is collected in the side drains and drained off into the nearest water body without treatment. It is recommended to construct a settling tank of adequate size to settle the suspended impurities. Effluents are expected to be generated from adit locations. The sludge from the various settling tanks can be collected once in 15 days and disposed at the site designed for disposal of municipal solid wastes from the labour camps. The sludge after drying could also be used as cover material for landfill disposal site. An amount of Rs.0.20 lakh has been earmarked for construction of various settling tanks.

10.13.4 Control of Water Pollution During Construction

The cost of mitigative measures suggested for control of water, air and noise is given in **Table 10.50.**

Table 10.50: Maximum Exposure Periods specified by OSHA

S. No.	Particulars	Amount (Rs. Lakh)
1.	Control of air pollution	9.60
2.	Control of noise pollution	0.20
3.	Control of water pollution	10.20
Total		**20.00**

10.14 PUBLIC HEALTH MANAGEMENT PLAN

10.14.1 Introduction

From the information collected, it has been revealed that no ethnic disease is associated with people of the region but acute dysentery, gastrointestinal problems,malaria, and jaundice are common endemic diseases prevalent in the area. The incidence of hypothyroidism has reduced with the mandatory sale of iodized salt in the area.

The prevalent diseases observed by the health centers among the local inhabitants of the area are, fever, re-productory tract infection (RTI), scabies, worm disease, ENT, skin diseases, common cold, diarrhea, leuchoria, back pain, accidental cases and eye infection etc. Initial health assessment reveals that there is no specific health hazard in study area.

The nearby government run medical facilities available in the project area is district hospital at Singhtam, Central Referral Hospital at 5thmile Tadong, PHC at Rangpo, besides Public Health Sub Centre (PHSC) in 3 project affected revenue blocks.

10.14.2 Likely Impacts on Human Health Due to The Project

Construction of the proposed project may cause the following impacts on the health of local residents and the workforce: -

(i) Fuel and dust emission may cause respiratory problems like asthma, for which mitigative measures like wet excavation of exposed surfaces, battery operated muck cars in underground excavation may be deployed. Frequent water sprinkling at least thrice a day shall be carried out on haul roads in the project activity area. All approach roads to site shall be metaled.

(ii) The scheme being R-O-R type involving a diversion barrage, where the flowing discharge is made to impound upstream of the barrage to be diverted through underground conveyance system for continuous generation of power. Thus, the pond level shall be subjected to fluctuation and the chances of water surface being still are not there. However, localized stagnation in borrow pit areas is expected during construction in some of areas. This may require sprinkling of antibacterial/insecticides to control propagation of bacteria related disease.

(iii) The influx of labour-force during construction warrants proper sanitation and hygiene facilities to avoid diseases related to sewage pollutants such as Typhoid, cholera & gastroenteritis.

10.14.3 Proposed Health Management Plan

Based on the impact evaluation following mitigation measures are proposed to be adopted for management of health environment: -

10.14.3.1 Awareness Programme

The project authorities should undertake various awareness programmes by organizing camps and poster presentation etc. in the directly affected areas to bring about awareness on prevention and control of various diseases such as Malaria, Dengue, Cholera, Gastroenteritis, STD, AIDS, and Cancer etc. Special emphasis should also be given to provide awareness on family planning to the local people. Special awareness programmes should be undertaken to explain to people about diseases like Tuberculosis (TB) and Asthma.

10.14.3.2 HIV / AIDS

A virus known as Human Immunodeficiency Virus (HIV) causes AIDS. This virus is what destroys the immune system. HIV can also invade the central nervous system causing severe neurological problems. HIV can also invade the central nervous system causing severe neurological problems. It can take up to 10 years after a person is infected with HIV to develop AIDS. An HIV-infected person can look perfectly normal and healthy. In addition, anyone infected with HIV can infect another person. HIV is spread through certain body fluids, mainly: · Blood, Semen, Vaginal secretions and breast milk. HIV is spread by certain behaviors and/or situations, which inter-alia include sexual contact (anal, vaginal, and oral) with infected person, sharing injection equipment, blood or its components and Infected mother to infant. The following measures are recommended for AIDS control:

Prevention

Awareness programme educating people to enable to make life saving need to be implemented. Intravenous drug users to be informed about the perils of sharing of needles. Use of various modes of media to educate people on AIDS, its nature, transmission and prevention. People in high-risk groups to be refrained from donating blood, body organ, etc. Strict sterilization practiced to be ensured in hospitals and dispensaries. Pre-sterilized or disposable syringes to be used as far as possible.

Anti-Retroviral Treatment

At present, there is no vaccine or cure for treatment of HIV infection/AIDS. However, drugs that suppress the HIV infection rather than its complications can be used for prolonging the life of terminally ill patients.

Primary Health Care

AIDS touches all aspects of primary health care, including mother and child, family planning and education. Thus, it is recommended that the AIDS control programme integrate various related issues into country's primary health care system. The AIDS control and awareness programs, developed by National Aids Control Organization (NACO) need to be strictly implemented in the project area as w ell. In addition to primary health care, it is also recommended that the workers should be made aware not to hurt the traditional cultural and regions customs and practices.

Asthma

Asthma is a long-term (chronic) disease of the airways which are involved in carrying air in and out of the lungs. Its symptoms are caused by inflammation, which makes the airways red, swollen, narrower and extra sensitive to irritants. This leads to recurrent attacks of wheezing, breathlessness, chest tightness and coughing. Asthma does not stay the same, but changes over time and every person with asthma has a good and bad days. However, if asthma is properly treated, one can enjoy long periods without symptoms or attacks. The causes of asthma are not fully understood. Asthma is usually caused by a mixture of hereditary (which a person is born with) and environmental factors.

Allergens from house dust mites and pets are the most common causes, but many other allergens, such as pollen and moulds, can cause asthma. Some patients with asthma have no obvious allergies.

Treatment of asthma requires two types of medicines, preventers and relievers. Preventers are medicines that prevent asthma attacks from starting. The most effective and most commonly used preventer medicines are inhaled glucocorticosteroids. Reliever medicines, like inhaled salbutamol, salmeterol etc., provide rapid relief from an asthma attack by quickly opening the narrowed airways (dilating the bronchi).

Tuberculosis (TB)

It is a communicable, but curable bacterial infection caused by Mycobacterium tuberculosis. The lungs are primarily involved, but the infection can spread to other organs.

TB is spread through the air when a person with TB in the lungs or throat coughs or sneezes, sending TB germs in the air. When other people breathe in these germs, they may become infected. The primary stage of the infection is usually asymptomatic (without symptoms). Pulmonary TB develops in the minority of people whose immune systems do not successfully contain the primary infection. In this case, the disease may occur within weeks after the primary infection. TB may also lie dormant for years and reappear after the initial infection is contained.

This TB infection becomes 'disease' when the body's defenses are weakened, due to aging, a serious illness, stressful event, drug or alcohol abuse, HIV infection (the virus that causes AIDS) or other conditions. When inactive TB germs become active, they multiply and damage the lungs or other parts of the body and the disease develops. Only about 10% of people infected with TB germs develop TB disease.

Malaria

Once adult mosquitoes have emerged, the ambient temperature, humidity and rains will determine their chances of survival. To transmit malaria successfully female anopheles must survive long enough after they have become infected (through a blood meal on an infected human) to allow the parasite they know harbor to complete their growth cycle. That cycle takes 9-21 days @ 250 C. Below a minimum ambient temperature (150 C for plasmodium vivax, 200 C for P falciparum) the cycle cannot be completed and malaria cannot be transmitted.

Spray Operation

There shall be regular fumigation, fogging, or sprays of insecticides in the areas where water is likely to be stagnant, to prevent the growth of malarial larvae. As per modified plan of operation SP is required to be sprayed in project area. The requirement of insecticide is as follows:

- SP 5%-37.5 M.T per million populations for two rounds
- SP 10%-18.75 M.T per million populations for two rounds

To undertake the spray operation field workers are required. One squad consisting of one superior field worker and five field workers each spraying squad need two stirrup pumps which will cover 25 t0 30 houses per day per pump

Reduce Exposure to Mosquitoes

Encourage prevention of mosquito-borne disease by helping people by reducing their exposure to mosquitoes during the day and at night. Work with the malaria control programme in the project area to:

- Popularize the use of bed net programme
- Conduct community education on the proper use of bed nets and how to avoid dawn to dusk mosquito bite. Regular spray of insecticides.
- Implementation of various management measures for vector control (drainage, filling, of breeding, sites) as outlined in the earlier section
- Vector Control is still one of the major measures to control malaria in endemic area.

Following measures are recommended:

Anti-Adult Measures

- Residual spraying with insecticides.
- Space application of insecticides in the form of a fog or mist. The method has proved economical due to ultra-low volume dispersion of pesticides in air.
- Prevention of man-vector contact by use of repellents, protective clothing, and bed nets.

Anti-Larvae Measures

- Use of larvicides at regular intervals
- Reduction of mosquitoes breeding sites by drainage or filling, deepening or flushing,
- Introduction of fish species in permanent water bodies which feed on mosquito larvae.

10.14.4 Establishment of Project Dispensary

The project proponent shall develop and maintain two dispensaries within the project area, which shall have trained staff, equipment and medicines. Onsite first-aid facility should also be provided in the labour at all the working sites. Besides this the project proponent shall establish and man one PHC each at Namli and Namchebung.The hospital facilities would be available to the staff, workers and local people. Free medicines should be distributed to the identified project affected families who shall be provided with identity cards and to the locals. Provision for purchase and running of one ambulance hasalso been made in the plan. Free facilities of ambulance shall be made available to the project affected families (PAFs) and project labourers and for the people meeting accident on the state highway /district roads. The project authorities should undertake various health care programmes in consultation with State Health Department such as providing vaccination and other primary health care facilities.

10.14.5 Malaria Control and Vaccination Programme

The borrow pits caused during construction activities, if not reclaimed, provide habitat ground for mosquito population increase and develop the risk of malaria & elephantiasis during rains. However, proper arrangements should be made and implemented for maintaining hygienic conditions in the area. Besides these, arrangements are proposed to distribute medicines and anti-malarial drugs as and when required. Various vaccination programmes shall be arranged periodically as and when required for the locals of the project area.

10.14.6 Bio-Medical Wastes from Hospitals

In view of proposed dispensary to be located at proposed permanent colony in the project area, the hospital waste management should be considered a priority. All kinds of hospital waste are considered as hazardous waste. Hospital waste is generated during the diagnosis, treatment or immunization of human beings. It may include waste like scrap, anatomical waste, culture media, discarded medicines, chemical waste, syringes, swabs, bandages, body fluids, human excreta, etc. This waste is highly infectious and can be serious threat to human health if not managed in a scientific and discriminate manner. It is expected that generation of such hazardous waste will be very less. For management, special type of collection container and incinerator should be placed near the hospital for proper collection and disposal of hospital waste. Hospital waste should be incinerated or buried at isolated, identified sites, strictly in accordance with the provisions of the Biomedical Waste (Management & Handling) Rules1998 and amendment,2003. Any kind of hospital waste should not be either recycled or reused. Incinerator/Autoclave is also a legal requirement for hospital waste management so that the non-biodegradable waste generated from colony as well as hospital can be scientifically disposed. One small-scale incinerator must be installed at suitable site in project area for reduction of total volume of non-biodegradable solid waste.

10.14.7 Cost Estimate for Health Management Plan

The details of the expenditure likely to be incurred on the implementation of the Health Management Plan other than the cost of project dispensary are given in **Table 10.51.**

Table 10.51: Budget Estimate of Health Management Plan

S.N.	Particulars	Amount (Rs. lakh)
1.	Free medicines for labourers, PAF, local people @ Rs. 2.50lakh per year for 10yr.	25.00
2.	Spraying of insecticide @ Rs. 0.30 lakh/year for 10 years	3.00
3.	Establishing and running dispensary at two places at site for labours	25.00
4.	EstablishingPHC at Namli and Namcheybung	21.00
5.	Provision for salary of a doctor & para-medical staff @ 8.00 lakh/month for 5yr	40.00
6.	Purchase cost of ambulance	5.00
7.	Running Charges for ambulance@ 2.0 lakh/month for 10yr	20.00
8	Electricity charges@ 0.6 lakh/month for 10yr	6.00
9	Cost of one small incinerator	5.00
10	Running charges @ Rs 0.50 lakh/y	5.00
	Total	**155.00**

10.15 LABOUR MANAGEMENT PLAN

10.15.1 INTRODUCTION

Construction projects, which invariably engaged large number of contract workers, are highly prone to hazards pertaining to site activities. Generally, the workers come from the rural areas and agricultural background and do not have adequate training in construction safety and some time workers from varied trades are drawn into construction activities. Thus, workers are exposed to various risks and occupational diseases and health hazards which sometimes cause grave injuries and prolong illness. Therefore, it is incumbent upon the project proponent to have certain safety guidelines for site activities and create awareness among the workers, supervisors and engineers.

The project like any other construction project has significant impact on health and safety during project execution and its operational stage, which need to be managed systematically since the project inception. In construction project, the risk is involved to the labour in various activities like excavation on slope, excavation, quarrying operation, works related to Electrical and Mechanical components, various activities in workshop and machine halls. The project envisages deployment of workforce to the tune of 400 mainly comprising of skilled/semi-skilled/unskilled workers at the peak construction stage.

10.15.2 Legal Framework for Health and Safety Management

The following Indian standard listed below contains provision for managing Occupational health and Safety Management (**Table 10.52**).

Table 10.52: International standards of Health & Safety

S. No	I.S. No	Title
1	15793:2007	Managing Environment, Occupation Health and Safety Legal Compliance – Requirement of good practices.
2	15883 (part-I) :2009	Guidelines for construction project management.
3	18001:2007	Occupational Health and Safety Management System
4	IS 15883 (Part 5)	Guidelines for construction project Management-Health and Safety Management

As per general requirement under OH&S management system the organization (project proponent) shall establish, document, implement, maintain and continually improve an OH&S management system, in accordance with the requirement of this standard. The organization shall define and document the scope of its OH&S management system.

10.15.3 Health and management safety requirement

The project proponent shall have a written statement prescribing the health and safety policy of the organization. The policy shall convey the management commitment and its intent towards health and safety, its implementing organization and arrangement to ensure that the set objectives are met. It shall also provide a framework for establishing, maintaining and periodically reviewing health and safety objectives and targets. The salient aspects which will be covered in the project health and safety plan are:

- Project specific health and safety objectives, targets and programmes in line with health and safety policy;
- Hazard identification and risk assessment;
- Health and safety organization;
- Resources, roles, responsibility and authority;
- General health and safety rules;
- Health and safety requirements to be followed by sub-contractors;
- Operation control procedure;
- Activities requiring work permit system and its procedure;
- Management of traffic safety inside the project;
- Access control of employees;
- Safety of visitors;
- Management of critical activities such as work a height, material handling and working with plant and machinery;
- Ensuring the competency and awareness of the workmen;
- Fire prevention and firefighting plan;
- Emergency preparedness and response plan;

- Traffic management plan;
- Training matrix; and
- Personal Protective Equipment Matrix.
- Health and safety performance monitoring measures such as Inspection, Audit Incident reporting and investigation procedure

10.15.3.1 Resource, Roles, Responsibility and Authority

Project manager shall define, document and communicate the roles, responsibilities and authorities of all personnel like health and safety officer and supervisor who manage, perform and verify activities influencing health and safety risks.

The line management personnel who are responsible for execution of activities is directly responsible for health and safety in the work under their control.

Health and safety officers shall administratively report to the project manager and functionally report to the senior health and safety representative of the organization.

Health and safety supervisors shall be engaged to assist the health and safety officers in performing their duties.

Management shall provide adequate resources essential to effectively manage the health and safety management system requirements of the project. The resources shall include human resources, organizational infrastructure, technology and financial resources.

10.15.3.2 Competence, Training and Awareness

It shall be ensured that all employees are competent to perform the assigned work safely based on appropriate education, training or experience. Training needs of the different category of employees shall be identified at the beginning of the project and a training matrix and training plan shall be prepared for implementation. The objective of health and safety Training shall be

- to equip the employee with necessary knowledge and skill to perform the work assigned to him in a safe manner;
- to foster continual improvement; and
- to imbibe safety culture.

After completion of training due procedure shall be followed for obtaining the feedback from the participants on the effectiveness of the training.

10.15.3.3 Health and Safety Reporting

Procedures shall be established for timely recording and reporting of information required for continual improvement of health and safety performance. Reporting procedures shall cover:

- Incident reporting
- Non-conformance reporting

Health and safety performance reporting

- Hazard Identification reporting
- Statutory reporting requirements
- Stakeholder reporting

The recording of reporting of health and safety performance shall be clearly documented in the project health and safety plan

10.15.3.4 Permit to Work Systems

Activities requiring permit to work shall be decided before starting the construction and shall be suitably documented in the project health and safety plan. Some of the activities which may require permit to work are:

- Excavation
- Entry into confined spaces
- Electrical work (HV/LV)
- Opening manholes, covers and grills
- Blasting operation
- Hot work
- Work on plant, machinery and other power-driven equipment.
- Working at height
- Working at night

The project team may establish a permit to work system for any other hazardous activity which they feel need to be controlled administratively for safe execution

10.15.3.5 Certification of Plant and Machinery, Lifting

Tools and Tackles Lifting appliance such as crane, hoist, derrick, winch, gin pole, sheer legs, jack, pulley block and other equipment used for lifting materials, objects or building worker; lifting gear such as ropes, chains, hooks and slings; and other accessories of a lifting appliance shall be tested and examined by a competent person for the first time. These shall thereafter be tested and examined by a competent person once every year as per the provision of Building and other Construction Workers (Regulation of Employment and Conditions of Service) Act, 1996 and other relevant central and state rules and regulations. Apart from the above statutory testing and examination, project specific procedures shall be established to ensure the fitness of machinery and equipment being deployed at the project for the first time. Regular Inspections shall be carried out to ensure that machinery and equipment continue to be in safe condition.

10.15.3.6 Fire Prevention and Control

Fire prevention measures such as controlling the ignition source and segregation of flammable materials shall be implemented to prevent fire.

Adequate firefighting facilities such as portable first aid fire extinguishers, fire buckets filled with water and sand, water pipelines and hoses shall be established and maintained regularly.

Firefighting arrangements provided shall be suitable to fight the possible type of fire that may occur depending on the type of flammable material. Fire facilities shall be placed strategically such that they are accessible from any location of the site without travelling for long distances. Employees shall be trained on fire prevention and firefighting measures on a regular basis.

10.15.3.7 Access Control

It is advisable to establish access control measures at the construction project to control movement of workmen and visitors. Access control may be achieved by entry pass, bar-coded cards and biometric systems or other suitable means.

10.15.3.8 Safety of Visitors

Visitors for the project shall be given health and safety induction before they are allowed in to the construction project. It shall include the minimum PPE to be used, hazards and risks at the work area, restricted areas of entry, emergency response arrangements, etc.

10.15.3.9 Traffic and Logistics Management

Traffic management plan shall be prepared as a part of the project health and safety plan at the initial stage of the project to manage the traffic inside the project site. Traffic management plan shall include:

- Measures for segregating pedestrian and vehicle traffic;
- Establish project specific traffic rules such as speed limit and one-wayetc.;
- Managing the flow of traffic such that blind zones and hazardous junctions are not present;
- Managing the flow of traffic such that reversing can be avoided as far as possible; and
- Use of traffic control devices such as road humps, convex mirrors, delineators traffic signals and barriers. It shall be planned to deploy flag man, security personnel and traffic marshals at critical areas to regulate traffic.

10.15.4 **Occupational Health Management Plan**

10.15.4.1 Potential Risk of Project Activities

The excavation for the project, by the nature of the activities involved, are accompanied with risk of medium to high degree involving blasting. The risks associated with the project are not hazardous, but if any, they are only accidents and incidents, associated with construction machinery or transportation activity, if adequate controls or safety systems are not adopted. The rock excavation by deploying excavators / JCB/loaders/ rock-breakers besides drilling and blasting and loading on to the trucks by backhoe can have risks of accidents if human failure or errors are not taken care of. The accidents, if any, may not be fatal, but are potential to cause temporary or permanent disabilities. Thus, the need for adequate safety at workplaces is needed. Some minor incidents like exhaustion, sunstrokes, or other health related incidents may take place, which can be avoided with adequate safety regulations and measures. Transportation of construction material, excavated muck for disposal and crushed stone aggregates to various construction sites are some of the activates associated with accidents on road and at the project site. However, with effective safety measures the accidents can be avoided and prevented.

10.15.4.2 Safety of Machine Use at Project Site

The major machinery to be deployed at site shall be excavators/JCB, Backhoe and loaders which can excavate earth mix with boulders / rock mass and load on to vehicles. The area where machinery shall be operated will be under supervision of trained operators and helpers besides technically qualified foreman to ensure that the machinery is operated as per specified design parameters of the manufacturer. Before the work is initiated every day, the routine check-up especially with regard to its hydraulic systems, mechanical conditions, and other operating systems shall be performed. The movement of trucks/trippers/tractors for loading /transportation of material within the project area and haul road area shall be regulated by a trained supervisor who shall be responsible for the safety of vehicle movement and prevention of accidents or incidents associated with the vehicular movement. All staff working with the construction machinery shall be trained in first-aid and other safety measures, accident or incident prevention and reporting and communication mechanisms.

10.15.4.3 Occupational Health & Safety (OHS)

The excavated material and construction material do not contain any toxic element. Therefore, the likelihood of any health hazard does not arise due to their handling per se. However, the process of excavation / quarrying leads to some health hazards. The dust generated due to excavation loading and movement on Kutcha/riverbed haul road creates air borne dust which has silica contents. The dust is the main pollutant of concern for the workers engaged in the mining activities. The most significant occupational health impacts are Noise Induced Hearing Loss (NIHL) and Occupational Lung Disease (OLD) like allergic rhinitis and asthma due to inhalation of dust. Working in open during summer can expose workers to the direct sun rays causing heat strokes, cramps and burns besides leading to exhaustion. In extreme windy conditions, the dust particles forcing way into the eyes can create itching as well as allergic conjunctivitis of eye. Medical examination of employees at the initial stage and periodically, shall be done by a team of qualified medical officers provided by the project proponent.

The initial medical examination of every person employed in the project within a period of five years of the date so notified and the said examination shall be so arranged over a period of five years that one fifth of the persons employed at the mine undergo the examination every year. The periodical medical examination thereafter of every person employed in the project shall be conducted at intervals of not more than five years.

Regular medical check-up camps shall also be arranged for detection of occupational diseases and minor disease in the nearby rural population. Free check-up and medicine for treatment for their acute and chronic illness shall be provided

10.15.4.4 Occupational Health & Safety Measures to Control Dust Inhalation

- Providing a working environment that is conducive to safety and health.
- The management of occupational safety and health is the prime responsibility of mine management.
- Employee involvement and commitment in the implementation of health and safety guidelines.

- Periodical health check-ups
- Implementing safety and health management system and assessing the effectiveness through periodic audits.
- Monitoring the effects of mining activities on safety and health and conducting regular performance reviews.
- Provision of necessary personal protective equipment.
- Establishing and maintaining a system of medical surveillance for employees
- Ensuring employees at all levels receive appropriate training and are competent to carry out their duties and responsibilities.

All the above precautions would be adopted to prevent dust generation at site and to be dispersed in the outside environment. However, for the safety of workers at site, engaged at strategic locations / dust generation points like loading and unloading points, screening sieve, dust masks would be provided. Dust masks would prevent inhalation of PM10/PM2.5 thereby reducing the risk of lung diseases and other respiratory disorders. Regular health monitoring of workers will be carried out.

10.15.4.5 Noise Induced Hearing Loss (NIHL)

Blasting causes intermittent high level of noises whereas the continuous running of construction machinery / compressors / wagon drills / rock breakers leads to high noise level in the immediate vicinity of the point of noise emission. Hearing conservation programmes exists at all operations. Baseline audiogram forms the basis for future assessment of employees in terms of hearing loss.

Using engineering initiatives to reduce noise at source is the priority management tool. The hearing conservation programme includes the provision of Hearing Protection Devises (HPDs) and annual audiometry examination of all employees. Apart from provision of HPDs emphasis is also laid on training the employees' responsibility to protect his / her hearing.

10.15.4.6 Occupational Lung Diseases (OLD)

There will be regular health camps for all the workers and nearby rural people. Lung function tests, chest X-rays etc. shall be carried out and any health disorders will be evaluated. The budget shall be earmarked for the necessary protective devices and training needs.

10.15.4.7 Cost Estimate

For initial and periodical medical check-up of employee, who are engaged at the active construction site, budgetary provision shall be made. The provision at this stage is being made for 400 skilled/semi-skilled / unskilled workers. The cost estimate is provided in **Table 10.53.**

Table 10.53: Cost Estimate

S. N.	Particular	Quantity	Unit	Rate	Amount (Rs. lakh)
1.	Initial medical check-up of employees for lung function, audiometric test, tuberculosis and pulmonary disease at the time of appointment	400	Man	1000	4.00
2.	Periodical Medical Check-up of the employees	400	Man	1000	4.00

	(Audiometric Test, Eye – Check-up, Lung function and respiratory test)				
3.	Provision for free medicines for all workers @ Rs. 200/year including up keep of on-site first aid facilities	400	Man	250	1.00
4	Provision for personal protection equipment like helmets, ear plug, dust mask, shoes, goggles etc., for workers	400	No.	500	2.00
Total					**11.00**

10.15.5 Safe Working Procedure:

10.15.5.1 Demolition:

Before any demolition work is commenced and also during the progress of the work:

- Appropriate warning signs shall be displayed for cautioning persons approaching the demolition area. The area shall be cordoned off properly.
- Before demolition operations begin, the Contractor shall ensure that the power on all electric service lines is shut off and the lines are cut or disconnected at or outside the demolition site. If it is necessary to maintain electric power during demolition operation, the required service lines shall be adequately protected against damage.
- Persons handling heavy materials /equipment shall wear safety shoes.

10.15.5.2 Earthwork in excavation and backfilling:

The Contractor shall take all safety precautions during the execution of awarded work and shall maintain and leave the site safe at all times.

- The Contractor shall ensure the stability and safety of the excavation, adjacent structures, existing services and the works of other agencies.
- Open excavations shall be cordoned off by suitable railing/barricading and photo-luminescent warning signals installed so as to prevent persons slipping or falling into the excavations. Warning signals shall be visible at night also and the area shall be well illuminated during the work.
- All blasting operations, if permitted by Engineer-in-charge, shall be carried out on the basis of procedures approved by Inspector of Explosives. All works in this connection shall be carried out as per I.S Code of Practice. Barricades, photo-luminescent warning signs, etc. shall be placed on the roads/open area. Prior approval of such operation shall be obtained from Safety Officer/Engineer-In-Charge of Works.
- Contractor shall arrange adequate and efficient mechanical dewatering system as recommended by Engineer-in-charge. These pumps shall be inspected and maintained in proper working condition. The electrically operated pumps shall be connected to ELCB of proper rating for safety of the person operating/shifting them.
- Contractor shall wash the wheels, of the transport vehicles carrying excavated soil, with water jet before moving out of the site premises so that there is no spill over of soil on the existing roads. In case there is any such spill over on the roads, the same shall be cleaned by the contractor by manual / mechanical means immediately at no extra cost.

10.15.5.3 Concreting:

- Proper exhaust ventilation shall be available at the cement store and during casting work in confined places. PPE for protection of workers viz. respirators, hand gloves, gumboots, etc. shall be provided by the contractor to the workers handling cement bags and concrete manually.
- The contractor shall provide ear-muffs to the operator / worker exposed to continuous high-level of noise and ear-plugs to all workers involved in the concreting work.
- Wheels of concrete pump / concrete mixer shall be placed on firm ground / platform. Pump accessories shall be checked for its safe working pressure considering maximum pipe line height. A pressure release valve shall be attached to the pump to release the excess pressure.
- The pipeline for transporting the concrete shall have the shortest route with minimum bends and shall be installed on firm supports at suitable intervals. Pipeline shall be properly joined with clamps and securely tied to nearby support and checked in advance before starting the concreting. Pipe segments shall be cleaned in advance to avoid choking of concrete during casting.
- All mechanical equipment/tools used in concreting activity like batching plant/concrete mixer, concrete pumps, vibrators, etc. shall be operated by trained person only.

10.15.5.4 Reinforcement:

- Bar bending and cutting yard shall be properly cordoned / barricaded and entry shall be restricted.
- Re-bar bending and cutting machines shall be handled by trained operator / skilled workers.
- Shifting of cut re-bars shall be done by mechanical means as far as possible. When re-bars are shifted manually, it shall be done with proper care and proper balance shall be maintained. Clear access shall be provided for shifting of re-bars.
- Proper support shall be given to the column bars by means of rings / props against undesirable sway.
- Free ends of the binding wires shall be bent inside to avoid injuries.
- Proper PPE viz. leather / cotton hand gloves, goggles, etc., for the people handling / shifting and cutting / tying of re-bar, shall be used for protection from injury and other occupational diseases.

10.15.5.5 Formwork for concreting:

- Shuttering and supporting members viz. props, tie rods, etc. shall be of adequate strength to support the load / pressure of concrete and the formwork scheme shall be approved by Engineer-In-Charge in advance. The procedure approved by Engineer-In-
- Charge shall be followed for mixing, transporting and pouring of concrete.
- While removing formwork from vertical surfaces, the shuttering board shall be adequately supported by props, in order to prevent the same from toppling / slipping, until it is lowered on ground safely. Same support with props shall be provided during erection of formwork too until the plywood is secured in desired place with tie rods.

10.15.5.6 Scaffolding and Working at Height:

General:

- All the workers, supervisors and engineers of the contractor, who will work at height, shall have valid height passes issued by the Safety Officer.
- The scaffold to be erected for working at height shall be designed for the estimated load.
- The erected scaffold shall be inspected and cleared by the safety officer of the contractor.

The scaffold shall be checked for its condition i.e. it shall be free from bends, cuts, rust, etc. All vertical members shall be in plumb and correctly spaced. The joints of vertical and horizontal members shall be properly connected with couplers, lock pins, etc. The scaffold shall be securely tied with permanent structure as per the requirement of IS:3696 – 1991 (Part 1) (Reaffirmed in 2002).

- The working platform and the access to the scaffold shall be free from all debris and loose materials.
- Contractor shall provide necessary PPEs as per relevant I.S. Codes for the workers working at height viz. full harness safety belt, fall arrestor, kinetic shock absorber, safety helmet, gloves, etc.

Working platform:

- The quality of wooden planks or MS grill plates for decking of working platform shall be made of good quality material and free from any defects, etc. The load carrying capacity of the working platform shall be designed in consultation with Engineer-in-charge. Working platform, gangways and stairways shall be so constructed that they shall not sag unduly or unequally.
- All working platforms shall have guard rails at 1.0 m height with middle rails at 0.5 m height from the platform and 15 cm high toe boards securely tied with the vertical posts.
- The spacing of vertical posts shall not exceed 2.0 m Centre to Centre.
- The contractor shall provide grab rope / life line all around the working platform/level, at height, which will provide tying / anchoring facility for the safety belt / fall arrestor.
- Contractor shall provide safety net under all working platform/level at height to protect fall of men and materials from above and such safety nets shall conform to IS:11057-1984.
- Adequate precautions shall be taken to prevent danger from electrical lines and equipment. Scaffolding, ladder, working platform, gangways, etc. shall not exist within 5m of any un-insulated electric wire. Whenever electric power and lighting cables are required to run through (pass on) the scaffolding or electrical equipment's are used, such scaffolding structures shall have minimum two earth connections with earth continuity conforming to relevant IS Code of Practice.

Ladder:

- Safe means of access shall be provided to all working platforms and other elevated working places with the help of ladders.

- Ladder shall be placed in an inclination not steeper than 1 in 4 (1horizontal and 4 vertical).
- Every ladder shall be securely fixed at bottom from sliding/slipping.

10.15.5.7Construction machinery and Tools:

The operation and maintenance of any construction machinery shall be as per manufacturer's guidelines & checklists and by trained personnel only.

Earth moving machinery:

The contractor shall ensure the stability of the equipment, while working, depending on the load bearing capacity of the ground; which may reduce due to presence of moisture and due to vibration effect. The contractor shall provide bearing plates, packing, etc. to strengthen the ground below outriggers or wheel or crawler of the equipment. All earth moving equipment shall have Roll Over Protective Structures, sound suppressers, seat belts, reverse alarms, warning horns, windshield wipers and easily approachable control and lever for brake system and emergency stop. They shall be checked at the time of delivery and they shall be properly maintained. Contractor shall display warning sign for keeping away from the moving parts of such equipment and the area of operation of such machinery shall be properly cordoned. The shovel / bucket of the earth moving equipment shall be rested on ground when the equipment is not working. Operation of such equipment shall always be carried out by trained operator accompanied by the designated helper.

- **Bulldozers:** The blade of Bulldozer shall be inspected at least once in a week. The blade shall not be used as a brake except in emergency. The position of the blade shall be adjusted while travelling up or down the gradient. The Bulldozer shall be parked on levelled ground, by applying hand brakes and by lowering blade.

Lifting and hoisting machinery:

Lifting machines and tackles shall be of good mechanical construction, sound material and adequate strength and free from any defects and shall be kept in good repair and in good working condition. Every rope used in hoisting or lowering materials or as the means of suspension shall be as per manufacturer's guidelines, of good quality and adequate strength and dimension and free from any defect. Test certificates of such ropes, D-shackles, etc. shall be submitted in advance by the contractor.

- Every crane operator or lifting appliance operator shall be properly qualified. No person under the age of 18 years shall be in charge of any hoisting machine or to give signal to operator of such machine.
- The base of such hoisting equipment shall be kept in perfect horizontal condition since any tilt would reduce the load carrying capacity of the equipment. The foundation shall be firm enough to support the equipment. The level shall be checked every day before starting the work in case of mobile hoisting equipment.
- Thorough inspection and load testing of lifting machines and tackles shall be done by a third party, at least once in every 12 months and the records of such inspection and testing shall be maintained and a copy shall be submitted by the contractor to the

departmental representative at site. Motors, transmission, couplings, belts, chain drives and other moving parts of hoisting appliances shall be provided with adequate safeguards. Hoisting appliances shall be provided with such means as it shall minimize the risk of any part of a suspended load becoming accidentally displaced or lowered.

Tower Cranes: Erection & Commissioning

The type of the tower crane to be used shall be selected based on the load to be lifted, the reach of the boom and the height at which the material is to be shifted. The contractor shall follow all the safety instructions given in the manufacturer's manual for erection, dismantling or extension (jumping) of tower cranes. The contractor shall submit the operation manual, provided by the manufacturer, to the departmental representative before erection of the same at site. For both movable and fixed tower cranes, the adequacy of the counterweight shall be ensured. The base of the tower crane shall be in perfect horizontal level. Base shall be capable of bearing the loads during the operation of tower crane.

Operation – The crane shall never be used to pick the loads which are out of the crane's reach or to do skew pulls of any sort. The load (to be lifted by the crane) shall be free from any sticky characteristic which may cause sudden jerk while lifting. No worker / person shall be lifted by tower crane. Any kind of swinging of lifted load, to put them out of crane's reach, shall not be tried. The operator shall not reverse the motor in order to achieve quicker stop to save time. He shall execute one operation at a time only and shall never combine horizontal movement of trolley with vertical movement of lifting hook. Tower crane shall be protected from sway due to wind load, etc. during operation. Precautions in high wind load shall be taken as per manufacturer's guide. Various components and parts of the tower crane like wire ropes, pulleys, structural members of the tower and boom, etc. shall be periodically checked and properly maintained by the mechanical engineer of the contractor. Proper lighting arrangement with the boom and the tower of the crane shall be provided as safety arrangements for clear visibility during night. The tower crane shall be provided with the siren / horn facility in order to caution the workers in vicinity during operation of the crane. The operator shall take "START" and "HOISTING" signal from the designated helper / supervisor only; however, "STOP" signal can be taken from anyone.

Maintenance- The balancing rope, trolley rope, hoisting rope and erection rope shall be checked as per maintenance guidelines given by the manufacturer and they shall be replaced immediately as and when required. For regular maintenance, the manufacturer's manual shall be followed.

Mobile Cranes:

The contractor shall take care that, the engine of the crane shall be kept running with the gear engaged and maintain a slow speed, while moving down the hill. While travelling uphill or downhill, the boom shall always be kept downhill in order to prevent the boom from falling back. The soil of working area, movement area and parking area of the mobile crane shall be well compacted and shall have proper drainage arrangement. The area shall be dry, levelled and firm enough to hold the load of the mobile crane. The lifting hook shall be tied / anchored while the crane is moving or not operational. Before starting operation at the beginning of day's work, the capacity load shall be picked up to 0.3 m above the ground to test the drift, if any, due to faulty brakes. The brakes shall be 'ON' when a rubber tyre crane is operated. The operator shall always avoid any jerky start or a fast swing during operation of the crane since it increases the risk of overturning of the crane. The pressure in the pneumatic tyres shall be maintained correctly in all wheeled machines.

Transporting Machinery:

Trucks, tippers, dumpers used in transportation of excavated earth or other materials; which are loaded with mechanical excavators, shovels / loaders shall have strong canopies over the driver's cabin to protect them from injuries while loading. The driver's cabin for all the vehicles at construction site shall have a system of sound and vibration suppression, seat belts, reverse horn/alarm, rear view mirror, wide windshield, triplex glass, wiper, sun visor, etc. Brakes and control shall be designed so as to get locked when the vehicle is parked. While going down the gradient, the speed of the vehicle should be controlled. Hydraulic retarder shall be used for big dumpers. Persons holding valid driving licenses for heavy motor vehicle shall be engaged as drivers of the respective type of vehicles. Every dumper, tipper, truck, etc. shall be accompanied by helper and driver shall take all signals from his helper only. The access road of such transport vehicle shall be firm and levelled as far as practicable and shall be free from any obstacle.

Batching plants:

The batching plants shall be calibrated by the contractor at least once in a month and such records shall be made available to the departmental staff for record.

The installation, operation, maintenance and decommissioning of batching plant shall be done as per manufacturer's guidelines and manuals. All electrical works and connections shall be done by a licensed electrician under supervision of electrical engineer of the contractor. The DG requirement (in case of power cuts) shall be of at least 150% of the overload capacity. The operations of hopper, scrapper and pan mixer shall be smooth and periodic inspection shall be done as per manufacturer's guidelines. The material bins shall be checked periodically for presence of any boulders, lumps, etc. which may choke in the hopper causing disruption of operation of the batching plant. Proper care shall be taken during feeding cement silo from the bulker for any loose joints in the feeder pipe and pump of the silo. The silo shall have a guarded monkey ladder for access to the top. The person accessing the top of silo shall seek work permit in advance and shall use proper PPE while climbing. The outer surface of the silo shall be properly painted and maintained against weathering effects. The contractor shall make available at least one fire extinguisher near the operator cabin of the batching plant and the same shall be maintained in good condition always. The operator cabin and the scrapper cabin shall be well ventilated and dust proof. The underground water tank/Vat of the batching plant shall be covered with suitable protective cover and shall be cordoned all around.

Hydraulic machines:

Hydraulic operated machines like mechanical excavators, jacks, or any other hydraulically operated parts, etc. shall be handled carefully. The pressure relief valves mounted on the Hydraulic construction equipment shall not be tampered. These machines shall be equipped with the foam-based fire extinguisher. These machines shall be maintained at regular intervals as per the manufacturer's manual, to avoid failure of brakes, hydraulic system, etc. Regular checking shall be done for such equipment for any leakage, condition of the hoses and connections, etc. Contractor shall give proper training to the operator, mechanic, etc. before they handle the equipment.

10.15.5.8 Dewatering pumps, Concrete pumps, Boom placer pumps:

- The rotating parts of the dewatering pump shall be well guarded. Only authorized operator / mechanic shall operate the pump on requirement. He shall not wear any loose clothes while operating the pump. The exhaust of the smoke shall be away from the workers working in the surrounding area. The pump shall be operated and maintained as per the manufacturer's guidelines.
- For electrically operated dewatering pumps including submersible pumps, special care shall be taken while operating them. Such pumps shall be fitted with ELCB of proper rating. The power shall be put off before shifting or removal of the submersible pumps.
- Only authorized operator / electrician shall be allowed to operate the same.
- Stationery Concrete Pumps and Boom Placer pumps:
- The commissioning, operation and maintenance of concrete pumps (both stationery and boom placer type) shall be done as per manufacturer's guidelines or manual provided along with the equipment. The safety procedure and tips as mentioned in these guidelines shall not be violated. A copy of such manuals shall be submitted to the department before installing the equipment at site. Apart from manufacturer's manual, the following guidelines shall be followed for operation and maintenance of the concrete pumps:
- The operation, maintenance and signalling of concrete pumps shall be done by trained and authorized personnel having minimum 18 years of age.
- Place of work shall be so selected that the visibility of batching plant operator/transit mixer driver, concrete pump operator, signal man/supervisor and hose man (at the pouring point) is ensured all at a time. In case such visibility between all the above people cannot be ensured, then at least the pump operator shall be able to see the batching plant operator and signal man separately. The pump operator shall play most key role in pouring and he shall be properly trained by the safety officer/site Engineer of the contractor to understand the signalling process properly in order to ensure smooth concreting activity at site.
- When the concrete is being placed in the hopper of the pump (either from batching plant chute or transit mixer chute), no person shall climb on the hopper of the pump.
- The danger zones (within working area) like hose end position, beneath the placing boom, moving parts of the concrete pump and its hopper, its support legs and the area of the concrete pipe line, etc. shall be identified by the safety officer/ mechanical engineer in advance. Accordingly, these areas shall be cordoned and restricted movement shall be ensured as practicable as possible.
- The concrete pipeline (delivery system) for stationary pumps shall be checked by the mechanical engineer before he seeks work permit for concreting activity, for proper clamping of the pipe joints, supports for pipe line, etc. The pipe line shall have minimum number of bends and shall be straight as far as possible. In case pipe line needs to change

the direction, then there shall be at least 5 m straight portion just after the concrete pump. The bends in the pipe line shall be as smooth as possible.

- Inspection interval shall be decided based on manufacturer's guide line, age of the concrete pump, quantity of the operating hours and output of concrete.
- Personal protective equipment like helmet, safety shoes, ear defenders (ear muff/ ear plug), protective gloves and goggles, face mask/respiratory protector, etc. shall be arranged by the contractor for all the workers working on concrete pump.
- Concrete pump shall have suitable pressure relief valve, set at a predetermined pressure level, in order to ensure safety of the workers as well as the pump.

10.15.5.9 Structural Steel Fabrication:

Welding and Gas Cutting:

- Welding and gas cutting operations shall be done only by qualified and authorized persons and as per IS: 818-1968 (Reaffirmed in 2008). No hot job shall be done without approved work permit.
- Welding and gas cutting shall not be carried out in places where flammable/any materials such as combustible/flammable chemicals, dyes, hessian cloth, wooden pieces, cylinders, etc. are kept within 10 m from the spot of fabrication or gas cutting.

Electric Arc Welding:

For Electric Arc welding the following additional safety precautions shall be taken:

- All power connections shall be routed through ELCB of proper rating and machine connections shall be through MCB. Double earthing shall be provided to the welding machine. A provision of a separate return path shall be ensured. ii) The cable to be used shall be of adequate capacity corresponding to output of the welding transformer / generator and shall be routed through dry isolated path. Welding cable terminals shall be provided with lugs and connected properly. Proper insulation of cable with insulation tape of approved quality shall be ensured and only double insulated cable shall be used. Extension of welding cables shall be done using standard connectors. iii) Pipe lines carrying flammables shall not be used as part of earth conductor, but a separate earth conductor shall be connected to the machine directly from the job. Painting and Dye Penetration testing shall not be done near electric arc welding. iv) Personal contact with the electrode or other live parts of electric welding equipment shall be avoided. Wires and cables shall not be hung from any metal hook.
- Accidental contact of electrodes with ground shall be prevented.
- The welding cables shall not be allowed to get entangled with power cables. It shall be ensured that the cables are not damaged by movement of materials. Dragging and coiling of cable shall be avoided. vii) For Dye Penetration test, necessary care shall be taken so that there is no hot job going on nearby. Place of the test shall be well ventilated.

Erection:

Only trained operators and workers shall be engaged for the erection of structural fabricated members. For erection by mechanical means, the safety procedures shall be followed in addition to the following guidelines:

- The heavy materials shall not be manually handled. They shall be handled and shifted by mechanical means like crane, hydra, trolley, etc. of adequate capacity.
- All mechanical transport devices and erection equipment shall be operated with the assistance of a helper / supervisor exclusively for proper signalling.
- While erecting fabricated members, suitable guy rope arrangement shall be made to avoid sudden toppling of derrick.
- Chain pulley block, D-shackles and wire ropes (lifting appliances) shall be of rated capacity at least 2.0 times more than the maximum desired load to be lifted. Hooks, jigs and fixtures used shall be marked with their capacities.
- Two or more slings shall be used for lifting the loads and they shall be tied as per the centreof gravity of the load to be lifted.

Electrical Safety:

Guide lines for providing temporary power supply at the site and general safety procedures for using electricity are given as under. Following safety requirements shall be complied with before the Contractor uses the power supply.

The Contractor shall submit a list of licensed electrical staff to be posted at site. It shall be the responsibility of the Contractor to provide and maintain complete installation on the load side of the supply point about the safety requirements at site. All cabling and installation shall comply with the appropriate statutory requirements given below and shall be subject to approval of the Departmental Engineer-in-charge/ Electrical Engineer.

- The Electricity Act, 1910 (as amended in 2003)
- Electricity (Supply) Act, 1948
- Indian Electricity Rules, 1956 (as amended in 2005)
- National Electric Code 1985 (as amended in 2005)
- Other relevant rules of Local Bodies and Electricity Boards

10.15.5.10 Fire Safety:

The contractor shall take all necessary precautions to prevent outbreak of fires at the construction site. Adequate provisions shall be made to extinguish fires should they still break out.

- Quantities of combustible materials like timber, coal, paints, etc. shall be the minimum required in order to avoid unnecessary accumulation of combustibles at site.
- Containers of paints, thinners and allied materials shall be stored in a separate room which shall be well ventilated and free from excessive heat, sparks, flame or direct rays of the sun. The containers of paint shall be kept covered or properly fitted with lid and shall not be kept open except while using.
- Fire extinguishers suitable for the different classes of fire such as Class A, B, C & D as per IS: 2190-1992 (Reaffirmed in 2010) shall be made available at the appropriate places in

the construction site. The date of last maintenance of fire extinguisher shall be displayed properly on the same by using maintenance tag. The fire extinguishers shall be sent for maintenance/refilling at least once in 6 months or whenever exhausted. The safety officer shall inspect the condition of the plunger, safety pin, switch grip, hose tube, etc. at least once in a month and

- report shall be submitted to the departmental representative as per the format enclosed as Annexure 14.
- Adequate number of contractor's workmen and supervisors shall be given training in firefighting and extinguishing methods.
- The safety officer of the contractor shall plan for site evacuation in fire emergency in order to facilitate to easy and safe exits for entire site work force and supervisory staff. He shall identify and train the designated staff or supervisor for specific role in site evacuation plan.
- The telephone number of the nearest fire station shall be displayed at suitable locations (near telephone, main entrance of the site, first aid canter, stores, etc.) in bold distinct font.

10.15.5.11 Housekeeping:

- The Contractor shall promote and upkeep the practice of good housekeeping throughout the contact period in order to create a safe and hygienic working environment at site. The contractor shall maintain a separate housekeeping team of workers and supervisors who shall maintain the hygienic conditions at site. He shall at all times, keep his work spot, site office, labour toilets and surroundings and roads clean and tidy from rubbish, scrap, surplus materials and unwanted materials, tools and equipment. The contractor shall follow the recommendation of IS: 4082-1996 (Reaffirmed in 2003) for stacking and storage of construction materials and components at site.
- After the completion of the work, the contractor shall have removed from the work premises all scaffoldings, surplus materials, scrap, rubbish and all temporary structures, huts and sanitary arrangements used/installed for his workmen at site. The contractor shall stack all undesirable materials and debris to the designated area at his own cost, as directed by Engineer-in-charge.

10.15.5.12 Common Hazards:

- Barricading and Sign Boards: All work areas around excavated pits, trenches, openings, scaffolding, vehicle movement areas, etc. shall be well cordoned / barricaded with the help of railing, safety tapes (photo luminescent), etc. Photo luminescent sign boards and warnings shall be displayed at required locations and they shall be clearly visible from a distance even at low or no illumination.
- Noise: Suitable ear protection (ear muff) shall be provided to the workers, who are exposed to high noise levels (85dBA and above), e.g. concrete pump operator, vibrator operator, batching plant operator, air compressor operator, grinding machine operator, breaking rocks with pavement breaker, etc. The exposure duration in case of these workers shall be restricted. Other workers and staff who are in the close vicinity of high

noise level such as unskilled worker engaged in concreting works, etc. shall be provided with ear plugs.

- Area Illumination: Adequate lighting facilities such as flood lights, halogen lamps, hand lights and area lighting shall be provided by the contractor at the site of work, storage area of materials and equipment and temporary access roads within his working area. The intensity of illumination shall depend on the nature of work and the same shall be planned by the contractor in advance based on the recommendations of Hand Book on Functional Requirements of Industrial Buildings (Lighting & Ventilation: SP32-1986).
- Dust and fumes: Adequate measure like dust extractor/arresters shall be available for use to prevent spread of dust to nearby areas during open area operations. Workers shall be rested for sufficient time after everyone hour of continuous working in dust. The same worker shall not be engaged for many days continuously and they shall be engaged/kept on job rotation. All necessary PPEs like dust respirators, safety goggles, hand gloves, ear plugs, protective clothes, etc. shall be provided. Any illness due to continuous work in dust or fume shall be immediately reported to the First Aid Centre.

The cost components for ensuring certain measures for safety of labour during construction have been enumerated in **Table 10.54**.

Table 10.54: Cost Estimate

S. N.	Particular	Amount (Rs. lakh)
1.	Cost of Barricading work areas around excavated pits, quarry area/muck disposal sites	1.00
2.	Cost of Caution and Sign Boards	0.50
3.	Cost of Fire extinguishers	0.50
4.	Implements for housekeeping in site offices and work site	2.00
5.	Illumination facilities in work area	1.00
Total		**5.00**

10.15.6 Cost Estimate for Occupational Health and Safety Management

The cost components for ensuring occupational health and measures for safety of labour during construction have been enumerated in **Table 10.55.**

Table 10.55: Cost Estimate

S. N.	Particular	Amount (Rs. lakh)
1.	Cost estimate for Occupational Health Management (Table 14.3)	11.00
2.	Cost of Safety management during construction (Table 14.4)	5.00
Total		**16.00**

10.16 SANITATION AND SOLID WASTE MANAGEMENT PLAN

10.16.1 Introduction

Sewage and solid waste will be generated from the colonies. It is very essential that from the planning stage, sewerage management and solid waste disposal facilities should be conceptualized to maintain the health of the people and the environment. The main sources of wastes in case of the proposed project can be divided into following categories:

- Municipal waste from residential areas
- Solid wastes from labour camps
- Bio-medical wastes from Dispensary

Since most of the barrage operations shall be automated or mechanized, very few people shall be staying in the project during the operation phase. The solid waste is primary problem during the construction phase of the project. Solid waste generated from temporary and permanent colonies in construction as well as operation phase requires special management to dispose of as warranted under the new Solid Wastes Management Rules, 2016.

10.16.2 Responsibility of Project Authority

The project authority, as principal waste generator, shall, within the territorial area of the project complex/ colony, be responsible for the implementation of the provisions of Solid Wastes Management Rules, 2016, issued by MOEF vide S.O.1357 (E) dated 8th, April 2016, and for any infrastructure development for collection, storage, segregation, transportation, processing and disposal of municipal solid wastes.

Any municipal solid waste generated in the project complex/ project colony/ labour colony, shall be managed and handled in accordance with the duties set forth under clause 4 (1) through 4(3) and clause 20 in respect of landfill. The management plan has, therefore, been framed taking into consideration compliance criteria against each parameter as set out under Schedule-II, some of which are described in the foregoing paragraphs.

10.16.2.1 Collection of Municipal Solid Wastes

The project authorities shall prohibit littering of solid wastes in the area under their control by resorting to following: -

- Organizing house-to-house collection of solid waste on regular pre-informed timing and scheduling through any of the methods, like community bin collection (Central bin).
- Devising collection of wastes from office complexes, hotels and commercial areas.
- Avoiding mixing of Bio-medical wastes with municipal solid wastes.
- Collected waste from residential areas shall be transferred to community bin by hand-driven containerized carts or another small vehicle. Horticulture and construction / demolition wastes or debris shall be separately collected and disposed of.
- Waste like dry leaves shall not be burnt.
- Collection of wastes from vegetable and fruit shops and meat shops and also dry leaves collected from avenues/ parks, which are biodegradable in nature to be finally disposed of through aerobic composting in composting units of size 8 m x 2.5 m built from bricks. The compost thus obtained shall be used for development of flower beds and avenue plantation around colonies and office areas and also in biological measures to be adopted in respect of soil tips developed at muck disposal sites.

10.16.2.2 Segregation of Municipal Solid Wastes

The project authority shall organize awareness programmes to encourage the generators of wastes and to ensure community participation in waste segregation. For this purpose, regular meeting at quarterly intervals shall be arranged with representatives of resident of colonies.

10.16.2.3 Storage of Municipal Solid Wastes

The project authority shall establish and maintain storage facilities in such a manner as they do not create unhygienic and insanitary conditions around it. Following criteria shall be considered while establishing and maintaining storage facilities.

- Storage facilities of bins shall have 'easy to operate 'design for handling, transfer and transportation of waste. Bins for storage of bio-degradable wastes shall be painted green, those for storage of recyclable wastes shall be painted white and those for storage of other wastes shall be painted black.
- Manual handling of waste shall be prohibited. If unavoidable due to constraints, manual handling shall be carried out under proper precaution with due care for safety of workers.

10.16.2.4 Transportation of Municipal Solid Wastes

Vehicles used for transportation of wastes shall be covered. Wastes should not be visible to public, nor exposed to open environment preventing their scattering. Transportation vehicles shall be so designed that multiple handling of waste, prior to final disposal, is avoided.

10.16.2.5 Processing of Solid Wastes

The project authorities shall adopt suitable technology or combination of such technologies to make use of wastes to minimize burden on landfill. Following criteria shall be adopted: -

- The biodegradable wastes shall be processed by composting, vermin-composting, anaerobic digestion for stabilization of wastes in terms of Schedule II
- Mixed waste containing recoverable resources shall follow the route to recycling. Incineration can also be used for processing wastes.

10.16.2.6 Disposal of Municipal Solid Wastes

Land filling shall be restricted to non-biodegradable inert waste and other waste that are not suitable for recycling or for biological processing. Three landfill sites shall be selected as per criteria mentioned under Schedule I (A) and (I) of rules. In terms of clause 21of the rules any-recyclable waste having calorific value of 1500K/Cal/kg or more shall not be disposed on landfills and shall be used for generating energy by giving away as feed stock for preparing refuse derived oil. Before establishing any land fill site ground water quality within 50m of its periphery should be monitored covering pre-monsoon, monsoon and post-monsoon

10.16.2.7 Municipal Waste from Residential Areas

Two small permanent project colony for staff (50) shall be created at headworks and powerhouse site. The colony will have family accommodations. The total expected population in the project colony would be 250 persons. In the colony, use of plastic bags be discouraged and use of biodegradable cotton and jute bags be encouraged. The average solid waste generated in the colony has been assumed to be approx. 0.75 kg [dry-weight]/ per person/day. Thus, the solid waste generated by 250 persons in the project colony on average daily, weekly, monthly and annual basis is given in the **Table 10.56.**All households need to be instructed to sort their wastes and store the food, biodegradable and non-biodegradable wastes viz. bottles, cans etc. in separate containers. Two numbers of doorstep waste collectors per house will be arranged and given to each family. A handcart shall be deployed to collect the wastes from the doorsteps daily.

Table 10.56: Solid Waste Generated from Project Colony (kg dry weight)

Garbage Generation	Per Day(kg)	Per Month(kg)	Per Year(kg)
Per Person	0.75	22.5	270.00
By 250 persons	187.50	5625	67500

The collected biodegradable wastes will be disposed of at a suitable landfill site, to be developed. The area will be properly fenced to avoid animals to feed on the wastes. The organic waste collected will be suitably processed to form compost. The compost thus produced shall be utilized in parks and plantation area around colony. The recyclable (non- biodegradable) wastes can be collected at a place and can be incinerated at regular interval of time. Apart from this, there will be provision for cleaning the streets of the colony to keep the surrounding area clean.

Considering water requirement of about 70 liter / head / day and on an average a person generates about 56 lit. of sewage per day and therefore, about 14000 lit. /day of domestic sewage along with other waste are expected to be generated from the colony. In the light of the fact that conventional septic tank system, which is too expensive and requires a large volume of water for flushing and is also riddled with problems like periodic cleaning and disposal of sludge, flush compost toilet which requires only 1.5-2.0 liters of water for flushing as against 12 to 14 liters in case of former shall be resorted to. Flush toilet is eco-friendly, technically appropriate, socio-culturally acceptable and economically affordable. Flush compost toilet shall be adopted in residential area. For inspection houses / office areas Thermophilic Aerobic Composter which requires only 6 to 10 days to make compost from any biodegradable waste, without any manual handing during composting shall be adopted. Adequate provision shall have to be earmarked under the sub-head “O-Miscellaneous” as the capital cost of sewerage disposal and storm water drainage and O & M charges respectively.

10.16.3 Solid Waste from Labour Colony

About 1000 workers (labour and staff) would be engaged temporarily during peak construction period. It is expected that 70% of the total work force shall be locally available from adjacent areas and thus labour colony at four places shall be designed to house 300 workforces. It is proposed to provide family residences to 30 workers while the balance (270) shall remain in bachelor accommodation. Proper care has to be taken to manage the solid waste generated from the labour colony for a population of 420 residential persons and 15 floating population i.e. for 435 persons.

It is estimated that total solid waste generation per day by labour population residing in the labour colony would be approximately 362.25 kg dry weight. This would be to 9788 kg dry weight, and 117456 kg dry weight per month and per annum respectively. For maintaining the cleanliness of the labour colony and to restrict from disposing the solid waste into the river, this solid waste management plan has been formulated. No dumping of solid waste should be allowed near any water body or drain. For solid waste collection 4 iron storage vats, each of 5 cum capacity, will be located at convenient dumping locations in the colonies. Each vat will have the capacity of holding 500 kg dry weight of garbage, which will be emptied at regular time intervals and the biodegradable waste will be transported to the landfill sites. Use of plastic bags need to be totally banned in the labour colony. Periodical awareness should also be provided to avoid use of plastic bags.

Proper sanitary facilities would also be provided at the labour colonies. The standard municipal designs for community sanitation facilities in hill areas have been taken into consideration while formulating the sanitation scheme for the labour colony. Flush compost toilets shall be provided for 30 residences of workforce besides 4 community latrines of five-seated unit each with three bathrooms constructed at appropriate locations at a cost of Rs. 10.0 lakh per unit having a total cost of Rs. 50.00 lakh. The financial provision for this purpose has been provided in cost estimate for solid waste management in **Table 10.57.**

Generally, from landfill, there is negligible risk for generation of methane, due to the decay of vegetable matters, as it slowly diffuses at low concentration through the covering material. The most serious risk from sanitary landfill is that of pollution from leachates. Hence, the bed of the disposal sites should be covered with an impervious material to ensure that leachate does not lead to soil and water pollution. During long dry periods the surface of a sanitary landfill can become dusty, causing discomfort to locals in and around such sites. Covering of the disposed material would prevent entrainment of fugitive emissions as well. Paper and other material also flies off the landfill area due to wind currents. This often creates a nuisance in the immediate vicinity of the landfill site. The landfill site, therefore, needs to be skirted with wire fence of about 3 m high with paper catchers to avoid fly of papers. Once the landfill operation is complete, the entire landfill site is to be suitably capped by an impervious material like clay. To ward off entries of dogs and monkeys, the landfill site shall have welded wire fencing all around.

Proper provision for water storage in sufficient quantities will be needed to maintain hygienic environment. Septic tanks of appropriate size be constructed and care be taken to avoid mixing of wastewater and sewage with local water body especially during rainy season.

Apart from the municipal solid waste in labour colony of project area, a lot of waste is expected to be generated on account of construction activities mainly consisting of cement bags, iron scrap, packing material, etc. It is expected that most of the iron scrap and packing material would be recycled since it has reuse value apart from monetary values and hence, it is proposed that stipulations should be imposed on suppliers and contractors to take away the scrap and packing materials. Apart from above, substantial cement will be required for constructional works. Since cement is supplied in 50 Kg plastic bags, many plastic bags would require proper disposal through annual public auction with a provision of monthly disposal of such bags. Iron scraps have a resale value and therefore these shall be auctioned to steel re-rollers.

10.16.4 Cost Estimate for Solid Waste Management

The overall cost estimates for the management plan is shown in **Table 10.57**.

Table 10.57: Cost Estimate for Solid Waste Management Plan

S.N.	Description	Qty.	Unit	Rate (Rs lakh)	Amount (Rs. lakh)
1.	Flush composite toilets for labour colony	30	No.	0.05	1.50
2.	Community toilet with 10 seats and septic tanks	4	No.	4.00	16.00
3.	Cleaning worker for 10 years (2x 12 x 10)	240	Mon.	0.04	9.60
4.	Door- step plastic dustbin 20-liter capacity @ 2 No/family	50	No	0.005	0.25
5.	Waste collection handcarts including one-time replacement	10	No	0.025	0.25
6.	Landfill R&M	1	Job	L.S.	5.00
7.	Implements such as. Brooms, spade etc.	1	Job	L.S.	0.25
8.	Storage vat	4	No.	0.25	1.00
9.	O& M charges of 1 Truck @ Rs 0.4 lakh / Yr.	10	Yr.	0.40	4.00
10.	Developing simple composting unit	4	No.	0.25	1.0
11.	Contingency	1	Job	L.S.	0.15
Total					**39.00**

10.17 CORPORATE ENVIRONMENTAL RESPONIBILITY

10.17.1 Introduction

The Minister of Environment and Climate Change (MOEF&CC), New Delhi, vide OM dated May 01,2018 and OM dated 22.6.2018, has made it mandatory for project proponent of Greenfield as well as Brown field projects, except for such projects where there is no increase in air pollution load, R&R element etc., to undertake CER initiative in project affected areas. The Para 6(i) of the O.M. reads

"The cost of CER is to be in addition to the cost envisaged to · the implementation of the EIA/EMP which includes the measures for the pollution control, environmental protection and conservation, R & R, wildlife and forest conservation/protection measures including the NPV and Compensatory Afforestation, required, if any, and any other activities, to be derived as part of the EIA process."

Funds allocation for CER has been based on capital investment and the maximum percentage has been prescribed as laid down in Para 6(ii) in respect of Greenfield as well as Brownfield projects.

The activities proposed under CER shall be worked out based on the issues raised during the public hearing, social need assessment, R&R plan, EMP, etc. The proposed activities shall be restricted to the affected area around the project. The recommended activities which can be carried out in CER, are infra- structure creation for drinking water supply, sanitation, health, education, skill development, roads, cross drains, electrification including solar power, solid waste management facilities, scientific support and awareness to local farmers to increase yield of crop and fodder, rain water harvesting, soil moisture conservation works, avenue plantation, plantation in community areas, etc.

10.17.2 Environment Policy of Project Developer

The Project Developer follows the policy adopted by the Center Government which is affirmed to its commitment in sustainable development of the state. The Project Developer is strictly adhering to the Central and the State Rules and Acts in context to the environment protection. The department is responsible for monitoring and evaluation of the various provisions of the policy and is expected to perform in future is to mainstream environmental concerns in various development initiatives of the state, specially poverty and livelihood related issues. The Project Developer shall comply with the environmental norms and conditions set forth in the main Environmental Clearance of various project and shall submit compliance to the MoEF&CC periodically as warranted under the EC letter.

10.17.2.1 Infringement / deviation of the environment or forest norms/conditions

The Project Developer shall comply with the environmental norms set out by the Center / State Government, which are being closely monitored by the MoEF&CC, New Delhi and the State Pollution Control Board, Forest Department. Any infringement / deviation / violation of the rules contained in various environment and other rules and acts such as Wildlife Protection Act, 1972, Air (Prevention and Control of Pollution) Act, 1981, 1987, and Noise Pollution (Regulation & Control) Rule 2000, if and whenever brought to the notice of Project Developer, the same shall be addressed by the corporation / construction agencies engaged for the project. As a safeguard a well-documented Environment monitoring plan has been formulated.

10.17.2.2 Aim of Project Developer

The project developer would aim at the improvement in the living standards of inhabitants in the project area not only by being a catalyst for development but also by developing infrastructure in the area. The infrastructure development will be in addition to the rightful compensation to the project affected families. Besides, meeting the mandatory requirement, certain works relating to social welfare and community development, besides providing environmental services, are also considered in consultation with local authorities and representatives of Gram Panchayats of project affected area where in the project area is covered, so that more acceptability for implementation of the plan is achieved. A provision of 0.5 % of the capital cost of project shall be made for implementing CER initiatives to be financed by the project developer as corporate social initiative.

As large-scale investment is being made in the area by way of construction of project, benefits should reach to the local population so that there is remarkable improvement in their quality of life. Provisions will be made by the project proponent for the infrastructure development programme in the project area as per the needs of the local population. Thus, the proposed CER/CSR strategy should be formulated by keeping in view the existing facilities and giving due consideration to the views of the local people.

10.17.3 Development Committee

The entire contribution towards CER activities to be maintained in the shape of Corporate Environmental Responsibility Fund (CERF), which will be administered by a committee comprising of various stakeholders including Government departments, project developers and local members from project affected areas.

10.17.3.1 Aims & Objectives

A special provision of CER under the Central Policy has been made for ensuring sustainable development by ensuring that while the projects are developed in the State, the local communities in the project area also benefit in the process by way of enhanced development at project cost. Further allocation of such resources also needs to be based on pre-determined objective parameters. The people of the affected area should be aware of the allocations likely to flow to them so that on the one hand gainful infrastructure and local development activities can be planned well in advance and on the other hand local communities develop an interest in expeditious completion of projects.

10.17.3.2 Institutional Arrangement for Administration of Fund

The fund will be administered by a committee which will be constituted as shown in **Table 10.58.**

Table 10.58: Committee for Administration of Fund

S.N.	Committee Members	Designation
1	Deputy Commissioner of concerned district	Chairman
2	Chairman, Zila Parishad concerned district	Member

S.N.	Committee Members	Designation
3	Representative of the Project Developer	Member
4	District level officers of PWD, Irrigation	Member
5	Forest, Rural Dev. Departments	Member
6	Representatives of Block Samiti	Member
7	Pradhan(s) of all affected Panchayat (s)	Member
8	Additional District Magistrate	Member Secretary

10.17.3.3 Functions and Responsibilities of Committee

The Committee is entrusted with, but not limited to, the following activities in its jurisdiction and will be subject to directions of State Government from time to time: -

a) Realization of contributions to fund from project promoters as per norms fixed by the State Government.
b) Overall management, control and administration of fund including documentation and maintenance of accounts.
c) Approval of shelves of schemes and finalization of Annual Action Plan in respect of each project, allotment of funds to executing agencies.
d) Monitoring and supervision of implementation of schemes under LADC.
e) Review the progress of all administrative and statutory clearances and removal of local hurdles, if any, settlement of local issues to facilitate timely execution of the projects.

10.17.3.4 Execution and Monitoring

The schemes sanctioned shall be executed by Gram Panchayat concerned or by Government Department or by project authorities. The Committee may also decide the agency for the execution of schemes. Govt. departments executing the works will not levy Departmental Charges if such scheme is mandated to be executed in normal course and fund should be treated as one of the sources of funding. The funds for sanctioned schemes would be released to the executing agency in installments. The Executing Agency shall furnish accounts along with Utilization Certificate and Completion Certificate to the committee which after consolidating the details will submit the Certificates to Project Developer as well as to Project Developer. The progress of activities shall be monitored regularly by Committee.

10.17.3.5 Management of Fund and Utilization of Interest Amount

The interest earned on the funds deposited in fund will become Part of fund. The interest earned may be used by committee to cover cost for organizing meetings, monitoring, office expenses, audit, hiring experts/technical staff to check fund works or hire services of experts for quality assurance, dispute resolution etc. without any obligation on the State Government. The assets created under fund shall belong to the institutions for which they are constructed or to Panchayat as the case may be.

The funds would be kept in a joint account in Post Office or nationalized bank. The deposits will be managed efficiently to secure best interest income. The account shall be operated jointly by the chairman and Member Secretary of the concerned committee. The fund would be subject to Audit and instructions of State Government as issued from time to time.

10.17.4 Activities Proposed Under CER

The activities proposed under CER shall be worked out based on the issues raised during the public hearing, social need assessment, R&R plan, EMP, etc. The proposed activities shall be restricted to the affected area around the project. The recommended activities whi6ch can be carried out in CER, are infra- structure creation for drinking water supply, sanitation, health, education, skill development, roads, cross drains, electrification including solar power, solid waste management facilities, scientific support and awareness to local farmers to increase yield of crop and fodder, rain water harvesting, soil moisture conservation works, avenue plantation, plantation in community areas, etc.

10.17.4.1 Human Resource Development

Following activities are proposed under the local area development plan, however exact schemes will be formulated by LADC.

a) Training Courses

The willing and eligible youth from project affected families shall be imparted education and training through technical institutes conducting diploma courses and ITI certificates with a view to absorb them in the project construction and operation.

b) Tailoring, Knitting& Embroidery Training Centers:

To create sustainable and long-term job opportunities & generate income levels among the project affected and other local families; tailoring, knitting and embroidery centers shall be opened in consultation with the local panchayats. Necessary equipment/kit, sewing machines along with raw material and instructors shall be made available at subsidized rate. Arrangements shall be made through government agencies to sell the products to M.P. Handloom Department and other private/ state agencies involved in the trade.

c) Computer Courses:

Computer training center at any appropriate place in consultation with local panchayats shall be opened to train eligible candidates from either sex to help them to avail job opportunities within and outside the project. Infrastructure and equipment for training courses along with instructor shall be provided.

d) Income Generating Activities/Projects

Capacity building programmes would be implemented for the development of skills in dairy farming, horticulture and host of other income generating activities.

e) Vocational Training

Creating institutions to impart vocational training for acquiring and upgrading technical skills with a view to enhance employability. Establishing partnerships with District Administration and various Non-Governmental Organizations to assist gainful self-employment schemes for the unemployed youth in the area, such programs would include:

a) Organization of training programs in driving of 4 Wheelers,
b) Welding and fabrication,
c) Repair of TVs, Radio and other electronic gadgets.

10.17.4.2 Infrastructure Development and Public Utilities

a) Community Centers:

To facilitate project affected people to organize marriages/ other social functions community centers at places selected by the locals shall be constructed & provided with required furniture, tent house facilities and guard.

b) Hospital Facilities:

The project Hospital facilities shall be extended to the project affected persons free of cost. Ambulance and provision of life support system shall be made to meet emergencies.

c) Sports and other activities:

The project proponent will endeavor to promote sports activities in affected Panchayats. For promotion of sports, the corporation will go by the collective decision of all project developers in the district. Facilities for different games shall be provided to inculcate interest for sports amongst the youths.

d) Setting up of Recreation Facilities

There is a need to set up recreation facilities like development of gym, parks, etc. near the project area.

e) Assistance to Schools:

The schools in the project affected villages shall be provided with computers, furniture, library etc. to develop these Institutions as model Institutions.

f) Development of concrete paths from Village to Road heads &drainage system:

The affected villages shall be connected with the roads through concrete paths, wherever required. Effective drainage system shall be developed in the villages.

g) Community Toilets:

Community toilets shall be constructed in the project affected villages in association with panchayats and proper maintenance shall be ensured.

h) Enhancing Medicare in Govt. hospital:

The Govt. Medicare system at m nearby PHC shall be improved by providing the latest equipment in consultation with hospital authorities.

i) Development of Cremation Center/ Graveyard

On the request of PAF development of cremation center shall be carried out at suitable location in consultation with the gram Panchayat / district authority.

10.17.4.3 Social Services:

a) Assistance to Physically Handicap:

One-time financial assistance of Rs. 10000.00 in cash shall be provided to the physically handicapped in the project affected Villages in presence of Panchayat Sarpanch and Panch.

b) Assistance for female marriages:

An amount of Rs. 10000.00 shall be provided to the project affected family under BPL category, for the marriage of female in the family.

c) Medical Camps:

Medical Camps shall be organized every three months in the project affected Villages and free medicines shall be provided to the patients.

d) Assistance to Critically ill:

As a goodwill gesture assistance of Rs. 10,000.00 shall be made available to the critically ill persons in the project affected Villages.

10.17.5 Cost Under Corporate Environmental Responsibility

The project authorities will contribute 0.5% of the direct and indirect charges of basic project cost (Rs. INR 1061.21Crore) towards this fund i.e. INR 531.00 lakh towards creation of CER fund to undertake works under corporate environmental/social responsibility. The activities earmarked under the plan and their year wise allocation is shown in **Table 10.59.**

Table 10.59: Budget Estimate for CER Plan

S. N.	Description	Quantity	Unit	Rate (Rs. Lakh)	Amount (Rs. Lakh)
1	Health Care				
(i)	Health checkup camps; awareness programme in a year in PAV i.e. 6 X 3	18	No.	0.25	4.50
(ii)	Renovation of male and female wards &OPD and Laboratories in District Hospital Singhtam,East Sikkim district and supplying of medical equipment to CHC	1	Job	L.S.	75.00
(III)	Organizing veterinary camps 1/year/village for 3 years	18	No.	0.20	3.60
2	Education				
(i)	Books to district/block/village and school libraries	1	Job	LS	5.00
(ii)	Support for infrastructure development in village schools	1	Job	LS	50.00
3	Infrastructure Development				
(i)	Providing 15 Watts Solar Street Light	100	No.	0.30	30.00

S. N.	Description	Quantity	Unit	Rate (Rs. Lakh)	Amount (Rs. Lakh)
(ii)	Setting up of Recreation Facilities	10	No.	3.00	30.00
(iii)	Support for developing playgrounds	2	No.	5.0	10.00
(iv)	Supportinglocal school with game equipment/gadgets	10	No.	0..30	3.00
4	Sanitations and drinking water facilities				
(i)	Providing flush composite toilet	20	No.	0.25	5.00
(ii)	Iron Storage Vat (3.1m x 1.25m x 1.25m)	20	no.	0.75	15.00
(iii)	Door- steps plastic dustbin	2000	no.	0.005	10.00
(iv)	Renovation of storm water drainage system	1	job	LS	50.00
(v)	Setting up of STP 10 kld capacity	7	No.	18	126.00
5	Skill Development and Training				
(i)	Vocational training like goat rearing/poultry rearing	500	man	0.01	5.00
(ii)	Promotion of self-help groups by proposing livelihood activities in goatry, poultry, bee keeping, tailoring.	6	No.	1.5	9.00
(iii)	Women empowerment by way of training in Kitchen garden sewing and providing kits	400	No.	0.10	40.00
6	Environment Enhancement				
(i)	Plantation in Village Panchayat	10	ha	3.00	30.00
(ii)	Horticulture development in Village Panchayat	10	ha	3.00	30.00
Total					**531.10**
Say					**531.00**

10.18 ENVIRONMENTAL SAFEGUARD DURING CONSTRUCTION

10.18.1 Introduction

All the major components of the project i.e. barrage, Intakes, Powerhouse, Tail Race Tunnel and other associated structures will be required to be connected to the existing road system by creating permanent new access roads having a formation width of 7/9 m in about 5 km length. Besides this kutcha approach road to proposed quarry sites shall also be constructed.

10.18.2 Impacts Due to Construction of Roads

The construction of roads can lead to the following impacts:

- The topography of the project area has steep to precipitous slope, which descends rapidly into valleys. The conditions can give rise to erosion hazards due to net downhill movement of soil aggregates.
- Construction of new roads increases the accessibility of a hitherto undisturbed areas resulting in greater human interferences and subsequent adverse impacts on the ecosystem.
- Increased air pollution during construction phase.

10.18.3 Management Measures

The approach roads will have to be constructed as a part of the access to the construction site. Road construction may result in loosening of soil/rock at places and give rise to landslides particularly due to seepage water.

Landslides on steeply sloping bank can largely be controlled by provision of suitable drainage. The basic principle is to intercept and divert as much water as possible, before it arrives at a point, where it becomes a nuisance. The other erosion hazard is that of surface erosion of the bank, which is best controlled by vegetation. For such terrain of the project area which does not support vegetation, engineering solutions such as surface drainage, sub-surface drainage, toe protection and rock bolting can be used. The cost required for implementation of various measures has already been incorporated in the overall budget earmarked for construction of roads.

Road construction will generate muck due to the stripping / blasting of the rocks. The stripped material would be collected (to the maximum extent) and dumped in the designated muck disposal area, which will have retaining wall to prevent the muck to flow down into the river. After disposal operation is complete at the dumpsite, the dump yard shall be stabilized by terracing and overlain with geo-textile and seeded with suitable grass species.

The various aspects to be considered while making the project roads are briefly described in the following paragraphs.

10.18.3.1 Construction

The clearing area shall be properly demarcated. Where erosion is likely to be a problem, operations shall be so scheduled and performed that grading operations and permanent erosion control of features can follow immediately thereafter, if the project conditions permit; otherwise temporary erosion control measures shall be provided between successive construction stages.

The method of balanced cut and fill formation shall be adopted to avoid large difference in cut and fill quantities.

The cut slopes shall be suitably protected by breast walls, provision of flat stable slopes, construction of catch water and intercepting drains, treatment of slopes and unstable areas above and underneath the road, etc.

Excavated material shall not be thrown haphazardly but dumped at designated dumping sites which shall be stabilized by terracing and overlain with geo-textile and seeded with suitable grass species.

10.18.3.2 Drainage

- All artificial drains shall be linked with the existing natural drainage system.
- Surface drains shall have gentle slopes. Where falls in levels are to be negotiated, check dams with silting basins shall be constructed and that soil is not eroded and carried away by high velocity flows.
- Location and alignment of culverts shall also be so chosen as to avoid severe erosion at outlets and siltation at inlets.

10.18.3.3 Grassing and Planting

- Tree felling for road construction/works shall be avoided wherever possible. However, compensatory afforestation shall be carried out for forest land used for the purpose.
- Afforestation with suitable species will be attempted and sustained along the roadside to an enough distance on either side of the road.

10.18.3.4 Other measures

- Water will be sprayed regularly during construction phase of the roads to prevent entrainment of dust.
- Regular compaction of temporary roads shall also be carried out

10.18.4 Budget

An amount of Rs 10.00 lakh has been earmarked for implementation of measures to mitigate adverse impacts due to construction of roads. The details are given in **Table-10.60.**

Table 10.60: Details of Expenditure for Implementation of Measures

S. N.	Item	Cost (Rs lakh)
1.	Provision of water for spray @ Rs. 750/tanker for 2 tanker per day for a construction period of 240 days/year	7.20
2.	Providing Revetments and Breast walls	2.80
	Total	**10.00**

10.19 ENERGY CONSERVATION MEASURES

10.19.1 Introduction

The execution of Rongnuchu HEP and appurtenant works there under have been proposed to be carried out contractually to be completed in 55-month time. Infrastructure facilities shall be developed *pari passu* with the construction activities. With the commencement of construction activities, the deployment of labour force comprising of skilled/semi-skilled/unskilled will take place and at peak of the works about 1000 workforce shall be engaged. It is expected that 70% of the total work force shall be locally available and manpower to the tune of 300 persons shall be imported from other parts of the country. The temporary labour camps will be established at suitable location in the project area. The fuel need of the labourers/ workers must be attended in an organized manner otherwise the labour may resort to indiscriminate felling of trees and shrubs owing to their cost free and easy availability at leisure. Consequent deforestation if continued shall adversely affect the ecosystem; therefore, pre-emptive action plan must be devised to meet the fuel needs of workers especially those residing in the labour camps. These objects can be best accomplished by mandatory banning of the use of fuel wood in the labour camps besides complying with the following obligatory steps:

- In every contract document mandatory clause should be made for the contractors to provide community kitchen facilities to labourers who reside without family and also to ensure supply of LPG fuel to the laborers living with families in camps failing which the contractor shall solely be held responsible and liable for penalty and or remedial action.

- Establishing an LPG go-down and a state-owned kerosene oil depot within the township of project complex.
- Providing free electricity for domestic purpose to the labourers residing in labour camps.

10.19.2 Alternate to Fuelwood

The fuel shall be required by the labour for cooking purpose, warming the rooms during cold months and for warming water. In natural course, if the workforce is asked to manage these at their will, the first choice shall be the free and readily available natural and conventional resources i.e. fuel wood. Thus, pressure due to immigrating labour using fuelwood extracted free from the local forest shall increase in alarming proportion which may lead to complete denudation of forest in nearby pockets. Therefore, to avoid immediate pressure for fuelwood in the adjoining forest and consequential increased production of carbon emission it is proposed to use LPG for cooking and electricity for heating in the camps and kerosene stoves at site.

10.19.3 Scheme for Substitute Fuel to Labourers

Under this scheme a practical work plan has been prepared for implementing the subsidized fuel scheme for the work force of the project. It is proposed to provide LPG connection for cooking, kerosene and electricity for heating purposes. The supply of LPG and kerosene can be ensured on regular basis through written arrangement with local LPG/kerosene suppliers for supply of the same.

10.19.3.1 Provision for LPG

Each worker family can refill 1 (one) cylinder after every 30 or more days depending on actual consumption. About 1000 work force (skilled/unskilled) would be engaged temporarily during peak construction period, of which 70% shall be from bona fide residents of the state. It is expected that 80% of the work force shall be locally available from the adjacent areas and shall manage to work at site by making back and forth journey from their home. Thus, out of balance 300 numbers, about 30 workmen shall reside in colonies with their families and rest 270 in bachelor accommodations like dormitories/ field camps. The requirement of gas cylinder per month has been worked out based on one cylinder per month for workmen living in family accommodations and one cylinder for a group of 3 workers living in dormitories/ labour camps. The total requirement of LPG cylinders for stipulated 120-month project period @ 120 cylinder / month works to 14400 numbers.

10.19.3.2 Provision for Electricity

Electricity supply should be arranged for lighting purpose to the tune of two 100 W bulbs per family and provision of streetlight should be made in the labour colony at the contractor’s cost. However, use of CFL should be encouraged from the consideration of saving of power and economy. The electricity for heating purposes shall be provided at one (01) unit/day for each of 270 workers residing in bachelor’s accommodation and three (03) unit/day for each of 30 workers residing in family accommodations. Thus, the total consumption per day on this count shall be 360 units and about 20 units for streetlights, the overall consumption for 120 months shall be 1368000 units.

10.19.3.3 Energy Conservation Devices

With a view to conserve electrical energy, wherever possible, it is proposed to resort to solar lighting system for street lighting / park lighting etc. Besides this the workers shall be discouraged for using conventional electric bulb/florescent tube lights which consume more wattage. For this the workers shall be encouraged to use energy saving lighting devices like CFL/LED Bulbs which shall be provided at subsidized rates to the workers.

10.19.4 Debit able Cost of Providing Fuelwood Substitute

The difference in cost of using fuel wood and other suggested substitutes which the contractors shall be loading in their tendered rates and which finally shall be debited to the cost of project has been assessed to the tune of Rs. 46.00 lakh as is shown in **Table-10.61.**

Table 10.61: Cost of providing fuel wood substitute

S. N.	Item	Unit	Estimated Consumption		Rate(Rs)	Cost(Rs. lakh)
			Per month	Projectperiod		
1	Fuel wood @1.5kg/person/day	Quintal	180	21600	250	54.00
2	Alternate fuel					
(i)	LPG	Cylinder	120	14400	450	64.80
(ii)	Electricity	Unit	10500	1368000	3.00	34.65
Sub Total						99.45
3	Difference between conventional and alternate cost	-	-	-	-	45.45
4	Providing CFL/LED Bulbs at 50% subsidy to workers	Job	-	-	L.S.	0.50
Total						**45.95**
Say						**46.00**

10.20 SUMMARY OF COST ESTIMATES UNDER EMP

10.20.1 Summary of Cost

The summary of cost estimate of various environment management plans as contained in this report is enumerated below in **Table-10.62**.

Table 10.62: Summary of Total Cost Estimate

S. N.	Plans	Cost(Rs. Lakh)	Capital Cost(Rs lakh)	Recurring(Rs lakh)
1.	Catchment Area Treatment Plan	578.00	488.00	9.00
2.	Compensatory Afforestation Scheme	606.00	591.00	1.50
3.	Wildlife and Bio-diversity Management plan	101	83.00	1.80
4.	Resettlement & Rehabilitation Plan	284.00	284.00	0.00
5.	Green Belt Development Plan	15.00	5.00	1.00
6.	Reservoir Rim Treatment Plan	11.00	11.00	0.00

S. N.	Plans	Cost(Rs. Lakh)	Capital Cost(Rs lakh)	Recurring(Rs lakh)
7.	Landscape and Restoration Plan	12.00	3.00	0.90
8.	Fisheries Management Plan	170.00	110.00	6.00
9	Muck Management Plan	128	117.00	1.10
10.	Restoration Plan for Quarry Sites	16.00	11.00	0.50
11.	Disaster Management Plan	65.00	60.00	0.50
12.	Water, Air and Noise Management Plan	20.00	10.00	1.00
13.	Public Health Delivery Plan	155.00	35.00	12.00
14.	Labour Management Plan	16.00	3.00	1.30
15.	Sanitation and Solid Waste Management Plan	39.00	19.00	2.00
16.	Corporate Environmental Responsibility	531.00	506	2.50
17.	Environmental Safeguards	10.00	0.00	1.00
18.	Energy Conservation Measures	46.00	0.50	4.55
19.	Environmental Monitoring Plan	90.00	5.00	8.50
Grand Total		**2893 .00**	**2341.5**	**55.15**

11 SUMMARY AND CONCLUSION

11.1 BACKGROUND

Rongnichu Hydroelectric Project (96 MW) on Rongnichu stream in East Sikkim district of Sikkim, being developed by M/s. Madhya Bharat Power Corporation Ltd. (MBPCL). The present project having an installed capacity of 96 MW will generate approximately 384 GWh of electricity (gross) per annum in a 90 % dependable year with 95 % machine availability. The EC was accorded on 4.4.2007 for a period of 10 years as per the provisions of EIA Notification, 2006. After obtaining the EC in April 2007, there has been an initial delay of more than 3 years to start the actual construction. The geological difficulties of lower Himalayan region resulted in slower pace of excavation of underground works. Viewing the delays being encountered, M/s. Madhya Bharat Power Corporation Ltd., had applied for extension of validity of EC for 3 years. The Ministry vide letter dated 16.6.2017 granted extension of validity of EC initially for six months and vide letter No J-12011/56/2006-IA-I dated 9.11.2017 accorded extension of validity for two and half year i.e. up to 3.4.2020.

M/s. Madhya Bharat Power Corporation Ltd. intends to enhance the installed capacity of power house from 96 MW to 115 MW owing to higher inflows available during 5 10-daily blocks in monsoon period and in the light of enabling provision of running machines at 20% overload as stipulated in power potential studies carried earlier

11.2 NEED FOR PROJECT

The need for Rongnichu HEP, installed capacity 115 MW, in the Teesta Basin, has therefore been considered in context of power shortage in the Eastern region in general and in the country as whole. The H.E.P. after being operational and capacity enhancement from 96 MW to 115 MW would be able to provide an annual design energy (90% dependability) of 413.78 GWh.

11.3 LOCATION

The barrage location is about 2 Km downstream of Namli village and 16 Km south of Gangtok along NH-31A. The powerhouse is proposed on the right bank of Rangpo River 2.5 km from Rangpo Town on Rangpo-Rongli State Highway.

11.4 PROJECT FEATURES

The project shall comprise the following structures:

- 14m high barrage with 3 bays of free flow spillway with sill crest level at 728.00 masl, with 3 gates (12.2mx 6.5m).
- Surface desilting basin, fitted with trash rack of 24 panels, with 2 troughs (59m x 35.9m x 9.5m) to exclude sediments >0.2 mm m through 1000m flushing pipe.
- One gated power intake for passing 38.16 cumec
- 12.581 km long D-shape lined HRT of finished diameter of 4.0m
- 88m high and 10 m diameter vertical surge shaft with 1.7m diameter meter orifice

- Underground steel lined Pressure shaft comprising of UHPS (160.8m/3.0m), VPS (318m/3.0m) and LHPS (924m/3.0m)
- Surface powerhouse (61.5mx 45.75mx 38.0m) for housing 2 vertical shaft Pelton turbine

11.5 ENVIRONMENT IMPACT ASSESSMENT

M/s EQMS India Pvt. Ltd., 304-305, 3rd floor, Rishabh Corporate Tower, Community Center, Karkardooma, Delhi-110092., has conducted the Environment Impact study.

11.6 METHODOLOGY

The methodology and techniques used for studying, during three seasons (pre-monsoon, monsoon and post-monsoon 2019), the various parameters of the environment viz. land, air, noise, water, flora, fauna and socio-economics in the study area are described as follows:

11.6.1 Air Quality Assessment

To generate, a database on the existing status of the pollutants, the study area was evaluated for setting up five locations to conduct air quality monitoring in respect of PM_{10}, SO_2 and NOx.

11.6.2 Sound Level Measurement

The sound level was measured at five locations by sound level meter RS-232 (Digital-Instrument).

11.6.3 Soil Quality Assessment

Physical and chemical characteristics of the soil were studied in respect of five samples taken from the study area.

11.6.4 Water Environment Assessment

For evaluating physical, chemical and biological characteristics of surface and ground water samples were taken from five and one location respectively.

11.6.5 Aquatic Environment

Evaluation of the parameters related to aquatic environment has been done in respect of biological characteristics of river water.

11.6.6 Floral Study

It is based on extensive field survey of the area. In this the phytosociology of plants and diversity of the forest vegetation was determined.

11.6.7 Faunal Study

Various transects were identified along the villages to carry out faunal studies as the village trails were the best options to cover-up the complete area. Observer walked at a constant pace for their observation.

11.6.8 Socio-economic Study

The data on socio economic and dependency aspects were collected. The process involved assessment of the study area to obtain an overall perspective of the project affected villages that were located in the submergence zone / 10 km radius from the barrage. In order to gather information on public perception of the proposed project the attitude/psychology survey was carried out which depicts the prevailing awareness and acceptance/no-acceptance about the project. Data collection from secondary sources has also been made to validate some of the information and to supplement the data on demographic aspects.

11.7 EXISTING STATUS OF ENVIRONMENT

11.7.1 Land use/Land Cover

The existing predominant land use class is dense forest (50.16%), followed by open forest (23.26%), agriculture land (20.29%), settlement (3.91%) and waterbody (1.42%).

11.7.2 Total Land Requirement for Construction of the Project

Total land requirement under the project has been assessed as 59.872 ha of which private land is 11.3895 ha and forest land is 48.4825 ha.

11.7.3 ARCHAEOLOGICAL / HISTORICAL MONUMENTS/SENSITIVE AREA

No archaeological monument of national importance lies either in the project area or in its submergence area. Fambong Lho Wildlife Sanctuary exists within 3.79 km from the project area but no part of the project falls within the ESZ of WLS as per map authenticated by the Chief Wildlife Warden and Environment, Sikkim, communicated by DFOWildlife East vide letter No. 360/WL/E, dated, 20.12.2019.

11.7.4 SOIL QUALITY

The results of the soil analysis show that the soil is neutral to slightly basic at all the locations having pH varying from5.32 to 6.84, thereby indicating the soils are strongly acidic to neutral. The most commonly observed soil textures are silty clay.Available nitrogen content in the surface soils ranges between275.4 to 315.6 kg/ha thereby indicating that soils are low to medium in available nitrogen.Available phosphorus content ranges between9.4 to 13.5 kg/ha thereby indicating that soils are low to medium in available phosphorus.Available potassium content in these soils' ranges between 156.5 to 178.5 kg/ha), thereby indicating medium in potassium content in the area. The organic carbon varies from 0.66% to 0.88 %, thereby implying that soils are medium to high in organic carbon.

11.7.5 AIR AND NOISE ENVIRONMENT

The maximum concentration of PM_{10}, NO_X and SO_2 was 61.0 µg/m3, 15.7µg/m3 and 9.5 µg/m3 respectively which shows that concentration of pollutants was within the limits of standards prescribed by CPCBas there are no industries in the area and the density of vehicular traffic is not alarming. The noise monitoring showsthat the highest noise levels recorded during daytime are at powerhouse site being 50.3 dB (A) Leq and during nighttime 41.9 dB (A) Leq and both are within the CPCB limits. The major source of the noise in the study area is the flow of river, community noise and vehicular movement. The noise levels for the rest of the stations are within the prescribed limits.

11.7.6 WATER ENVIRONMENT

The analysis results have been compared with the Tolerance limits for inland surface waters, Class – C as set forth in IS: 2296-1982. The pH values of all analyzed samples ranged between 6.88 to 7.42 and were within the tolerance limit (6.5-8.5). The TDS levels ranged from 80 to 158 mg/l and were within the tolerance limit of 1500 mg/l. The chlorides level in surface water samples ranged from 21.5 to 32.8 mg/l and were below the tolerance limit of 600 mg/l. The sulphates level ranged from 5.2 to 8.5 mg/l and were below the tolerance limit of 400 mg/l. The fluorides level ranged between 0.1 to 0.22 mg/l was lower than the tolerance limit of 1.5 mg/l. The nitrate level ranged between 0.3 to 0.54 mg/l and were within the desirable limit of 50 mg/l. The BOD values exceeded the tolerance limit of 3.0 mg/l in some samples.

The water is suitable for meeting drinking water requirements after conventional treatment and disinfection. The ground water had all parameters within the desirable limits. Concentration of all parameters recorded in the ground water samples for all locations were within the permissible limit.

11.7.7 STATUS OF BIOLOGICAL ENVIRONMENT

11.7.7.1 Flora of the Project Area

- During the surveys, an inventory of different plant groups found in the study area was prepared. In the study area 121 species of plants were recorded. These include 82 trees, 11 shrubs, 28 species of herbs/grasses/climbers.
- About 24 economically important plant species were recorded from the study area.
- No RET species falling under IUCN Red List was recorded/reported from study area.

11.7.7.2 Fauna of Project Affected Villages

The faunal study for the proposed project was carried out in both the submergence and influence zone of both upstream and downstream

- 43 mammalian species were recorded /reported during the survey of which two belong to Schedule-1 of WPA, 1972.
- 91 bird species were observed /reported during the survey of which none belong to Schedule-1 of WPA, 1972.
- As many as 14 species of herpetofauna were recorded /reported.
- Twenty-five species of fishes belonging to 4 families were recorded.

11.7.8 SOCIAL AND CULTURAL BACKGROUND OF THE AREA

11.7.8.1 Demography of Project Affected Villages

As per the Census of India 2011, the total population of project affected villages comprising of 2869 household aggregates to 13490 of which male population is 6994 and female population is 6496. The overall sex ratio is 935 females per thousand males. The cast wise composition of the total population of the project affected villages is made up of SC 913 (6.77%) and ST3749(27.80%) and General Category is 65.43%of total population. Total literate population is 9340 (77.52%) of which male and female literate population is 5125(82.34%) and 4215(72.62%) respectively.There are total 6909(51.20%) workers of which 4126(59%) are male and 2783(42.80%) are female, which implies there is a gender gap of 16.20%.The main workers are 5313 (39.40%), whereas the marginal workers are 1596(11.80%). This implies that 48.8% of population is comprised of non-workers.

11.7.8.2 Village-wise Land to be Acquired

There are 5 project affected villages which are being impacted due to acquisition ofprivate land and other assets besides diversion of forest land. The total private land requirement for the project is 11.3895 ha. Besides this diversion of 48.4825 ha, forestland shall be involved. The village-wise details of Project Affected Family and Displaced Family are given in**Table 11.1.**

Table 11.1:Village-Wise Details of PAF/Displaced Families

S.N.	Name of Village	Land To be Acquired (ha)	No. of PAF	No. of D.F.
1	Sumen	0.8510	19	0
2	Central Pendam	5.013	15	0
3	Namli	3.2860	11	0
4	Namcheybung	0.9005	12	0
5	Yangtam	1.3390	5	0
Total		**11.3895**	**62**	**0**

11.8 IDENTIFICATION, PREDICTION AND EVALUATION OF IMPACTS

11.8.1 Impacts on the Micro-Climate of the Area

Felling of trees in the reservoir area shall reduce Carbon Di-oxide absorption and release of Oxygen, consequently slight increase in temperature. The creation of water body shall result in increased evaporation and humidity and small increase in minimum temperature near the reservoir area. Due to construction activities, there shall be temporary and nominal effect on the ambient temperature and humidity.

11.8.2 Change in Land use / Land Cover

11.8.2.1 Construction Phase

The land use class of forest land and agriculture land required for project components and internal roads shall have land use class changed to built-up area. The land use class of 4.5 ha forest land required for quarry sites shall remain unchanged as the quarry sites shall later on developed with vegetal cover. The present land use of 13.6 ha agriculture land involved in muck sites shall permanently change into forest land use after completion of the work and creation of vegetal canopy by way of plantation over the spoil tips.

11.8.2.2 Operational Phase

The land use class of 2.62 ha forest land and 4.39 ha agriculture land involved in submergence shall change into waterbody. The change shall be permanent and irreversible. The present land use of private land involved in quarry sites/muck sites shall permanently change into forest land use after completion of the work and creation of vegetal canopy by way of plantation over the spoil tips. During the operation phase many of the redundant areas having no further usage will be brought under plantation.

Soil Erosion and Siltation

Construction Phase

Soil erosion due to excavation of different components of the project, construction of roads will accelerate soil erosion.

11.8.2.3 Operational Phase

Soil erosion due to project activities will not exist in the operation phase as the construction would be completed and landscape restoration work would also be implemented

11.8.3 Impact on Geology

The intensity of anticipated environmental impact on geology of the area will be weak and extent of anticipated impact will be local. No impact is anticipated on the geology of the area during the operation phase.

11.8.4 Impact on Hydrology

From intake structure a maximum diverted discharge of 31.56 cumec shall be carried through water conductor system to surface power house for power generation and thereafter released to the Rangpo Chhu through TRC outfall. The abstraction of water through intake shall reduce the flow of Rongni Chhu d/s of barrage as the diverted water is repatriated to Rangpo Chhu.Thus, there shall be remarkable change in hydrological cycle of Rongni Chhu and Rangpo Chhu as the discharge of former shall reduce and increase for the latter.

Since the major water usage for construction will be mainly from the river water for meeting construction water requirement, some adverse impact (0.011MCM) on surface water availability is expected annually. This quantum which is equivalent to a discharge of 0.00035 cumec is insignificant as compared to the minimum 10 daily flow of 2.98 cumec in 2nd Ten Daily of January of 90% dependable year (196-97).

11.8.5 Environmental Degradation due to Labour Immigration

During the construction phase a maximum congregation of approximately 1000 workershad taken place in the project area, which did increase pressure on land and water resource. Conflict between the migrants and the local population did not occur for employment as preference was given to local people. Labour engaged in construction activity will also move away once the project work is completed; therefore, no additional impact is expected.

11.8.6 Impacts on Air Environment

Temporary changes in air quality during construction phase are expected due to emission of hydrocarbons from vehicles and gases from blasting operations. The predicted ground level concentration in air for PM10 due to fugitive dust emissions from construction activities at the barragecomplex was found to be 9.3 µg/m3 and nearby settlement viz. Namli and Yangtam would be 0.4 µg/m3 and 2.3 µg/m3 respectively. The resultant concentration at these places shall be 64.3 µg/m3, 55.4 µg/m3 and 46.3 µg/m3 which is within the limits. Due to increased transportation during construction phase at 25 m predicted concentration is 8.6 µg/m3 which reduces to 5.4 µg/m3, 2.4µg/m3 and 1.0 µg/m3 at 50m, 150m and 500m respectively. Thus, the impact on the pollutant level (PM10) due to increased traffic due to transportation of material shall be minimal. The increased GLC in respect of NOx were insignificant being 0.12 µg/m3 up to 25m and 0.11 µg/m3 up to 50m and 0.10 µg/m3 up to 1km.

11.8.7 Impacts on Noise Environment

Temporary increase in noise levels are expected during construction phase only. The maximum noise level of 74 dB(A) gets attenuated to 48 dB(A), 42 dB(A) and 36 dB(A) about 300m, 600m and 1200 m respectively from the point source (barrage site).

11.8.8 Impacts due to Ground Vibration and Air -overpressure

Due to blasting, the resulting PPV shall be 3.97 mm/sec at Namli which shall be considerably lower than the limiting values 5.0 mm/sec for excitation frequency less than 8 Hz, in case of temporary structures. Predicted air over pressure due to blasting at Namlishall be 111.3 dB(A), which is less than 120dB(A).

11.8.9 Impacts on Water Environment

During the construction phase, the water environment of the river due to proposed project shall be impaired due to increase in silt rate from the discharge coming out open air works, batching and crushing plants and from the foundation works. Due to this minor impact on the water quality and aquatic fauna of temporary nature shall be experienced in the river water. The sewage generated at the labour camps and other residential areas may also bring considerable pollutants to river sections, if disposed in the river section without treatment.

The problems related to reservoir stratification is not anticipated as the reservoir is dynamic and water is always abstracted from it continuously Enrichment of impounded water with organic and inorganic nutrients will be the main water quality problem immediately on commencement of the operation. However, this phenomenon is likely to last for a short duration of few years from the filling up of the reservoir. Therefore, any significant impact on reservoir water quality is not anticipated.

Considering the low fertilizer usage in the area, significant loading of nutrients is not anticipated. Thus, problems due to eutrophication are not anticipated in the proposed project

11.8.10 Impact due to Change in Hydrological Cycle

The abstraction of water through intake shall reduce the flow of Rongni Chhu d/s of barrage as the diverted water is repatriated to Rangpo Chhu.Thus, there shall be remarkable change in hydrological cycle of Rongni Chhu and Rangpo Chhu as the discharge of former shall reduce and increase for the latter.

11.8.11 Impact due to Acidification of Reservoir

There will be no acidification of reservoir due to the nature of the river water at barrage site and upstream having pH vary between6.88 to 7.42.

11.8.12 Impacts on Flora

- 2.62 ha of forest land shall be brought under submergence along with standing trees will affect the ecosystem of the forest consisting of flora and fauna
- The felling of trees in the submergence will bring imbalance to ecology.
- The construction activities, including movement of vehicles, men and material, camping places for the labor, storage of construction waste, etc., will have direct impact on the existing natural resources.
- Due to project, riverine regime of submergence area will change into lacustrine environments.

11.8.13 Impacts on Fauna

- The construction of barrage and reservoir shall fragment the forest area and restrict the movement of wildlife.
- The edible fruits available in the forest on which the birds and animals depend may also be destroyed / consumed due to human interference.
- Increase in temporary stress levels of wildlife during construction phase due to noise, human interference and reduction in present habitat.
- Threat due to poaching might increase.

11.8.14 Impacts on Aquatic Life

- The completion of the proposed project would bring about significant changes in the riverine ecology, as the river transforms from a flowing water system to a quiescent lacustrine environment. Such an alteration of the habitat would bring changes in physical, chemical and biotic life.
- The construction of project shall have impact on the fisheries as their movement for spawning shall be impacted.
- The congregation of labor force in the project area may result in enhancement in indiscriminate fishing in the project area

11.8.15 Summary of Positive and Negative Impacts

The positive impacts are-

- Additional annual generation of 413.78 MU of energy in a 90 % dependable year.
- 12 % free power of total generation will be given to state, which will help in regular power supply in the area.
- Employment opportunities/to locals in project work and fisheries.
- Benefits to economy and commerce.

- Access to improved infrastructure facilities.
- Recreation and tourism potential may boost.
- Improvement in environment through implementation of CAT, Compensatory Afforestation, Green belt Development and different several plans.

The negative impacts are -

- No village shall be fully submerged while 5 shall be partially affected due to acquisition of land and other assets for project purpose.
- There shall be 62 Project Affected Families of which none shall be displaced
- The loss of agriculture land (11.3895 ha) and agriculture produce.
- Loss of forest habitat (48.4825 ha).
- Loss of livelihood and income.
- The change of river status from riverine to lacustrine regime
- Likely decrease in agriculture and horticulture production due to air pollution
- Disturbance to the fauna of the study area during construction
- Pressure on the existing provincial / state road will increase.

11.9 IMPACT MANAGEMENT

To ameliorate the negative effects of the project construction and overall improvement of the environment following management plans are formulated for implementation concurrent to the project construction. The cost of the management plans is shown in **Table 11.2.**

Table 11.2: Summary of Cost of Environmental Management Plan

S. N.	Plans	Cost(Rs. Lakh)	Capital Cost(Rs lakh)	Recurring(Rs lakh)
1.	Catchment Area Treatment Plan	578.00	488.00	9.00
2.	Compensatory Afforestation Scheme	606.00	591.00	1.50
3.	Wildlife and Bio-diversity Management plan	101	83.00	1.80
4.	Resettlement & Rehabilitation Plan	284.00	284.00	0.00
5.	Green Belt Development Plan	15.00	5.00	1.00
6.	Reservoir Rim Treatment Plan	11.00	11.00	0.00
7.	Landscape and Restoration Plan	12.00	3.00	0.90
8.	Fisheries Management Plan	170.00	110.00	6.00
9	Muck Management Plan	128	117.00	1.10
10.	Restoration Plan for Quarry Sites	16.00	11.00	0.50
11.	Disaster Management Plan	65.00	60.00	0.50
12.	Water, Air and Noise Management Plan	20.00	10.00	1.00
13.	Public Health Delivery Plan	155.00	35.00	12.00
14.	Labour Management Plan	16.00	3.00	1.30
15.	Sanitation and Solid Waste Management Plan	39.00	19.00	2.00
16.	Corporate Environmental Responsibility	531.00	506	2.50
17.	Environmental Safeguards	10.00	0.00	1.00
18.	Energy Conservation Measures	46.00	0.50	4.55

S. N.	Plans	Cost(Rs. Lakh)	Capital Cost(Rs lakh)	Recurring(Rs lakh)
19.	Environmental Monitoring Plan	90.00	5.00	8.50
Grand Total		**2893 .00**	**2341.5**	**55.15**

12 DISCLOSURE OF CONSULTANTS

12.1 BRIEF PROFILE OF COMPANY

EQMS India Pvt.Ltd., is a leading ISO 9001: 2008 complied and NABET/QCI consulting company constantly striving towards newer heights since its inception in 1998. EQMS is accredited in 17 sectors including 1 (c) River Valley Projects, 7 (c) (Industrial estates/park/complexes/areas, export processing zones (EPZs), Special Economic Zones (SEZs), Biotech Park, Leather Complexes) and 8 (b) (Area Development and Township Projects). EQMS has experience of about 20 years in field of EIA and is one of the pioneer company to get QCI/NABET Accreditation. NABET/QCI Accreditation EQMS is providing consulting services in almost all states in India and also in Sri Lanka, Nepal, Bangladesh, Bhutan, Saudi Arabia and Abu Dhabi. EQMS has experiences of carrying out EIA study as per regulatory requirements (MoEF&CC) guidelines and as per policy requirement of International Funding Agencies like World Bank, Asian Development Bank, IFC, USAID, UNDP etc. EQMS has carried out EIA study for various Hydro Power, Thermal Power, Solar Power, Wind Power, Industrial Estate/Economic Zone Projects located in India and Bangladesh.

The company has huge clientele comprising of Government Agencies (IWAI, MPPWD, JKSPDCL, UJVNL, UPDCC, MEPGCL, MMRDA, NMRC, Govt of Maharashtra, UPPWD etc.), PSUs (GAIL, TCIL etc.) and Private Clients. Our company is dedicated to providing strategic services in the areas of Environmental Impact study, Risk Assessment study, Environmental Audits, Due Diligence Assessments, Policy Trainings, Quality, Occupational Health & Safety, Social Accountability Management Systems; Enterprise level Behavioral Based Safety (BBS) Management; EHS Performance Benchmarking and Post Project Management.

EQMS has already experience of working in PAN India. EQMS has worked on some of the major projects in state, i.e. development of EIA, EMP, EMP implementation monitoring and Environmental monitoring for Navi Mumbai Airport Project: Package II, III and IV proposed by CIDCO, EIA /SIA/RAP study for conversion of overhead electricity network to underground system for three coastal towns (Alibag, Ratnagiri and Satpati) and for development of 8 nos of Saline embankments under NCRMP-II Project of Government of Maharashtra and SIA/RAP study for metro line project 2B and 4 of MMRDA, EIA Study for the Kerala Power Sector Reform Project, EIA study for development of the electricity transmission system for Turkmenistan, ESIA study for various hydro-electric power plants, Thermal power plants, solar power plants, wind power plants and transmission of electricity to the nearest substation as per IFC guidelines. Other than this there are various industrial projects in different states wherein EQMS has conducted environmental impact assessment study and obtained environmental clearance.

EQMS has worked on various projects which are funded by bilateral and multilateral funding agencies like World Bank, ADB, IFC etc. EQMS has experts from all the fields and has experience of working on river valley, water sector, irrigation and water supply projects

12.2 TEAM OF PROFESSIONAL

EQMS has team of highly talented and experienced professionals including all required NABET approved Environmental Coordinators and Functional Area experts who work in sync with each other & clients ensuring that the defined assessment, survey or reporting is executed with high level of efficiency. Our experts team consists of Environment engineers, Environment specialist, Policy analysts, geologists, chemists, Safety Experts, civil engineers, Chemical Engineers, hydro geologists, Bio-diversity experts, industrial hygienists, technicians, research associates, sociologists and others with expertise in various niche areas. They undergo various training sessions at regular intervals to keep themselves updated with new ideas, techniques and tools.

Table 12.1: Qualification and Area of Expertise of Professional

Name	Experience	Key Qualifications	Areas of Expertise
Mr. S.K. Jain	30	• B.Tech (Chemical) • M.Tech (Chemical)	• Environment Impact Assessment • Due Diligence • Education, Capacity Building & Training • Air Pollution Monitoring and Control • Water Pollution Monitoring & • Control. • Solid & Hazardous Waste Mgt • Risk & Hazard Analysis & Mgt. • Designing of STP, ETP & WTP • Consent Management • Public Consultation
Mr. A.K. Chaturvedi	30	• BE (Civil.) • ME Environmental Engg.	• Environment Impact Assessment • Air Pollution Monitoring and Control • Air Quality Modeling & Prediction • Noise & Vibration • EHS Legislations. • Health & Safety Audits • Energy Audits • Environmental Audits • Training on Behavioral Based Safety • Training & education
Mr. T.G. Ekande	30	• B.A. Economics • M.A. Economics • PG Dip. Development Planning.	• Social Impact Assessment • Resettlement & Rehabilitation • Public Consultation • Land Acquisition • Monitoring & Evaluation • Institutional Development • Institutional Strengthening, Capacity
Mr. Yamesh Sharma	48	• B.Sc. (Civil Engg.)	• Environment Impact Assessment • Hydrology &Hydro-Geology

			• Ground Water Estimation & Modeling • Water optimization & conservation • Land Use and Cover Study • Noise modelling & Vibration • Soil Conservation & Quality Analysis • Rainwater Harvesting & Storm Water Management • Catchment Area Treatment • Dam Break Analysis
Mr. P. K. Srivastava	49	• B. Tech (Chemical Engg.)	• Environment Impact Assessment • Air Pollution Monitoring and Control • Water Pollution Monitoring & Control. • Risk & Hazard Analysis & Mgt. • Consent Management
Mr. Hardik Pramodbhai Patel	11	• M.Sc. (Geology) • B.Sc. (Geology)	• Geology • Hydrogeology • Ground water Estimations and modeling • Rainwater harvesting
Mr. Ratnesh Kotiyal	14	• M. Sc. Botany	• Ecological & Biodiversity Study • Ecological Impact Assessment • Socio Economics Survey
Mr. Manoj Kumar Sharma	25	• M.Sc. (Agriculture)	• Environment Impact Assessment • Laboratory Monitoring & Analysis • Soil Quality Analysis. • Ecology & Biodiversity Studies. • Agriculture
Mr. Anil Kumar	8	• M.Sc. (Geography) • P.G. Diploma (Remote Sensing & GIS)	• Land Use & Land Cover • Mapping (Remote Sensing &GIS Software) • Change in Land Use /Land cover • Socio Economy
Ms. Shweta Gupta	3	• B. tech. Biotechnology • M. Tech Environment Engineering	• Environment Impact Assessment • Noise & Vibration Studies • Water Pollution & Control
Mr. Kaleem Qureashi	6	• M.A. (Geography) • Certification Course (GIS)	• Land Use & Land Cover • Mapping (Remote Sensing &GIS Software) • Change in Land Use /Land cover • Socio Economy

Annexures

Annexure – 1 : NABET Certificate

Quality Council of India

National Accreditation Board for Education & Training

QCI

NABET

Certificate of Accreditation

EQMS India Private Limited

304-305, Plot No.16, Rishabh Corporate Tower, Karkardooma Community Centre, Karkardooma, Delhi-110092

***Accredited as Category** - A organization under the QCI-NABET Scheme for Accreditation of EIA Consultant Organizations: Version 3 for preparing EIA-EMP reports in the following Sectors:*

Sl.No	Sector Description	Sector (as per)		Cat.
		NABET	MoEFCC	
1	Mining of minerals including Open cast/ Underground mining	1	1 (a) (i)	A
2	River Valley projects	3	1 (c)	A
3	Thermal power plants	4	1 (d)	A
4	Metallurgical industries (ferrous & nonferrous) - both primary & secondary	8	3 (a)	B
5	Cement plants	9	3 (b)	A
6	Chemical Fertilizers	16	5 (a)	A
7	Pesticides industry and pesticide specific intermediates (excluding formulations)	17	5 (b)	A
8	Synthetic organic chemicals industry (dyes & dye intermediates; bulk drugs and intermediates excluding drug formulations; synthetic rubbers; basic organic chemicals, other synthetic organic chemicals and chemical intermediates)	21	5 (f)	A
9	Pulp & paper industry excluding manufacturing of paper from wastepaper and manufacture of paper from ready pulp without bleaching	24	5 (i)	A
10	Isolated storage & handling of hazardous chemicals (As per threshold planning quantity indicated in column 3 of Schedule 2 & 3 of MSIHC Rules 1989 amended 2000)	28	6 (b)	B
11	Air ports	29	7 (a)	A
12	Industrial estates/ parks/ complexes/ Areas, export processing zones (EPZs), Special economic zones (SEZs), Biotech parks, Leather complexes	31	7 (c)	A
13	Ports, harbours, break waters and dredging	33	7 (e)	A
14	Highways	34	7 (f)	A
15	Common Municipal Solid Waste Management Facility (CMSWMF)	37	7 (i)	B
16	Building and construction projects	38	8 (b)	B
17	Townships and Area development	39	8 (b)	A

Note: Names of approved EIA Coordinators and Functional Area Experts are mentioned in SA AC minute dated May 11, 2018 posted on QCI-NABET website.

The Accreditation shall remain in force subject to continued compliance to the terms and conditions mentioned in QCI-NABET's letter of accreditation bearing no. QCI/NABET/ENV/ACO/18/0701 dated July 17, 2018.The accreditation needs to be renewed before the expiry date by EQMS India Private Limited, following due process of assessment

Sr. Director, NABET	**Certificate No.**	**Valid up to**
Dated: July 17, 2018	**NABET/EIA/1619/ SA 070**	**May 23, 2019**

For the updated List of Accredited EIA Consultant Organizations with approved Sectors please refer to QCI-NABET

National Accreditation Board for Education and Training

(Member - International Accreditation Forum & Pacific Accreditation Cooperation)

May 10, 2019

QCI/NABET/EIA/ACO/19/0969
EQMS India Pvt. Ltd.
304 & 305, 3rd Floor, Plot No. 16,
Rishabh Towers, Community Centre,
Karkardooma, Delhi – 110 092
(Kind Attention: **Dr. S. K. Jain**)

Sub: Validity of Accreditation

Dear Sir,

This has reference to the accreditation of your organization under QCI-NABET EIA Scheme, the validity of **EQMS India Pvt. Ltd.** is hereby extended till November 23, 2019 or completion of assessment process, whichever is earlier.

The above extension is subject to the submission of required information/documents related to assessment on time to NABET.

You are requested not to use this letter after expiry of the above stated date.

With best regards,

10/05/2019

A.K Jha
Senior Director| NABET

National Accreditation Board for Education and Training

(Member - International Accreditation Forum & Pacific Accreditation Cooperation)

November 19, 2019

QCI/NABET/EIA/ACO/19/1125

EQMS India Private Limited

304-305, Plot No.16, Rishabh Corporate Tower,

Karkardooma Community Centre, New Delhi - 110092

(Kind Attention: **Mr. Sanjay Kumar Jain**)

Sub: Validity of Accreditation

Dear Sir,

This has reference to the accreditation of your organization under QCI-NABET EIA Scheme, the validity of **EQMS India Private Limited, New Delhi** is hereby extended till February 18, 2020 or completion of assessment process, whichever is earlier.

The above extension is subject to the submission of required information/documents related to assessment on time to NABET.

You are requested not to use this letter after expiry of the above stated date.

With best regards,

19/11/2019

A.K Jha

Senior Director| NABET

Institute of Town Planners India, 6th Floor, 4-A, Ring Road, I.P Estate, New Delhi-110 002, India

Tel. : +91-11-233 23 416, 417, 418, 419, 420, 421, 423 E-mail : ceo.nabet@qcin.org Website : www.qcin.org

Annexure – 2 : ToR Letter

No. J-12011/14/2019-IA-1(R)
Government of India
Ministry of Environment, Forest & Climate Change
(IA.I Division)

Indira Paryavaran Bhawan
5th Floor, Vayu Wing
Jor Bagh Road
New Delhi-110 003

Dated: 16th January, 2020

To

M/s Madhya Bharat Power Corporation Limited
Gouma Devi Pradhan's Building
N.H. 31-A, Gohtar, Singtam, East Sikkim
Sikkim -737 104

Sub: Rongnichu Hydroelectric Project (115 MW) in East Sikkim district of Sikkim, by M/s. Madhya Bharat Power Corporation Ltd. – Regarding fresh ToR

Sir,

This has reference to your, online proposal No. IA/SK/RIV/114561/2019 and Letter No. MBPCL/96MW/EC/5036 dated 10.08.2019 submitted to the Ministry for Terms of Reference to the project cited in the subject.

2. The above proposal was appraised by the Expert Appraisal Committee (EAC) for River Valley & Hydroelectric Power Projects (RV & HEP) in its 27th meetings held on 23.09.2019. The comments and observations of EAC may be seen in the Minutes of the meeting that are available on the Ministry's website.

3. Rongnichu Hydroelectric Project (96 MW) on Rongnichu stream in East Sikkim district of Sikkim, being developed by M/s. Madhya Bharat Power Corporation Ltd. (MBPCL), is a runof-river hydro development project. The Barrage complex is located about 2 km downstream of Namli village and 16 km south of Gangtok city along NH-31A. The project envisages construction of a 120 m long, 35 m width and 14m high Barrage across Rongni Chu, a tributary of Teesta river. Power Intake Structure located near the left end of this chamber feed a 12.581 km long Head Race 2 Tunnel (HRT) leading to a Surge Shaft at its tail end and a Pressure Shaft, which will terminate at the valve house. The total catchment area at barrage site is 190 km2 and the project has no irrigation component and thus there is no command area. The gross storage at FRL is only 0.33 MCM of which live storage at FRL is 0.24 MCM. Reservoir area at FRL is 10.70 ha. The total cost of project is Rs. 1187.48 Crores.

4. On 4th April 2007 MoEF granted prior Environmental Clearance to MBPCL for setting up 96 MW RHEP in east district of Sikkim. After obtaining other statutory clearances MBPCL has been implementing the project satisfactorily. The Ministry vide letter dated 16.6.2017 granted extension

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of validity of EC initially for six months and further, vide letter No J-12011/56/2006- IA-I dated 9.11.2017 accorded extension of validity for two and half year i.e. up to 3.4.2020.

5. Work of Barrage complex is 92% completed, work of water Conveying system is 82% completed and work of Powerhouse complex is 70% completed. The balance works including testing of power plant and other components of project are to be completed by April 2021. The construction/implementation got delayed due to:

i. The extremely poor geology (class V-flaky rock/mud) encountered during the excavation of the last 1,128 m section of HRT,
ii. Heavy flow of slush encountered during excavation,
iii. Heavy water ingress made it impossible to continue excavation and
iv. halted supply of material to power house complex due to Rongpo-Kumrek road Sliding.

6. M/s. Madhya Bharat Power Corporation Ltd. intend to enhance the installed capacity of power house from 96 MW to 115 MW owing to higher inflows available during five 10-daily blocks in monsoon period and in the light of enabling provision of running machines at 20% overload as stipulated in power potential studies carried earlier. The Energy and Power Department, Government of Sikkim, vide letter No, 91/GOS/EIP/2004-05/Part-III/924, Dated 2.8.2019 has issued no objection, if the generation capacity of RHEP is enhanced from 96 MW to 115 MW. Subsequently, a review of the original DPR (inflows and Section of unit size) revealed that 2x48 MW configuration was selected on the techno-economic criterion (cost-benefit analysis). Sufficient water was found available to sustain higher sized units without changing hydraulic structures such as barrage height, HRT/Penstock size, design, etc. of the project by increase in the installed capacity from 96 MW to 115 MW owing to higher discharge available in the river.

7. The total land requirement under the project for barrage, submergence, appurtenant works, has been assessed to be as 71.1836 ha of which private land is 33.9483 ha, forest land is 25.1388 ha, Power Department land is 0.707 ha and revenue land is 11.3895 ha. All private land has been acquired; diversion of forestland has been completed and revenue land has been transferred to the PP. Stage-I Forest clearance for diversion of forestland has been accorded on 17.01.2008 and Stage-II forest clearance on 18.5.2019. The R&R package has been followed in toto and expenditure of Rs 2.06 crores has been spent for the purpose.

8. The above proposal was appraised by the EAC on 23.09.2019. The EAC after detailed scrutiny and deliberations on the information submitted and as presented by the PP, recommended the proposal for grant of fresh ToR/Scoping clearance for increasing the installed capacity of the existing powerhouse from 96 MW to 115 MW

9. Request of the PP regarding exemption of conducting fresh Public Hearing was considered by the EAC. EAC observed that since the public hearing was held on 28.10.2006 and commitments made during the public hearing held on 28.10.2006 has been fully complied with. R&R package has been followed in toto and expenditure of Rs 2.06 crores has already been incurred. No family was displaced and there is no further additional land requirement, fresh public hearing may not be necessitated. Based on recommendations of the EAC, the Ministry of Environment Forest & Climate

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hereby **accords a fresh Terms of Reference (TOR)** as per the Annexure I for activities at the proposed site as per the provisions of the Environmental Impact Assessment Notification, 2006 and as amended time to time along with the following additional ToR for preparation of EIA/EMP report:

i. The EIA/EMP report should contain the information in accordance with provisions &stipulations as given in the **Annexure-I**.

ii. The consultant engaged for preparation of EIA/EMP report has to be registered with Quality Council of India (QCI/ NABET) under the scheme of Accreditation & Registration of MoEF& CC. This is a pre-requisite.

iii. Consultant shall include a "Certificate" in EIA/EMP report regarding portion of EIA/EMP prepared by them and data provided by other organization(s)/ laboratories including status of approval of such laboratories. Declaration by the Consultant that information submitted in the EIA/EMP is factually correct and shall be submitted along with EIA/EMP reports.

iv. An undertaking from the project proponent shall be submitted as part of the EIA report, owning the contents (information and data) of the EIA report. If any stage, it is observed or brought to the notice of this Ministry that the contents of the EIA report pertaining to a project have been copied from other EIA reports, such project shall be summarily rejected and the proponent will have to initiate the process afresh including public hearing.

v. The draft EIA/EMP report be prepared as per the Generic Structure **(Appendix III of EIA Notification, 2006)** by incorporating information as per the Annexure-I. Fresh EIA/EMP report shall be uploaded in the public domain for one month at the State Pollution Control Board website, requesting the local affected persons and others who have plausible stake in the environment impacts to send their comments. PP shall address all comments/issues raised in the EIA/EMP report along with the issues raised in the earlier public hearing with detailed present status.

vi. Compliance to the comments received during one-month time should be incorporated in the EIA/EMP report. Final EIA/EMP report should be submitted to the Ministry for Environmental Clearance only after incorporating these issues, before the expiry of validity of ToR.

vii. Consolidated EIA/EMP report is to be submitted as per the generic structure (Appendix III) and Summary EIA (Appendix IIIA) given in the EIA Notification, 2006.

viii. The ToR will remain valid for a period of 4 years from the date of issue of this letter for submission of EIA/EMP report along with public consultation. The ToR will stand lapsed after completion of 4 years in case final EIA/EMP is not submitted and the validity is not extended.

ix. In case the validity is to be extended, necessary application is to be submitted to the Regulatory Authority before expiry of validity period along with an updated Form-I based on proper justification.

x. Baseline data shall not be older than 3 years, at the time of submission of the proposal, for grant of Environmental Clearance.

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xi. In case of any change in the scope of the project such as capacity enhancement, change in submergence, etc., fresh scoping clearance has to be obtained.

xii. A copy of TEC of the revised DPR for 115 MW should be submitted with the EIA/EMP report.

xiii. Fund allocation for Corporate Environment Responsibility (CER) with time line shall be made as per Ministry's O.M. No. 22-65/2017-IA.III dated 1st May, 2018 for various activities therein. The details of funds allocation and activities for CER shall be incorporated in EIA/EMP report.

xiv. The EIA report should clearly mention activity wise EMP and CER cost details and should earmarked clear break-up of the **capital and recurring** cost along with the timeline for incurring the capital cost.

xv. Details of the name and number of posts to be engaged by the project proponent for implementation and monitoring of environmental parameters be specified in the EIA report.

xvi. The EIA/ EMP report must contain an Index showing details of compliance of all ToR conditions. The Index will comprise of page No. etc., vide which compliance of a specific ToR is available. It may be noted that without this index, EIA/ EMP report will not be accepted.

xvii. The PP should complete all the tasks as per the provisions of EIA Notification, 2006 and as amended time to time) and submit the application for final clearance within the stipulated time.

xviii. Appropriate Biodiversity Conservation and Management plan for the Native, Rare & Endangered floral and faunal species getting affected due to the project shall be prepared.

xix. Land acquired for the project shall be suitably compensated in accordance with the law of the land with the prevailing guidelines. Private land shall be acquired as per provisions of Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement Act, 2013, if any.

xx. Forest clearance shall be obtained as per the prevailing norms of Forest (Conservation) Act, 1980, if any.

xxi. In case Forest land is further required, application to obtain prior approval of Central Government under the Forest (Conservation) Act, 1980 for diversion of forestland required should be submitted as soon as the actual extent of forest land required for the project is known, and in any case, within six months of issuance of this letter.

xxii. As the Fambong Lho Wildlife sanctuary is 3.87 km away from the project boundary, NBWL clearance shall be obtained, if any project component is falling inside the notified ESZ.

xxiii. A detailed map regarding distance of the project boundary from the nearest wildlife sanctuary, duly authenticated by the Chief Wildlife Warden shall be submitted with EIA/EMP report.

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xxiv. Impact of the proposed project on the nearest Wildlife sanctuary shall be studied and proper conservation plan/mitigation measures shall be included in the EIA/EMP report.

xxv. Conservation plan for the Scheduled I species in the project study area, if any, shall be prepared and submitted to the Competent Authority for approval.

This has approval of the Competent Authority.

Yours faithfully,

(Dr. S. Kerketta)
Director

Copy to:

1. The Secretary, Ministry of Power, Sharm Shakti Bhawan, Rafi Marg, New Delhi-110001
2. The Secretary, Ministry of Water Resources, RD & GR, Sharm Shakti Bhawan, Rafi Marg, New Delhi-3.
3. The Secretary (Power), Department of Power, Govt. of Sikkim, Secretariat, Gangtok-737102.
4. The Secretary, Department of Forest, Environment & Wildlife Management, Govt. Of Sikkim, Gangtok-737102.
5. The Chief Engineer, Project Appraisal Directorate, Central Electricity Authority, Sewa Bhawan R.K. Puram, New Delhi-110066.
6. The Deputy Director General of Forests (C), Ministry of Environment, Forest & Climate Change North Eastern Regional Office, Law-U-SIB, Lumbatngen, Shilong-793021.
7. The Member Secretary, State Pollution Control Board, Department of Forest, Environment & Wildlife, Deorall, Govt. Of Sikkim, Gangtok-737101.
8. NIC Cell- request to upload on the MoEF website.
10. Sr PPS to JS (GM)
11. Guard File

(Director)

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Annexure-I

TERMS OF REFERENCE FOR CONDUCTING ENVIRONMENT IMPACT ASSESSMENT STUDY FOR 'A' CATEGORY HYDRO POWERPROJECTS AND INFORMATION TO BE INCLUDED IN EIA/EMP REPORT

(1) Scope of EIA Study:

The EIA Report should identify the relevant environmental concerns and focus on potential impacts that may change due to the construction of proposed project. Based on the baseline data collected for two seasons (Pre- Monsoon & Monsoon) the status of the existing environment in the area and capacity to bear the impact on this should be analyzed. Based on this analysis, the mitigation measures for minimizing the impact shall be suggested in the EIA/EMP study.

(2) Details of the Project and Site

- General introduction about the proposed project.
- Details of Project (existing and proposed) and site giving L-sections of all U/S and D/S projects of River with all relevant maps and figures. Connect such information as to establish the total length of interference of Natural River, the total length of tunnelling of the river and the committed unrestricted release from the site of diversion into the main river.
- A map of boundary of the project site giving details of protected areas in the vicinity of project location.
- Location details on a map of the project area with contours indicating main project features. The project layout shall be superimposed on a contour map of ground elevation showing main project features (viz. location of dam, Head works, main canal, branch canals, quarrying etc.) shall be depicted in a scaled map.
- Layout details and map of the project along with contours with project components clearly marked with proper scale maps of at least 1:50,000 scale and printed at least on A3 scale for clarity.
- Existence of National Park, Sanctuary, Biosphere Reserve etc. in the study area, if any, should be detailed and presented on a map with distinct distances from the project components.
- Drainage pattern and map of the river catchment up to the proposed project site.
- Delineation of critically degraded areas in the directly draining catchment on the basis of Silt Yield Index as per the methodology of All India Soil and Land Use Survey of India.
- Soil characteristics and map of the project area.
- Geological and Seismo-tectonic details and maps of the area surrounding the proposed project site showing location of dam site and power house site.
- Remote Sensing studies, interpretation of satellite imagery, topographic sheets along with ground verification shall be used to develop the land use/land cover pattern of the study

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using overlaying mapping techniques viz. Geographic Information System (GIS), False Color Composite (FCC) generated from satellite data of project area.

- Land details including forests, private and other land.
- Demarcation of snow fed and rain fed areas for a realistic estimate of the water availability.
- Different riverine habitats like rapids, pools, side pools and variations in the river substratum bedrocks, rocks, boulders, sand/silt or clay etc. need to be covered under the study.

(3) Description of Environment and Baseline Data

To know the present status of environment in the area, baseline data with respect to environmental components air, water, noise, soil, land and biology & biodiversity (flora & fauna), wildlife, socio-economic status etc. should be collected within 10 km radius of the main components of the project/site i.e. dam site The air quality and noise are to be monitored at such locations which are environmentally & ecologically more sensitive in the study area. The baseline studies should be collected for 2 seasons (Pre-monsoon& Monsoon). The study area should comprise of the following:

- Catchment area up to the dam site
- Submergence Area
- Project area or the direct impact area should comprise of area falling within 10 km radius from the periphery of reservoir, land coming under submergence and area downstream of dam upto the point where Tail Race Tunnel (TRT) meets the river.
- Downstream upto 10 km from the tip of Tail Race Tunnel (TRT).

(4) Details of the Methodology

The methodology followed for collection of base line data along with details of number of samples and their locations in the map should be included. Study area should be demarcated properly on the appropriate scale map. Sampling sites should be depicted on map for each parameter with proper legends. For Forest Classification, Champion and Seth (1968) methodology should be followed.

(5) Methodology for Collection of Biodiversity Data

- The number of sampling locations should be adequate to get a reasonable idea of the diversity and other attributes of flora and fauna. The guiding principles should be the size of the study area (larger area should have larger number of sampling locations) and inherent diversity at the location, as known from secondary sources (e.g. eastern Himalayan and low altitude sites should have a larger number of sampling locations owing to higher diversity).
- The entire area should be divided in grids of 5km X 5km preferably on a GIS domain. There after 25% of the grids should be randomly selected for sampling of which half should be in the directly affected area (grids including project components such as reservoir, dam, powerhouse, tunnel, canal etc.) and the remaining in the rest of the area (areas of influence in 10 km radius form project components). At such chosen location, the size and number of sampling units (e.g. quadrates in case of flora/transects in case of fauna) must be decided by species area curves and the details of the same (graphs and cumulative number of species in

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a tabulated form) should be provided in the EIA report. Some of the grids on the edges may not be completely overlapping with the study area boundaries. However, these should be counted and considered for selecting 25% of the grids. The number of grids to be surveyed may come out as a decimal number (i.e. it has an integral and a fractional part) which should be rounded to the next whole number.

- The conventional sampling is likely to miss the presence of rare, endangered and threatened (R.E.T.) species since they often occur in low densities and in case of faunal species are usually secretive in behavior. Reaching the conclusion about the absence of such species in the study area based on such methodology is misleading. It is very important to document the status of such species owing to their high conservation value. Hence likely presence of such species should be ascertained from secondary sources by a proper literature survey for the said area including referring to field guides which are now available for many taxonomic groups in India. Even literature from studies/surveys in the larger landscapes which include the study area for the concerned project must be referred to, since most species from adjoining catchments is likely to be present in the catchments in question. In fact, such literature form the entire state can be referred to. Once a listing of possible R.E.T species form the said area is developed, species specific methodologies should be adopted to ascertain their presence in the study area which would be far more conclusive as compared to the conventional sampling. If the need be, modern methods like camera trapping can be resorted to, particularly for areas in the eastern Himalayas and for secretive/nocturnal species. A detailed listing of the literature referred to, for developing lists of r.e.t. species should be provided in the EIA reports.

- The R.E.T. species referred to in this point should include species listed in Schedule I and II of Wildlife (Protection) Act, 1972 and those listed in the red data books (BSI, ZSI and IUCN).

(6) Components of the EIA Study

Various aspects to be studied and provided in the EIA/EMP report are as follows:

A. Physical and Chemical Environment

I. Geological & Geophysical Aspects and Seismo- Tectonics:

- Physical geography, Topography, Regional Geological aspects and structure of the Catchment.

- Tectonics, seismicity and history of past earthquakes in the area. A site specific study of the earthquake parameters will be done. The results of the site specific earthquake design shall be sent for approval of the NCSDP (National Committee of Seismic Design Parameters, Central water Commission, New Delhi for large dams.

- Landslide zone or area prone to landslide existing in the study area should be examined.

- Presence of important economic mineral deposit, if any.

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- Justification for location & execution of the project in relation to structural components (dam height).
- Impact of project on geological environment.

II. Meteorology, Air and Noise:

- Meteorology (viz. Temperature, Relative humidity, wind speed/direction etc.) to be collected from nearest IMD station.
- Ambient Air Quality with parameters viz. Suspended Particulate Matter (SPM), Respirable Suspended Particulate Matter (RSPM) i.e. suspended particulate materials <10 microns, Sulphur dioxide (SO_2) and Oxides of Nitrogen (NO_X) in the study area at 6 Locations.
- Existing Noise Levels and traffic density in the study area at 6 locations.

III. Soil Characteristics:

- Soil classification, physical parameters (viz., texture, Porosity, Bulk Density and water holding capacity) and chemical parameters (viz. pH, electrical conductivity, magnesium, calcium, total alkalinity, chlorides, sodium, potassium, organic carbon, available potassium, available phosphorus, SAR, nitrogen and salinity, etc.) at 6 locations.

IV. Remote Sensing and GIS Studies:

- Generation of thematic maps viz, slope map, drainage map, soil map, land use and land cover map, etc. Based on these, thematic maps, an erosion intensity map should be prepared.

V. Water Quality

- History of the ground water table fluctuation in the study area.
- Water Quality for both surface water and ground water for [i] Physical parameters (pH, Temperature, Electrical Conductivity, TSS); [ii] Chemical parameters (Alkalinity, Hardness, BOD, COD, NO3, PO4, Cl, So4, Na, K, Ca, Mg, Silica, Oil & grease, phenolic compounds, residual sodium carbonate); [iii] Bacteriological parameter (MPN, Total coliform); and [iv] Heavy Metals (Pb, As, Hg, Cd, Cr-6, Total Cr, Cu, Zn, Fe) at 6 Locations.
- Delineation of sub and micro watersheds, their locations and extent based on the All India Soil and Land Use Survey of India (AISLUS), Department of Agriculture, Government of India. Erosion levels in each micro-watershed and prioritization of micro-watershed through Silt Yield Index (SYI) method of AISLUS.

B. Water Environment & Hydrology

- Hydro-Meteorology of the project viz. precipitation (snowfall, rainfall), temperature, relative humidity, etc. Hydro-meteorological studies in the catchment area should be established along-with real time telemetry and data acquisition system for inflows monitoring.

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- Run off, discharge, water availability for the project, sedimentation rate, etc.
- Basin Characteristics.
- Catastrophic events like cloud bursts and flash floods, if any, should be documented.
- For estimation of Sedimentation Rate, direct sampling of river flow is to be done during the EIA study. The study should be conducted for minimum one year. Actual silt flow rate to be expressed in ha-m km2 year-1.
- Set-up a G&D monitoring station and a few rain gauge stations in the catchment area for collecting data during the investigation.
- Flow series, 10 daily with 90%, 75% and 50% dependable years discharges.
- Information on the 10-daily flow basis for the 90 per cent dependable year the flow intercepted at the dam, the flow diverted to the power house and the spill comprising the environmental flow and additional flow towards downstream of the dam for the project may be given.
- The minimum environmental flow shall be 20% of the flow of four consecutive lean months of 90% dependable year, 30% of the average monsoon flow. The flow for remaining months shall be in between 20-30%, depending on the site specific requirements. A site specific study shall be carried out by an expert organization.
- Hydrological studies/data as approved by CWC shall be utilized in the preparation of EIA/ EMP report. Actual hydrological annual yield may also be given in the report.
- Sedimentation data available with CWC may be used to find out the loss in storage over the years.
- A minimum of 1 km distance from the tip of the reservoir to the tail race tunnel should be maintained between upstream and downstream projects.

C. Biological Environment

Besides primary studies, review of secondary data/ literature published for project area on flora & fauna including RET species shall be reported in EIA/EMP report.

I. Flora

- Characterization of forest types (as per Champion and Seth method) in the study area and extent of each forest type as per the Forest Working Plan.
- Documentation of all plant species i.e. Angiosperm, Gymnosperm, Pteridophytes, Bryophytes (all groups).
- General vegetation profile and floral diversity covering all groups of flora including Lichens and Orchids. A species wise list may be provided.

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- Assessment of plant species with respect to dominance, density, frequency, abundance, diversity index, similarity index, importance value index [IVI], Shannon Weiner Index etc. of the species to be provided. Methodology used for calculating various diversity indices along with details of locations of quadrats, size of quadrats etc. to be reported within the study area in different ecosystems.

- Existence of National Park, Sanctuary, Biosphere Reserve etc. in the study area, if any, should be detailed.

- Economically important species like medicinal plants, timber, fuel wood etc.

- Details of endemic species found in the project area.

- Flora under RET categories should be documented using International Union for the Conservation of Nature and Natural Resources (IUCN) criteria and Botanical Survey of India's Red Data list along with economic significance. Species diversity curve for RET species should be given.

- Cropping Pattern and Horticulture Practices in the study area.

II. Fauna

- Fauna study and inventorisation should be carried out for all groups of animals in the study area. Their present status along with Schedule of the species.

- Documentation of fauna plankton (phyto and zooplankton), periphyton, benthos and fish should be done and analyzed.

- Information (authenticated) on Avi-fauna and wild life in the study area.

- Status of avifauna their resident/migratory/ passage migrants etc.

- Documentation of butterflies, if any, found in the area.

- Details of endemic species found in the project area.

- RET species- voucher specimens should be collected along with GPS readings to facilitate rehabilitation. RET faunal species to be classified as per IUCN Red Data list and as per different schedule of Indian Wildlife (Protection) Act, 1972.

- Existence of barriers and corridors, if any, for wild animals.

- Compensatory afforestation to compensate the green belt area that will be removed, if any, as part of the proposed project development and loss of biodiversity.

- Collection of primary data on agricultural activity, crop and their productivity and irrigation facilities components.

- For categorization of sub-catchment into various erosion classes and for the consequent CAT plan, the entire catchment (Indian Portion) is to be considered and not only the directly the draining catchment.

D. Aquatic Ecology

- Documentation of aquatic fauna like macro-invertebrates, zooplankton, phytoplanktons, benthos etc.
- Fish and fisheries, their migration and breeding grounds.
- Fish diversity, composition and maximum length & weight of the measured populations to be studied for estimation of environmental flow.
- Conservation status of aquatic fauna.
- Sampling for aquatic ecology and fisheries and fisheries must be conducted during three seasons Pre-monsoon (summer) and monsoon. Sizes (length & weight) of important fish species need to be collected and breeding and feeding grounds should also be identified along the project site or in vicinity.

E. Socio-Economic

- Collection of Baseline data on human settlements, health status of the community and existing infrastructure facilities for social welfare including sources of livelihood, job opportunities and safety and security of workers and surrounding population.
- Collection of information with respect to social awareness about the developmental activity in the area and social welfare measures existing and proposed by project proponent.
- Collection of information on sensitive habitat of historical, cultural and religious and ecological importance.
- The Socio-economic survey/profile within 10 Km of the study area for Demographic profile; Economic Structure; Development Profile; Agricultural Practices; Infrastructure, education facilities; health and sanitation facilities; available communication network etc.
- Documentation of Demographic, Ethnographic, Economic structure and development profile of the area.
- Information on Agricultural practices, Cultural and aesthetic sites, Infrastructure facilities etc.
- Information on the dependence of the local people on minor forest produce and their cattle grazing rights in the forest land.
- List of all the Project Affected Families with their name, age, educational qualification, family size, sex, religion, caste, sources of income, land & house holdings, other properties, occupation, source of income, house/land to be

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acquired for the project and house/land left with the family, any other property, possession of cattle, type of houses etc.

- Special attention has to be given to vulnerable groups like women, aged persons etc. and to any ethnic/indigenous groups that are getting affected by the project.

(7) Impact Prediction and Mitigation Measures

The adverse impact due to the proposed project should be assessed and effective mitigation steps to abate these impacts should be described.

A. Air Environment

- Changes in ambient and ground level concentrations due to total emissions from point, line and area sources.
- Effect on soils, material, vegetation and human health.
- Impact of emissions from DG sets used for power during the construction, if any, on air environment.
- Pollution due to fuel combustions in equipment & vehicles
- Fugitive emissions from various sources.

B. Water Environment

- Changes in surface & ground water quality.
- Steps to develop pisci-culture and recreational facilities.
- Changes in hydraulic regime and down stream flow.
- Water pollution due to disposal of sewage.
- Water pollution from labour colonies/camps and washing equipment.

C. Land Environment

- Adverse impact on land stability, catchment of soil erosion, reservoir sedimentation and spring flow (if any) [a] due to considerable road construction/widening activity [b] interference of reservoir with the inflowing streams [c] blasting for excavation, commissioning of HRT, TRT and some other structures.
- Changes in land use/land cover and drainage pattern.
- Immigration of labour population.
- Quarrying operation and muck disposal.
- Changes in land quality including effects of waste disposal.

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- River bank and their stability.
- Impact due to submergence.

D. Biological Environment

- Impact on forests, flora, fauna including wildlife, migratory avi-fauna, rare and endangered species, medicinal plants etc.
- Pressure on existing natural resources.
- Deforestation and disturbance to wildlife, habitat fragmentation and wild animal's migratory corridors.
- Compensatory Afforestation-Identification of suitable native tree species for compensatory afforestation & green belt.
- Impact on fish migration and habitat degradation due to decreased flow of water.
- Impact on breeding and nesting grounds of animals and fish.

E. Socio-economic Aspects

- Impact on local community including demographic profile.
- Impact on socio-economic status.
- Impact on economic status.
- Impact on human health due to water / vector borne disease.
- Impact on increased traffic.
- Impact on Holy Places and Tourism.
- Impacts of blasting activity during project construction which generally destabilize the land mass and lead to landslides, damage to properties and drying up of natural springs and cause noise pollution, will be studied. Proper record shall be maintained of the base line information in the post project period.
- Positive and negative impacts likely to be accrued due to the project are to be listed.

(8) Environment Management Plan (EMP)

i. Catchment Area Treatment (CAT) Plan should be prepared micro-watershed wise. Identification of free draining/directly draining catchment based upon Remote Sensing and Geographical Information System (GIS) methodology and Sediment Yield Index (SYI) method of AISLUS, Deptt. Of Agriculture, Govt. of India coupled with ground survey. Areas/watersheds falling under 'very severe' and 'severe' erosion categories are required to be treated. Both biological as well as engineering measures should be proposed in consultation with State Forest Department for areas requiring treatment. Year-wise schedule of work and monetary allocation should be provided. Mitigations

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measures to check shifting cultivation in the catchment area with provision for alternative and better agricultural practices should be included.

ii. Compensatory Afforestation shall be prepared by the State Forest Department in lieu of the forest land proposed to be diverted for construction of the project as per the Forest (Conservation) Act, 1980. Choice of plants for afforestation should include native and RET species, if any. This will be a part of the forest clearance proposal.

iii. Biodiversity and Wildlife Conservation and Management Plan for the conservation and preservation of rare, endangered or endemic floral/faunal species or some National Park/Sanctuary/ Biosphere Reserve or other protected area is going to get affected directly or indirectly by construction of the project, then suitable conservation measures should be prepared in consultation with the State Forest Department and with the physical and financial details. Suitable conservation techniques (in-situ/ ex-situ) will be proposed under the plan and the areas where such conservation is proposed will be marked on a project layout map.

iv. Fisheries Conservation and Management Plan - a specific fisheries management measures should be prepared for river and reservoir. If the construction of fish ladder/ fish-way etc. is not feasible then measures for reservoir fisheries will be proposed. The plan will detail out the number of hatcheries, nurseries, rearing ponds etc. proposed under the plan with proper drawings. If any migratory fish species is getting affected then the migratory routes, time/season of upstream and downstream migration, spawning grounds etc will be discussed in details.

v. Resettlement and Rehabilitation (R&R) Plan needed to be prepared on the basis of findings of the socio-economic survey couples with the outcome of public consultation held. The R&R package shall be prepared after consultation with the representatives of the project affected families and the State Government. The provisions of the R&R plan shall be as per the norms of Right to Fair Compensation Transparency in Land Acquisition and Rehabilitation and Resettlement Act, 2013. Detailed budgetary estimates are to be provided. Resettlements sites should be identified. The plan will also incorporate community development strategies.

vi. Green Belt Development Plan along the periphery of reservoir, approach roads around the colonies and other project components, local plant species must be suggested with physical and financial details. A layout map showing the proposed sites for developing the green belt should be prepared.

vii. Reservoir Rim Treatment Plan for stabilization of land slide/land slip zones if any, around the reservoir periphery is to be prepared based on detailed survey of geology of the reservoir rim area. Suitable engineering and biological measures for treatment of identified slip zones to be suggested with physical and financial schedule. Layout map showing the landslide/landslip zones shall be prepared and appended in the chapter.

viii. Muck Disposal Plan- suitable sites for dumping of excavated material should be identified in consultation with the State Pollution Control Board and Forest Department. All Muck disposal sites should be minimum 30 m away from the HFL of river. The quantity of muck to be generated and the quantity of muck proposed to be utilized shall be calculated in consultation with the project authorities. Details of each dumping site viz. area, capacity, total quantity of muck that can be dumped etc. should be worked out and discussed in the plan. Plan for rehabilitation of muck disposal sites should also be given. The L- section/ cross section of muck disposal sites and approach roads to be given. The plan shall have physical and financial details of the measures proposed. Layout map showing the dumping site vis-à-vis other project components will be prepared and appended in the chapter.

ix. Restoration plan for quarry sites and landscaping of colony areas, working areas, roads, etc. Details of the coarse/fine aggregate/clay etc. required for construction of the project and the rock/clay quarries/river shoal sites identified for the project should be discussed along with the Engineering and Biological measures proposed for their restoration with physical and financial details. Layout map showing quarry sites vis-s-vis other project components, should be prepared.

x. Study of Design Earthquake Parameters: A site specific study of earthquake parameters should be done. Results of the site specific earth quake design parameters should be approval by National Committee of Seismic Design Parameters, Central Water Commission (NCSDP), New Delhi.

xi. Dam Break Analysis and Disaster Management Plan: The outputs of Dam Break Model should be illustrated with appropriate graphs and maps clearly bringing out the impact of Dam break scenario. To identify inundation areas, population and structures likely to be affected due to catastrophic floods in the event of dam failure. DMP will be prepared with the help of Dam Break Analysis. Maximum water level that would be attained at various points on the downstream in case of dam break will be marked on a detailed contour map of the downstream area, to show the extend of inundation. The action plan will include Emergency Action and Management plan including measures like preventive action notification, warning procedure and action plan for co-ordination with various authorities.

xii. Water and Air Quality & Noise Management Plans to be implemented during construction and post-construction periods.

xiii. Public Health Delivery Plan including the provisions for drinking water facility for the local population shall be in the EIA/EMP Report. Status of the existing medical facilities in the project area shall be discussed. Possibilities of strengthening of existing medical facilities, construction of new medical infrastructure etc. will be explored after assessing the need of the labour force and local populace.

xiv. Labour Management Plan for their Health and Safety.

xv. Sanitation and Solid Waste Management Plan for domestic waste from colonies and labour camps etc.

xvi. Local Area Development Plan to be formulated in consultation with the Revenue Officials and Village Panchayats. Appropriate schemes shall be prepared under EMP for the Local Area Development Plan with sufficient financial provisions.

xvii. Environmental safeguards during construction activities including Road Construction.

xviii. Energy Conservation Measures for the work force during construction with physical and financial details. Alternatives will be proposed for the labour force so that the exploitation of the natural resource (wood) for the domestic and commercial use is curbed.

xix. Environmental Monitoring Programme to monitor the mitigatory measures implemented at the project site is required will be prepared. Provision for Environment Management Cell should be made. The plan will spell out the aspects required to be monitored, monitoring indicators/parameters with respect to each aspect and the agency responsible for the monitoring of that particular aspect throughout the project implementation.

xx. A Summary of Cost Estimates for all the plans, cost for implementing all the Environmental Management Plans and CER.

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17

Annexure – 3 : Certificate of Accreditation of Laboratory Engaged

रजिस्ट्री सं० डी० एल०-33004/99 REGD. NO. D. L.-33004/99

भारत का राजपत्र
The Gazette of India

असाधारण

EXTRAORDINARY

भाग II—खण्ड 3—उप-खण्ड (ii)

PART II—Section 3—Sub-section (ii)

प्राधिकार से प्रकाशित

PUBLISHED BY AUTHORITY

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पर्यावरण, वन और जलवायु परिवर्तन मंत्रालय

अधिसूचना

नई दिल्ली, 10 फरवरी, 2017

का.आ. 388(अ).—केन्द्रीय सरकार, पर्यावरण (संरक्षण) नियम, 1986 के नियम 10 के साथ पठित, पर्यावरण (संरक्षण) अधिनियम, 1986 (1986 का 29) की धारा 12 की उपधारा (1) के खंड (ख) और धारा 13 द्वारा प्रदत्त शक्तियों का प्रयोग करते हुए और तत्कालिन भारत सरकार के पर्यावरण और वन मंत्रालय की अधिसूचना सं. का.आ. 1174 (अ), तारीख 18 जुलाई, 2007 में निम्नलिखित और संशोधन करती है, अर्थात् -

उक्त अधिसूचना से संलग्न तालिका में –

(क) क्रम संख्यांक 12, 16, 18, 21, 22, 47, 75, 76, 77, 86, 89, 90.91 और 92 तथा उनसे संबंधित प्रविष्टियों के स्थान पर निम्नलिखित क्रम संख्यांक और प्रविष्टियां रखी जाएंगी, अर्थात् :-

(1)	(2)	(3)	(4)
12	मैसर्स होराईज़न सर्विसेज (एनवायरमेंट एण्ड सेफ्टी) श्री के 9/, एम.एन 10, इनटरनेशनल हाउसिंग सोसाईटी, दीनानाथ मंगेशकर हॉस्पिटल के विपरीत, पुणे 411004, महाराष्ट्र	(1) सुश्री सीमा रघुनाथ आमदार (2) श्रीमती [illegible] सुरवासे (3) सुश्री [illegible] गिरीश जोशी	09.02.2017 से 08.02.2022
16	मैसर्स मिटकान कन्सल्टेन्सी एण्ड इंजीनियर्स प्राइवेट लिमिटेड (एनवायरमेंट मैनेजमेंट एण्ड इंजीनियरिंग डिवीजन), पहला तल, उद्योग प्रौद्योगिकी, कृषि महाविद्यालय परिसर, डी आई सी ऑफिस के पास, शिवाजी नगर, पुणे-411005, महाराष्ट्र	(1) डा. महेश सुखदेव जाधव (2) श्री राहुल लक्ष्मण पाटिल (3) श्रीमती कादंबरी दलीप काटकर	09.02.2017 से 08.02.2022
18	मैसर्स शोभाके रिसर्च फाउंडेशन, प्लाट सं. 338/1,	(1) श्री गिरीश बाबूभाई पटेल (2) श्रीमती निर्मल मुकेश भंडारी	09.02.2017 से

744 GI/2017 (1)

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website
Sd(?)

92	M/s Environmental Health and Safety Research and Development Centre (EHSRDC) No. 13/2, 1st Main Road, Near Fire Station, Industrial Town, Rajajinagar, Bangalore-560010, Karnataka.	(i) Mr. Shivanand M. Dambal (ii) Ms. Sindhu Kumari (ii) Ms. Praveena Kumari H.N.	09.02.2017 to 08.02.2022

(ii) after serial number 143 and the entries relating thereto, the following serial numbers and entries shall be inserted, namely:-

144	M/s Green Envirosafe Engineers and Consultant Pvt. Ltd Gat No. 1405/06, Mayuri Residency, Office No. 16, 2nd Floor, Sanswadi, Pune-Nagpur Highway, Tal-Shirur, Pune-412208, Maharashtra.	(i) Dr. Satish Damodar Kulkarni (ii) Dr. Ayodhya Kshirsagar (iii) Mr. Vinod Prataprao Hande	09.02.2017 to 08.02.2022
145	M/s Siddhi Green Excellence Private Limited Kamal Arcade, Shop No.3, Commercial Plot No.C-3/3, Near State Bank of India, G.I.D.C Ankleshwar-393002, Gujarat	(i) Dr. Vinod Kumar Brijmohan Gaur (ii) Mr. Purvesh Mahendra Bhai Shah (iii) Mrs. Twinkle Hiren Modi	09.02.2017 to 08.02.2022
146	M/s Omega Laboratories S.F. No. 55/5B. Plot No.10, Near Collector Office, Thiruchengodu, Main Road, Namakkal-637003, Tamil Nadu.	(i) Dr. S. Palaniappan (ii) Mr. N. Kandasamy (iii) Mr. U. Manimaran	09.02.2017 to 08.02.2022
147	Environmental Testing Laboratory M/s ENPRO Enviro Tech and Engineers Pvt. Ltd. D/29/16, Road No.17 Hojiwala Industrial State, Gate No.3, , Surat-394230, Gujarat.	(i) Mr. Paresh Mevawala (ii) Dr. Dhaval Naik (iii) Ms. Shehenaz Jadeja	09.02.2017 to 08.02.2022
148	M/s MATS India Private Limited (Laboratory Service Division). 1A & 1B Perumal Koil Street, Nerkundram, Chennai-600107.	(i) Ms. V. Sri Priya (ii) Shri. P. Prabakaran (iii) Shri V. Rambabu	09.02.2017 to 08.02.2022
149	M/s LP Test & Research Centre 4/54, Site IV Sahibabad Industrial area Ghaziabad, U.P.-201010	(i) Mr. Dushyant Tyagi (ii) Ms. Anju Jain (iii) Ms. Himani Shrotriya	09.02.2017 to 08.02.2022
150	M/s TUV SUD South Asia Pvt. Ltd. No.11 & 13, 1st & 4th Floor, Origin Tower, Type-2, Dr. VSI Estate , Thiruvanmiyur, Chennai-600041, Tamil Nadu.	(i) Mr. Muthukumar V. (ii) Dr. S. Daniel Wesley (iii) Ms. Shilpi Kohli	09.02.2017 to 08.02.2022
151	M/s FICCI Research & Analysis Centre Plot No.2A, Sector-8, Dwarka, New Delhi-110077.	(i) Mr. Jasjit Singh Sandhu (ii) Mr. Surender Kumar Manocha (iii) Ms. Anita Singh	09.02.2017 to 08.02.2022
152	M/s Excellent Enviro Laboratory & Research Centre Plot No. D-52/18, MIDC Area, Waluj Aurangabad-431136, Maharashtra	(i) Mr. Sakharam Tumadu Patil (ii) Mr. Shashank Trimbak Pedram (iii) Ms. Kavita Sadanand Promallu	09.02.2017 to 08.02.2022
153	M/s Enviro Lab S-2 & S-3, Phase-II, RIICO Industrial Area, Bhiwadi, Alwar-301019, Rajasthan.	(i) Mr. Afaq Ahmed (ii) Mr. Nitin Kumar (iii) Mr. Girdhari Lal Yadav	09.02.2017 to 08.02.2022

National Accreditation Board for Testing and Calibration Laboratories

(A Constituent Board of Quality Council of India)

NABL

QCI

CERTIFICATE OF ACCREDITATION

J.P. TEST & RESEARCH CENTRE

has been assessed and accredited in accordance with the standard

ISO/IEC 17025:2005

"General Requirements for the Competence of Testing & Calibration Laboratories"

for its facilities at

4/54, Site IV, Sahibabad Industrial Area, Sahibabad, Ghaziabad, Uttar Pradesh

in the field of

TESTING

Certificate Number TC-8047 *(in lieu of T-4182 & T-4181)*

Issue Date 10/10/2018 **Valid Until** 09/10/2020

This certificate remains valid for the Scope of Accreditation as specified in the annexure subject to continued satisfactory compliance to the above standard & the relevant requirements of NABL.

(To see the scope of accreditation of this laboratory, you may also visit NABL website www.nabl-india.org)

Signed for and on behalf of NABL

89076970100030002320

Anil Relia

Chief Executive Officer

NABL

National Accreditation Board for Testing and Calibration Laboratories

(An Autonomous Body under Department of Science & Technology, Govt. of India)

CERTIFICATE OF ACCREDITATION

J.P. TEST & RESEARCH CENTRE

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"General Requirements for the Competence of Testing & Calibration Laboratories"

for its facilities at

4/54, Site IV, Sahibabad Industrial Area, Sahibabad, Ghaziabad, Uttar Pradesh

in the discipline of

BIOLOGICAL TESTING

(To see the scope of accreditation of this laboratory, you may also visit NABL website www.nabl-india.org)

Certificate Number T-4182

Issue Date 10/10/2016

Valid Until 09/10/2018

This certificate remains valid for the Scope of Accreditation as specified in the annexure subject to continued satisfactory compliance to the above standard & the additional requirements of NABL.

Signed for and on behalf of NABL

N. Venkateswaran Program Manager	Anil Relia Director	Prof. S. K. Joshi Chairman

Annexure – 4 : CMPDI Report

Empowering India • Nurturing Nature • Enabling Life

कोल इण्डिया Coal India

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A Mini Ratna Company

REPORT ON CONTROLLED BLASTING STUDY AT FACE-7/8 RONGNICHU HEP, MBPCL, SIKKIM (JOB NO. 281013144)

MARCH, 2014

BLASTING CELL

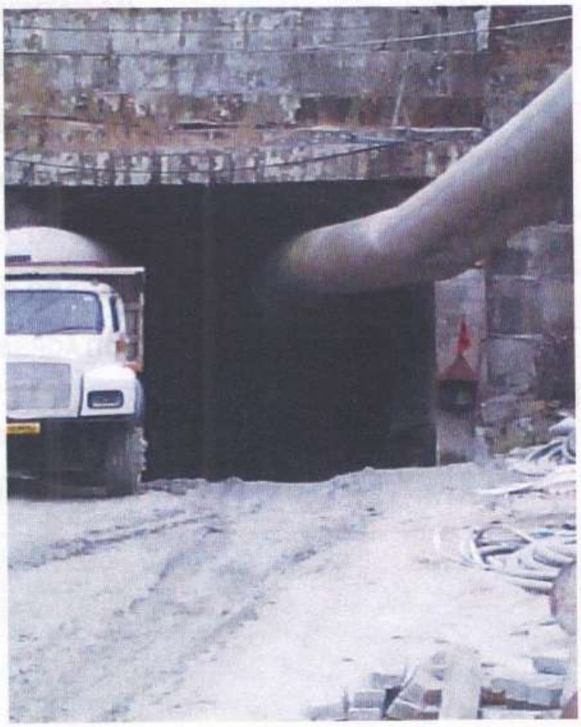
CENTRAL MINE PLANNING & DESIGN INSTITUTE LIMITED

GONDWANA PLACE, KANKE ROAD

RANCHI-834008

RESTRICTED CIRCULATION

REPORT ON CONTROLLED BLASTING STUDY AT FACE-7/8 RONGNICHU HEP, MBPCL, SIKKIM (JOB NO. 281013144)



MARCH, 2014

BLASTING CELL

CENTRAL MINE PLANNING & DESIGN INSTITUTE LIMITED

GONDWANA PLACE, KANKE ROAD

RANCHI-834008

REPORT ON CONTROLLED BLASTING STUDY AT FACE-6 RONGNICHU HYDRO ELECTRIC PROJECT, MBPCL SIKKIM

1.0 INTRODUCTION

At the request of the CEO-CUM-Director Madhya Bharat Power Corpn. Ltd. vide work order no. MBPCL/F-31/2013/WO-473,dated 13.01.2014 a study was undertaken by Blasting Cell of CMPDI (HQ) to assess the effects of blast induced ground vibration generated by the Face - 6 blasting of the Head Race Tunnel (HRT) being excavated by MBPCL, on the residential structures of nearby Middle Sumin villages.

Background of the study was that when the inhabitants of Middle Sumin village came to know that a Tunnel is being constructed beneath their village and it will cross the village soon, they apprehended that their residence might be affected by blast vibration and the entire Middle Sumin village may sink. They became annoyed and stopped the excavation of tunnel blasting and lodged complain to District Collector (East Sikkim). Tunneling job of Adit 2 face 6 was stopped from July 2013. On September 2013, the District Collector (East) instructed MBPCL to comply the suggestion made by Home Department, Government of Sikkim where it was mention that Design of optimum blasting pattern and a system of vibration measurement at crucial habituated places/other crucial areas may be done by employing specialised agencies like CMPDI/CIMFR/any other suitable reputed Government agency.
Accordingly MBPCL engaged Blasting Cell of CMPDI (HQ). The CMPDI team reached Gangtok on 03.02.2014 and the District Collector has given permission to resume the Tunneling job to plan & design the blasting pattern so as to reduce noise & vibration to avoid damage to the residential house nearby.

2.0 OBJECTIVES

2.1 To establish site-specific maximum explosive charge per delay and distance relationship through on site measurement of vibration levels, so that prediction of safe explosive charge may be made for different distances.

2.2 To establish a suitable blast design for the safe extension of face-6 Rongnichu HEP,MBPCL,SIKKIM and to achieved minimum over break keeping the ground vibration within permissible limit to protect the nearby villages/hutments or dwellings..

3.0 SCOPE OF WORK

The scope of work includes:

3.1 Study of Tunnel plans, Tunnel site, geology, surface structures and their distances from the blast point, fixing of stations and setting of geophones in consultation with the officials of MBPCL.

3.2 Recording of ground vibration by vibration monitors.

3.3 Analysis of blast data and design of blast parameter for safe blasting of nearby villages/hutments or dwellings not belonging to MBPCL.

3.4 To observe the reasons of over break and suggestions for its reduction.

4.0 DETAILS OF BLASTING SITE

4.1 LOCATION

Rongichu HEP, MBPCL, SIKKIM is located in East Sikkim district in the state of Sikkim. The project is situated at a distance of approx. 12 km from Gangtok. The nearest railway station is New jalpaguri WB situated at a distance of approx. 103 km from the project.

4.2 PROJECT LOCATION

The project is situated at East Sikkim district of Sikkim on Rongni Chu River and spread from village Namli near Ranipool(Barrage Site, E=657320.354,N=3017111.363) to Kumrek near Rangpo(Power House Site, E=652136.338,N=3007251.956) with 12.5km long Head Race Tunnel(HRT) and 4nos. of Adits to expedite HRT excavation.

Location of concerned Area: The main concerned area for the blasting experiment was Face-6 of HRT which is accessible from Adit-2(E=652076.6798, N=3014680.336) and located at village Sumin. The main study area was limited for 17m stretch of tunnel of Face-6 located between E=652076.680, N=3014680.336 to

E=652305.9513, N=3013988.4119. The elevation of the crown of the experimental stretch of the tunnel is 712.85m and the surface level is in between 1038m to 1040m with total top cover ranging between 325m to 327m.

4.3 TOPOGRAPHY

The project area comprises of hilly terrain characterized by high ridges, steep to moderately steep slopes. The area around the project forms the southern slope of an east-west aligned ridge forming a part of eastern flank of the Sikkim Himalayas. The area is drained by tributaries of Teesta River,namely, Rongni Chu and Rangpo Chu with few nallas. The HRT is passing under a hilly terrain with maximum elevation of 1775 m at peak and minimum elevation of 750m at nala (HRT have already completed successfully in these areas).

The HRT of Face-6 passing through a hill ranging its surface elevation from 1775m. to 805m.

4.4 GEOLOGY

The Rongni Chu Hydro Electric project is located in the Gorubathan Formation of the Daling Group of rock comprise of quartz-chlorite-sericite schists, phyllites and quartzites. Rocks are thinly foliated and 3sets of discontinuities have been traced within the project area. Numbers of shear seam have intersected the rocks of the entire project area for which rocks became fractured and powdered in several areas. The rocks of the project area are mainly soft to moderately strong with occasional hard rock ranging its Uni-axial Compressive Strength between 25-50 MPa.

4.5 INVESTIGATION OF THE FACE AND SURFACE STRUCTURES

The Tunnel face was inspected carefully. It is a horse shoe shaped Tunnel. It is 4.8m wide 4.5m height at the top of the crown. The rock at the face is quite competent. It is class II/III; Bienewaski. Wedge cut drilling with 45mm dia. Drill bit is being practiced.

Number of holes varies from 40 to 52 depending upon immediate geology of the rock. Powergel 801 explosive of 32 to 40mm dia. cartridges are being used. About 2m progress is being achieved per round of blast.

The surface structures of middle Sumin village were inspected. The houses are mostly of timber and masonry with roof made up with CGI sheets and sometimes with RCC framed structures. Some of the buildings were affected by the earthquake, which shook Sikkim in the year 2011.

5.0 INSTRUMENTATION

Blast induced ground vibration at Middle Sumin village, were measured by two (2) nos. of Minimate Plus vibration monitors. These instruments are microprocessor-based unit having tri-axial transducers. It measures Peak Particle Velocity (PPV) in three mutually perpendicular directions, i.e. longitudinal, transverse and vertical along with respective frequencies.

6.0 EXPERIMENTATION

Details of the blast monitored Over Face -6 of Adit - II are summarized below:

Details of Blast

No. of rounds	:	10
No. of observations	:	33
Dia of drill holes (mm)	:	45
Depth of holes(m)	:	1.5 - 2.0
Maximum charge/delay (kg)	:	1.2 - 12.48
Maximum charge/round (kg)	:	21.84 - 55.0

Adequate care was taken in respect of blast design, proper use of explosives, length of stemming column and delay settings to minimizing the level of ground vibration. Electrical detonators from delay no 1 to 10 were used.

The instruments were fixed on the surface of the tunnel at a radial distance of 303.88 m to 411.39 m from the blast point where the levels of ground vibration were recorded.

The details of each trial blast, blast geometry, explosive charge distribution, sequence of delay etc. are shown in the enclosed Annexure 1 to 10 and summarized statement of the levels of PPV and frequency recorded during trial period and its distances from blast point are shown in Table-1.

7.0 ANALYSIS OF VIBRATION DATA

The blast sites were fixed in consultation with officials of MBPCL at a radial distance of 303.88 m to 411.39 m on the surface of tunnel alignment of middle sumin village in & around the villages/hutments or dwellings not belonging to the owner of the MBPCL. The Panchayat and the villagers were present besides the IRB 3 Guards deployed by the Police Department of Government of Sikkim during the measurement of the readings. The data obtained from these observations were recorded by two nos. of Instantel-make Minimate plus vibration monitors and data analysis was carried out by a computer software package for deriving the site-specific propagation equation.

During trial period total 10 blasts were taken in the Tunnel and 33 observations were recorded at different distances from blast site.

The PPV (V), maximum explosive charge/delay (Q), and the distance (D) between blasting site and vibration monitoring stations were grouped together, and by least mean cube root method of regression analysis, a propagation equation valid for the site i.e. site specific propagation equation, has been established in the form of a Cube Root Scaled Distance formula as given below:

$$\mathbf{V = K\,(D/\,Q^{1/3})^{-A}}$$

Where, V= Peak particle velocity in mm/sec.

Q = Maximum explosive charge per delay in kg.

D = Distance from point of observation to the blasting site in m, and

K & A = regression co-efficient

After statically analysis of blast data including maximum charge in any delay and distance of observation station from blast site. It has been obserbed that due to small quantity of charge compared to larger distance, the PPV depend more on the geology of transmitting media than on the quantity of explosive used or radial distance of dwelling houses/hutments from the blast site.

8.0 DAMAGE CRITERIA

8.1 The peak particle velocity is a good indicator of the probability of damage to a structure. It is expressed in mm/sec. The peak particle velocity at any point depends mainly on the amount or charge exploded distance from the shot point to the station of observation and the local geological condition.

8.2 Accordion to Indian standard Bulletin no. 6922 of 1973 (Reprinted April, 11 1982 on Para 4.1.1.1 and 4.1.1.2), in order to provide adequate safety, the peak particle velocity need not exceed the following limits:

Sl. No.		Velocity from Impartial relation (mm/sec.)	Velocity monitored by suitable instrument (mm/sec.)
1.	Soil weathered or soft rock	50 mm/sec.	70 mm/sec.
2.	Hard rock	70 mm/sec.	100 mm/sec.

8.3 The Table below shows an interesting compression between the vibration level of terrain or rock on which a structure is built. It is based on the work of U. Lingerers and B.K. Krinostrom.

		Peak particle velocity (inches/sec.)		
Sl. No.	Damage Effect	Sand gravel, clay below water level C-3000-5000 ft./sec.	Moraine sales or soft lime stone C-6000-10000 (ft/sec.)	Granites hard lime stone or debase C-15000 to 20000 ft/ sec.
1.	No. notification crack formation	0.71	1.4	2.8
2.	Fine crack & falling of plaster	1.2	2.2	4.3
3.	Threshold crack formation	1.6	3.2	6.3
4.	Severe crack	2.4	4.5	9.1

* Propagation velocity in media is given by 'C'.

8.4 As per OSMRE (Office of the Surface Mining, Reclamation and enforcement, US Dept. of Interior), the maximum peak particle velocity shall not exceed the following limits.

At the location for any dwelling, public building outside the permit area.

Distance (D) from blasting site		Max. allocable Peak particle velocity (y max.) for ground vibration	
In ft.	In m.	Ins/sec.	mm/sec.
0-300	0-90	1.25	31.25
301-5000	90-1500	1.00	25.00
5001 and beyond	1500 and beyond	0.75	18.75

It has been found that ground vibration is dependent on both peak particle velocity and frequency. The maximum damage to buildings due to blasting vibration occurs with blast frequency matches the natural frequency of the buildings. The natural frequency low rise (1-2 storeys) residential structure is in a range of 3 to 12 Hz. These low frequencies are most predominant at greater distances from a blast point and that is the reason for the more restrictive particle velocity limit of 18.75 mm/sec. at a distance beyond 1500 mm from a blast site. At closer distance upto 0 m from a heavy blast higher frequencies (above 40 Hz) predominate the vibration road. These high frequencies above the fundamentals natural frequencies of residential structure allow a higher particle velocity limit of 31.25 mm/sec. and when the ground vibration frequencies are higher than 40 Hz, then the permitted peak particle velocity would be 50 mm/sec. regardless of the distance from the blast.

8.5 As per the latest study by USBM the safe blast vibration level (published in RI-8507 if 1988) are as follows:

Sl. No.	Type of structure	Ground vibration particle velocity mm/sec.	
		At law frequency (less than 40 Hz)	At High frequency (more than 40 Hz)
1.	Modern houses, drywall Interior	18.75	50
2.	Other houses , plaster on wood construction for interior walls	12.50	50

8.6 Therefore the possibility of actual threshold damage is dependent not only on peak particle velocity but also on the frequency of the vibration, type of terrain and the rock upon which the structure stands. It is also dependent on type, height and natural frequency of the structure, the state of repair or disrepair of the structure etc.

However all building eventually develop cracks not only due to vibration but also due to temperature difference at different seasons, difference in environmental conditions and due to ageing.

9.0 THRESHOLD VALUE OF GROUND VIBRATION

The study has been conducted keeping in view the norms set for the threshold value of PPV by DGMS.

As per DGMS Circular No.7 dated 29.8.97, depending on the type of structures and the dominant excitation frequency, the peak particle velocity (PPV) on the ground adjacent to structures should not exceed the values given in the following table.

Permissible peak particle velocity (PPV) at the foundation level of structures in mining area is in mm/sec:

	TYPE OF STRUCTURES	DOMINANT EXCITATION FREQUENCY (Hz)		
		< 8 Hz	8-25 Hz	> 25 Hz
(A)	**Building/structures not belonging to owner**			
	(i) Domestic houses/structures (Kuchcha, Brick in cement).	**5**	**10**	**15**
	(ii) Industrial building (RCC) framed structures	**10**	**20**	**25**
	(iii) Object of historical importance and sensitive structures.	**2**	**5**	**10**
(B)	**Building belonging to owner with limited span of life**			
	(i)domestic houses/structures (Kuchcha, Brick in cement)	**10**	**15**	**25**
	(ii) Industrial building (RCC) framed structures	**15**	**25**	**50**

THRESHOLD VALUE OF GROUND VIBRATION FOR DIFFERENT COUNTRIES/RESEARCHERS

1. **DGMS prescribed permissible limit of ground vibration (INDIA)**

Type of structures	Dominant excitation frequency, Hz		
	< 8Hz	8-25Hz	>25Hz
(A) Buildings/structures not belong to the owner			
1. Domestic houses/structures (Kuchcha, bricks & Cement)	5	10	15
2. Industrial building	10	20	25
	2	5	10
3. Objects of historical importance & sensitive Structures			
(B) Buildings belonging to the owner with limited span of life			
1. Domestic houses/structures	10	15	20
2. Industrial buildings	15	25	50

2. After Indian Standard Institution (1973)

Soil, weathered or soft conditions	70 mm/s
Hard rock conditions	100 mm/s

3. After CMRI Standard (Dhar et al, 1993)

Type of structures	PPV(mm/s)	
	<24 Hz	>24 Hz
Domestic houses, dry well interior, construction Structures with plasters, bridge	5.0	10.0
Industrial buildings, steel or reinforced concrete structures	12.5	25.5
Object of historical importance, very sensitive Structures, more than 50 years old construction and Structures in poor state condition	2.0	5.0

4. After Australian Standard (As A-2183) (Just and Chitombo,1987)

Type of structures	Ground ppv (mm/s
Historical building and monuments and buildings of special value	2
Houses and low rise residential buildings, commercial buildings not Included below	10
Commercial buildings and industrial buildings or structures of reinforced Concrete or steel construction	25

5. After Australian Standard (Ca-23-2183) (Just and Chitombo, 1987)

Types of structures	Ground ppv (mm/s)
Historical buildings and monuments and buildings of Special value	0.2 mm displacement for frequencies less than 15 Hz
Houses and low rise residential buildings, commercial Buildings not included below	19 mm/s resultant PPV for frequencies greater than 15 Hz
Commercial buildings and industrial buildings or Structures of reinforced concrete or steel construction	0.2 mm maximum displacement correspond to 12.5 mm/s PPV at 10 Hz and 6.25 mm/s at 5 Hz

6. After Hungarian Standard

Type of structures	Permissible limit (mm/s)
Construction demanding special protection, military, telephones, Airport, dams, bridges which have length of more then 20 m	Extra opinion from expert
Statistically not solid damaged construction, temples, monuments, Oil and gas wells and upto 0.17 Mpa and below 0.7 Mpa pressure In pipes (oil and gas)	2
Panel houses and statistically not fully determined structures	5
Statistically good condition structures, towers, electrical apparatus, water plant	10
RCC and structures concrete, tunnels, canals and other pipe lines Beneath the soil surface greater than 0.7m, opening the sublevel	20
Public road, railway and electrical lines, telephone lines ropeway	50

7. After USSR Standard

Type of structures	Allowable PPV (mm/s)	
	Repeated	One fold
Hospitals	8	30
Large panel residential buildings and children,s institution	15	30
Residential and public buildings of all type except large panels, Office and industrial buildings having deformations, boiler rooms And high brick chimneys	30	60
Office and industrial buildings, high reinforced concrete pipes, Railway and water tunnels, traffic flyovers, saturated sandy slopes	60	120
Single storage skeleton type industrial buildings, metal and block Reinforced concrete structures, soil slopes which are part primary Structures, primary mine openings(service life upto 10 years) pit bottom, main entries, drifts	120	240
Secondary mine openings (service life upto 3 years) haulages and drifts	240	480

8. After Swiss Standard

Type of structures	Frequency Band width [Hz]	Blast induced PPV [mm/s]	Traffic/machine induced PPV [mm/s]
Steel or reinforced structures such as factories, retaining walls, bridges, steel towers, open channels, underground tunnels and chambers	10-60	30	-
	60-90	30-40	-
	10-30	-	12
	30-60	-	12-18
Buildings with foundation walls and floor in concrete, well in concrete or masonry, underground chambers and tunnels with masonry linings	10-60	18	-
	60-90	18-25	-
	10-30	-	8
	30-60	-	8-12
Building with masonry walls and wooden ceilings	10-60	12	-
	60-90	12-18	-
	10-30	-	5
	30-60	-	5-8
Objects of historic interest or other sensitive structures	10-60	8	-
	60-90	8-12	-
	10-30	-	3

9. After Siskind et al., 1980

Type of structures	PPV (mm/s)	
	Frequency (< 40 Hz)	Frequency (> 40 Hz)
Modern homes, dry wall interior	18.75	50
Older homes, plaster on wood lath construction	12.5	50

10. After Sweden Standard (after Pesson et al., 1980)

Type of Structures	Limiting vibration parameters		
	Amplitude (mm)	Velocity (mm/s)	Acceleration (mm/s^2)
Concrete bunker steel-reinforced	-	200	-
High rise apartment block-modern concrete of steel frame design	0.4	100	-
Underground rock cavern roof hard rock, span 15-18 m	-	70-100	-
Normal block of flat-brick or equivalent walls	-	70	-
Light concrete buildings	-	35	-
Swedish National Museums-Building structures	-	25	-
Swedish National Museums-Sensitive exhibits	-	-	5
Computer centre	0.1	-	2.5
Circuit breaker control room	-	-	0.5-2.0

11. Blast damage criteria for mass concrete (Tennessee Valley Authority and Distance factor given by Oriard,2002)

Concrete age from Batching	Allowable Particle velocity In/s (mm/s)	Definition of Distance Factor		
		Distance Factor	Distance From Blast (ft)	Distance From Blast (m)
0-4 hrs.	4 (100) x D.F.	-		
4 hrs. – 1 day	6 (150) x D.F.	1.0	0-50	0-15
1 to 3 days	9 (225) x D.F.	0.8	50-150	15-46
3 to 7 days	12 (300) x D.F.	0.7	150-250	46-76
7 to 10 days	5 (375) x D.F.	0.6	250 +	76 +
10 days or more	20 (500) x D.F.	-		

12. After German DIN Standard 4150 (1986)

Type of Structures	Peak particle velocity (mm/s) at foundation		
	< 10 Hz	10-50 Hz	50-100 Hz
Offices and industrial premises	20	20-40	40-50
Domestic houses and similar constructions	5	5-15	15-20
Buildings that do not come under the above because of their sensitivity	3	3-8	8-10

13. Summary of residential criteria (After Oriard, 2002)

RANGE OF COMMON RESIDENTAL CRITERIA AND EFFECTS	
0.5 in/s (12.7 mm/s)	Bureau of mines recommended guideline for plaster-on-lath construction near surface (long-term, large-scale blasting operations, low frequency vibrations) RI-8507
0.75 in/s (19.1mm/s)	Bureau of mines recommended guideline for sheet rock construction near surface mines. (RI-8507)
1.0 in/s (25.4mm/s)	OMS regulatory limits fir residences near surface mine operations at distances of 301-5000ft. (long-term, large-scale blasting)
2.0 in/s (50.8 mm/s)	Widely accepted limit for residences near construction blasting and quarry blasting.(Bu Min Bulletin 656, RI 8507, various codes, specifications and regulations). Also allowed by OSM for frequencies above 30Hz.
5.4 in/s (137.0 mm/s)	Minor damage to the average house subjected to quarry blasting vibrations. (Bu Min Bulletin 656).
5.4 in/s (229.0 mm/s)	About 90% probability of minor damage from construction or quarrying blasting. Structural damages to some houses. Depends on vibration sources, character of the vibrations and the house.
20 in/s (500.8 mm/s)	For closed-in construction blasting, minor damage to nearly all houses, structural damage to some. A few may escape damage entirely. For low-frequency vibrations, major damage to most houses.
Note: The criteria shown in this table apply only to residences, not to any other structures, facilities or materials.	

14. After Langefors et al. (1958)

No damage	<50 mm/s
Fine cracking	100 mm/s
Cracks	150 mm/s
Serious crack	225 mm/s

15. After Edwards and Northwood (1960)

Safe zone	<50 mm/s
Damage zone	100-150mm/s

16. After Duval and Fogelson (1962)

Major damage (95%)	50 mm/s

17. After Nichols et al. (1971)

Safe zone (95%)	<50 mm/s
Danger zone	> 50 mm/s

18. Ground Vibration Effects Summary (David Siskind, 2000: Vibration from Blasting International Society of Explosives Engineers)

PPV (in/s)	PPV (mm/s)	Vibration Effects
0.001	0.0254	Quiet background
0.01	0.254	Threshold of human perception for steady-state Vibration (physical)
0.03	0.762	Traffic at 50 ft (16 m)
0.03	0.762	Noticeable houses rattling and response from vibration
0.06	1.524	Threshold of human perception for transient vibration (physical)
0.10	2.54	Truck traffic on bumpy road at 50 feet (16 m)
0.18-0.32	4.572-8.128	Train at 20 feet
0.30	7.62	Pavement breaker at 30 feet
0.50	12.70	Lowest threshold for plaster creak extension in house
0.50	12.70	Lowest USBM safe vibration criteria (USBM RI-8507, for low frequencies)
0.50	12.70	Typical household environment from inside activities and natural forces of wind, temperature and humidity
0.70	17.78	ANSI limit for human comfort: steady state vibration (S-3.18-1979)
0.75	19.05	Strictest federal to protect homes from cosmetic cracking from surface coal mine blasts (OSM, for distances >5,000ft)
0.79	20.066	Lowest level for an observed crack extension in wallboard (RI8507)
1.00	25.40	Federal limit to protect homes from cosmetic cracking from surface coal mine blasts (OMS, for distances of 301 to 5,000ft)
1.20	30.48	Response of house superstructure from 62-mph wind (BOCAcode, 10 psf)
1.25	31.75	Federal limit to protect homes from cosmetic cracking from surface coal mine blasts (OMS, for distance < 300 ft)
2.00	50.80	USBM recommendation for safe blasting from 1962 and 1971 (RI 5968 and B 656)
2.00	50.80	Most state,s limit for protecting homes from blasting
2.00	50.80	Safe-level criteria for cosmetic cracking in homes from high-frequency blasts, such as construction (USBM RI 8507)
2.00	50.80	ANSI limit for human health: Steady state vibration (S-3.18-1979)

2.00	50.80	Highest vibrations generated inside homes by walking, jumping , slamming doors, etc.
4.00	101.6	ANSI limit for human health: steady-state vibration (S-3. 18)
5.00	127.0	Vibration tolerance for buried utilities including wells and pipelines
5.00	127.0	Lowest vibration for masonry vibration cracking from blasting
10.0	254.0	Threshold for cracking of mass concrete
12.0	304.8	Damage threshold for underground works

19. After Rosenthal and Morlock (1983)

Distance from blasting site [m]	Maximum allowable ppv [mm/s]
0 to 91.4	37.75
91.4 to 1524.0	25.40
1524 and above	19.05

10.0 CONTROL OF OVERBREAK

The geology i.e. foliation, hardness etc. of the rock strata of Himalayan region changes within a couple of yards and so it is hardly possible to suggest a fixed pattern of blast to minimize the over-break. The geologists working at that place should judge the quality of rock before drilling and should take proper decisions for drilling pattern for that day. To reduce over-break following points may be considered which are in chronological order from hard rock to soft rock condition.

10.1 Low VOD and Low density explosives are to be used at crown holes. Otherwise alternate holes will be left uncharged.

10.2. Decoupling to be done between explosive cartridges and the skin of shot holes when alternate holes to be charged i.e. in a 45mm dia. shot hole 25mm dia. explosive cartridges to be used.

10.3. Use spacers between the cartridges of charged holes at the crown and reduce explosive quantity at the holes of the crown.

10.4. Use only one explosives cartridge with two numbers 40 gram/meter Detonating Fuse (Cortex etc.) at all holes of the crown

10.5. Use point 4 at alternate holes of crown.

10.6. Closely spaced 24cm to 28 cm holes to drill at the crown and left them uncharged.

10.7. Even above points may be repeated at the crown of last but one ring if required.

11.0 TRANING OF TUNNEL OFFICIALS

The officials of MBPCL are well trained in drilling and blasting. They should know to take blast vibration readings. However, adequate training was imparted to the blasting personnel who were continuously associated with blasting operations during the period of design of blast to the final observation of the blast. They have picked up the technique of controlled blasting as applicable to prevailing condition at face-6 Rongnichu HEP, MBPCL.

12.0 RECOMMENDATIONS

12.1 As the residential structures of the village at Middle Sumin are on the inclined surface of the hill and the foundations are not on very stable ground the structures may be considered a sensitive structure. After going through the threshold limit of vibration recommended by different countries it may be observed that for frequency related PPV, the recommendation made by DGMS, INDIA is more stringent where the recommended PPV (where frequency is 8-25 Hz) is 5 mm/sec and that for higher frequency (>25 Hz) is 10 mm/sec. During trial period, almost all the dominating frequencies are more than 25 Hz for which threshold value of PPV is 10 mm/sec. However, in this case, the statistical analysis shows that the vibration is not only dependent on maximum explosive charge / delay and distance of the observation station but depends on the geology of the transmitting media. **Hence, the threshold PPV may be taken as 2mm/sec.**

12.2 From the on-site measurements of Peak Particle Velocity (PPV) and analysis of data of trial blasts at the village of Middle Sumin, under the existing geo-mining conditions, it may be recommended that the workings of face-6, Adit 2 Rongnichu can be extended with a maximum explosive charge of any delay of 12.48 kg, that is the total explosive of 55 kg the blast of 10 delay can be used with other established blasting parameters.

12.3 These recommendations should be followed to prevent damage of dwelling houses/hutment in Middle Sumin Village area shall occur as demonstrated to the house owners & public during the experimental blasts taken.

12.4 Moist sand should be used as stemming material.

12.5 The day to day blasting operations shall be recorded in a bound paged book showing the blast parameters, e.g. charge/hole, charge/delay, charge/round, PPV observed with Dominating frequency, Location of Geophone etc, and should be countersigned by the Tunnel Manager.

12.6 The Tunnel Manager shall fix the blasting time and it should be circulated to all concerned officials and displayed on the notice board. Blasting should be done in day-light only.

12.7 The Management of Adit - II should ensure from time to time that recommendations of controlled blasting as outlined in this report are strictly followed.

S. MUKHERJEE **Chief Manager (M)** **Blasting cell CMPDI (HQ), Ranchi**	**P.K.SINGH** **Manager (M)** **Blasting cell CMPDI (HQ), Ranchi**
S. MEHTA **Sr. Manager (E)** **Blasting cell CMPDI (HQ), Ranchi**	**P.JAISWAL** **Asst. Manager (M)** **Blasting cell CMPDI (HQ), Ranchi**

TABLE - 1

Geophone Locations with respect to Blasts at HRT Face-6 and Vibration recorded at Middle Sumin Area.

BLAST NO.	DATE	FACE R.D (m)	Explosive Qty. (kg)	GEO PHONE NOS.	Location of Geophone						PPV.(mm/sec)
					NAME OF HOUSE OWNER	Surface Elevation (m)	Lateral distance from blasting face. (m)	Vertical distance from blasting face (m)	Inclined distance from blasting face. (m)	Dominant Frequency HZ	
1	05.02.2014	326	21.84	(1) (2) (3)	Near PHC Quarter	1034.01	75.454	321.38	330.118	66.1	1) 0.19mm/sec, 2) & 3) <0.13mm/sec
2	06.02.2014	327.5	35.0	(1) (2) (3)	Near PHC Quarter	1034.01	76.952	321.38	330.464	17.8 78.9 2.7	1)0.103mm/sec, 2) 0.464mm/sec 3) 0.150mm/sec
3	08.02.2014	329.5	38.0	(1)	Mr. Chejang Bhutia	1006	212.374	293.37	362.172	2.19 23.9	>0.13mm/sec 0.230mm/sec
				(2)	foothpath just above road near house of Mr. Chejang Bhutia	998.63	241.403	286.0	374.261	104	0.284mm/sec
				(3)	Near new Building (CMRHM) below road	994.6	267.276	281.97	388.514	40.9	0.189mm/sec
4	09.02.2014	331	40.0	(1)	Miss Doma Bhutia	989	172.260	276.37	325.659	40.8 95.1	0.637mm/sec 0.554mm/sec
				(2)	footpath just above road near house of Mr. Chejang Bhutia	998.63	239.903	286.0	373.295	60.1	0.186mm/sec
				(3)	Near new Building (CMRHM) below road	990	265.961	277.37	384.277		<0.13mm/sec

5	11.02.2014	333	45.0	(1)	Mr. Leda sir & Karma Tempo Bhutia	989	242.434	276.37	367.633	16.3	0.390mm/sec
				(2)	Mr.Lobzang Bhutia	985	241.786	272.37	364.205	33.4 2	0.128mm/sec > 0.13mm/sec
				(3)	Mr. Samten Bhutia	978	286.685m	265.37m	390.652m		<0.13mm/sec
6	13.02.2014	335	50.0	(1)	Mr. Karma Hisshey Lama	979.24	312.931m	266.61m	411.104m	96.1	0.172mm/sec
				(2)	In house of Karma Sanam Rinchen	1003	89.630m	290.37m	303.888m	74.2 27.8	0.189mm/sec 0.137mm/sec
				(3)	Infront of Norbu Bhutia house	999	106.858m	286.37m	305.657m	108	0.65mm/sec
7	15.02.2014	337	55.0	(1)	Miss Doma Bhutia	989	166.831m	276.37m	322.820m	113	0.637mm/sec
				(2)	Mr. Ghytso Bhutia	984	193.085m	274.37m	335.500m	72.6	0.237mm/sec
				(3)	Mr. Thinley Bhutia	984	226.569m	271.37m	353.518m		<0.13mm/sec
8	16.02.2014	339	55.0	(1)	Mr.Wongal Bhutia	1045	141.247m	332.37m	361.137m	50.7	0.16mm/sec
				(2)	Mr.Karma Sonam Bhutia	1036	177.815m	323.37m	369.034m	2.13	0.177mm/sec
9	18.02.2014	341	55.0	(1)	Mrs.Chiden Bhutia	1069	112.690m	356.37m	373.762m	2.75	0.176mm/sec
				(2)	Gompa	1089	135.478m	376.37m	400.010m	21.5	0.129mm/sec
				(3)	Mr.Thakpa Bhutia	1091	157.792m	378.37m	409.953m	49.3 46	0.318mm/sec 0.282mm/sec
10	20.02.2014	343m	40.0	(1)	Mr. Tenzing Bhutia	1058	223.525m	345.37m	411.392m	2.25	>0.13mm/sec
				(2)	Gompa	1089	135.405m	376.37m	392.473m	2.38	0.316mm/sec
				(3)	In PMGSY Road between house's of Mr. Tenzing Bhutia and Mr.Wongal Bhutia	1053.5	1053.5m	340.87m	376.37m	2.06	0.135mm/sec

RECORDIN OF GROUND VIBRATION BY VIBRATION MONITOR NEAR MIDDLE SUMIN

CMPDI

Job No. 281013144 22

ANNEXURE -1

RECORDS OF TRIAL BLASTING AT FACE-6 RONGNICHU HEP, MBPCL, SIKKIM

SI No	PARTICULARS	
1.	DATE	: 05-02-2014
2.	TRIAL NO.	: 01
3.	NATURE OF FORMATION	: soft stone
4.	DIA. OF DRILL HOLES (mm)	: 45
5.	TOTAL NO. OF HOLES BLASTED	: 16
6.	PATTERN OF HOLES	: Wedge cut
a)	HOLE DEPTH (m) AT CROWN & BELOW	: 1.5
b)	HOLE DEPTH (m) AT SPRING LEVEL	: 2.2-2.5
7.	DIAMETER OF TUNNEL (meter)	: 4.5
8.	TYPE OF EXPLOSIVE USED	: Power Gel Capsule
9.	CHARGE PER DELAY (Kg)	: 1.56
10.	MAX. CHARGE/DELAY (Kg)	: 7.8
11.	TOTAL EXPLOSIVE USED PER ROUND (kg)	: 21.84
12.	WEIGHT OF POWER GEL CAPSULE (kg)	: 0.2 & 0.390
13.	LENGTH OF EXPLOSIVE (cm)	: 30
14.	DIAMETER OF EXPLOSIVE (mm)	: 32 & 40
15.	TYPE OF DETONATOR USED	: CED 1 to 10
16.	OBERVATION TAKEN NEAR	: PHC Quarter
17.	DISTANCE FROM OBSERVATION STATION TO BLASTING SITE (meter)	:

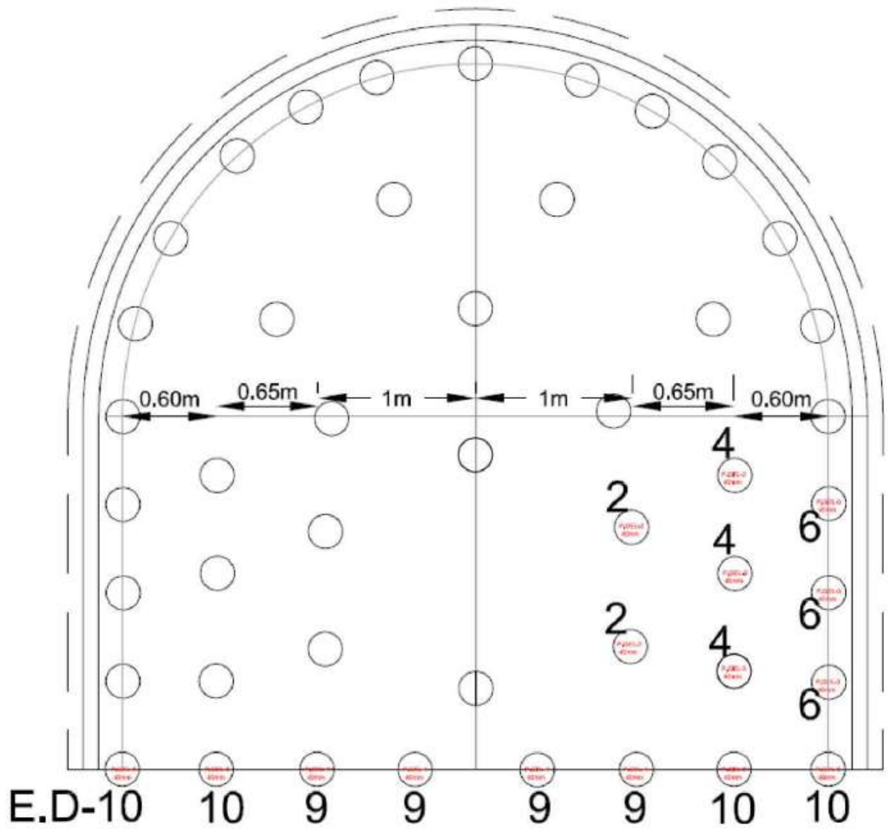
Lateral	vertical	inclined
75.45	321.38	330.118

Contd. Annexure –1

18. OBSERVATION

(a)	FRAGMENTATION	: Good
(b)	THROW	: Within limit
(c)	VIBRATION (IN TERMS OF PEAK PEAK PARTICLE VELOCITY) (mm/sec)	: Stn. A –0.19
(d)	FREQUENCY (Hz)	: Stn. A – 66.1

19. SKETCH SHOWING THE PATTERN OF HOLES, PLACEMENT OF DETONATOR AND SEQUENCE OF DELAY.



ANNEXURE -2

RECORDS OF TRIAL BLASTING AT FACE-6 RONGNICHU HEP, MBPCL, SIKKIM

SI No	PARTICULARS	
1.	DATE	: 06-02-2014
2.	TRIAL NO.	: 02
3.	NATURE OF FORMATION	: soft stone
4.	DIA. OF DRILL HOLES (mm)	: 45
5.	TOTAL NO. OF HOLES BLASTED	: 35
6.	PATTERN OF HOLES	: Wedge cut
a)	HOLE DEPTH (m) AT CROWN & BELOW	: 1.5
b)	HOLE DEPTH (m) AT SPRING LEVEL	: 2.2-2.5
7.	DIAMETER OF TUNNEL (meter)	: 4.5
8.	TYPE OF EXPLOSIVE USED	: Power Gel Capsule
9.	CHARGE PER DELAY (Kg)	: 1.2
10.	MAX. CHARGE/DELAY (Kg)	: 8.58
11.	TOTAL EXPLOSIVE USED PER ROUND (kg)	: 35.0
12.	WEIGHT OF POWER GEL CAPSULE (kg)	: 0.2 & 0.390
13.	LENGTH OF EXPLOSIVE (cm)	: 30
14.	DIAMETER OF EXPLOSIVE (mm)	: 32 & 40
15.	TYPE OF DETONATOR USED	: CED 1 to 10
16.	OBERVATION TAKEN NEAR	: PHC Quarter
17.	DISTANCE FROM OBSERVATION STATION TO BLASTING SITE (meter)	:

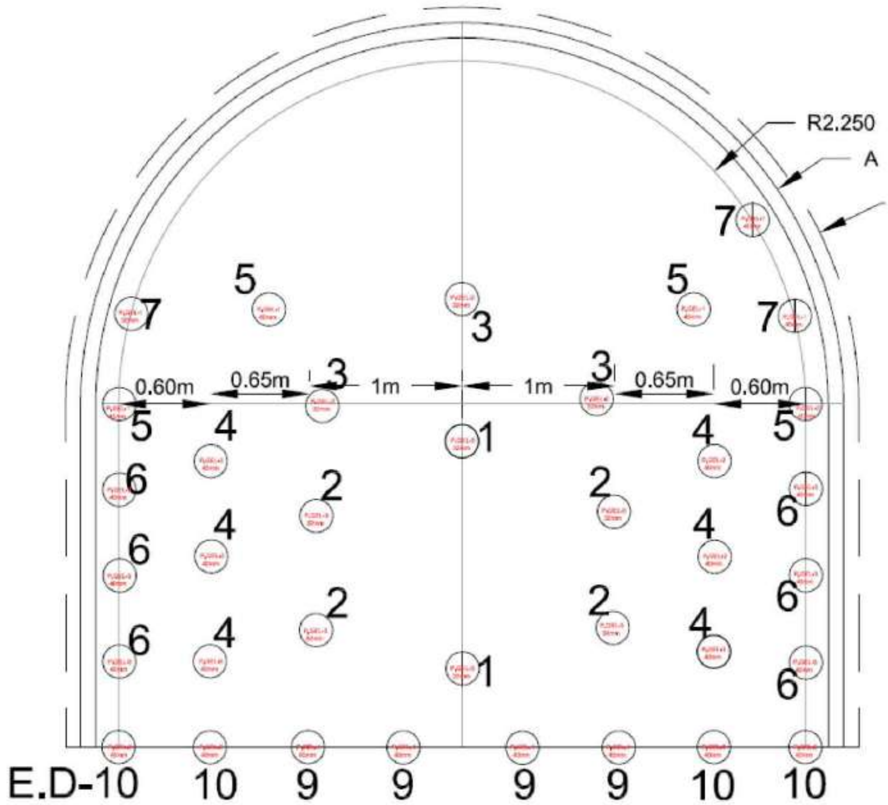
Lateral	vertical	inclined
76.952	321.38	330.464

Contd. Annexure –2

18. OBSERVATION

(a)	FRAGMENTATION	: Good
(b)	THROW	: Within limit
(c)	VIBRATION (IN TERMS OF PEAK PEAK PARTICLE VELOCITY) (mm/sec)	: Stn. A –0.103 : Stn. B –0.181 : Stn. C –0.150
(d)	FREQUENCY (Hz)	: Stn. A – 17.8 : Stn. B – 78.9 : Stn. C –2.74

19. SKETCH SHOWING THE PATTERN OF HOLES, PLACEMENT OF DETONATOR AND SEQUENCE OF DELAY.



ANNEXURE -3

RECORDS OF TRIAL BLASTING AT FACE-6 RONGNICHU HEP, MBPCL, SIKKIM

Sl No	PARTICULARS	
1.	DATE	: 08-02-2014
2.	TRIAL NO.	: 03
3.	NATURE OF FORMATION	: soft stone
4.	DIA. OF DRILL HOLES (mm)	: 45
5.	TOTAL NO. OF HOLES BLASTED	: 35
6.	PATTERN OF HOLES	: Wedge cut
a)	HOLE DEPTH (m) AT CROWN & BELOW	: 1.5
b)	HOLE DEPTH (m) AT SPRING LEVEL	: 2.2-2.5
7.	DIAMETER OF TUNNEL (meter)	: 4.5
8.	TYPE OF EXPLOSIVE USED	: Power Gel Capsule
9.	CHARGE PER DELAY (Kg)	: 1.2
10.	MAX. CHARGE/DELAY (Kg)	: 9.36
11.	TOTAL EXPLOSIVE USED PER ROUND (kg)	: 38.0
12.	WEIGHT OF POWER GEL CAPSULE (kg)	: 0.2 & 0.390
13.	LENGTH OF EXPLOSIVE (cm)	: 30
14.	DIAMETER OF EXPLOSIVE (mm)	: 32 & 40
15.	TYPE OF DETONATOR USED	: CED 1 to 10
16.	OBERVATION TAKEN NEAR	: 1. Mr. Chejang Bhutia 2. Footpath near house of Mr. Chejang Bhutia 3. near CMRHM building

17. DISTANCE FROM OBSERVATION STATION TO BLASTING SITE (meter) :

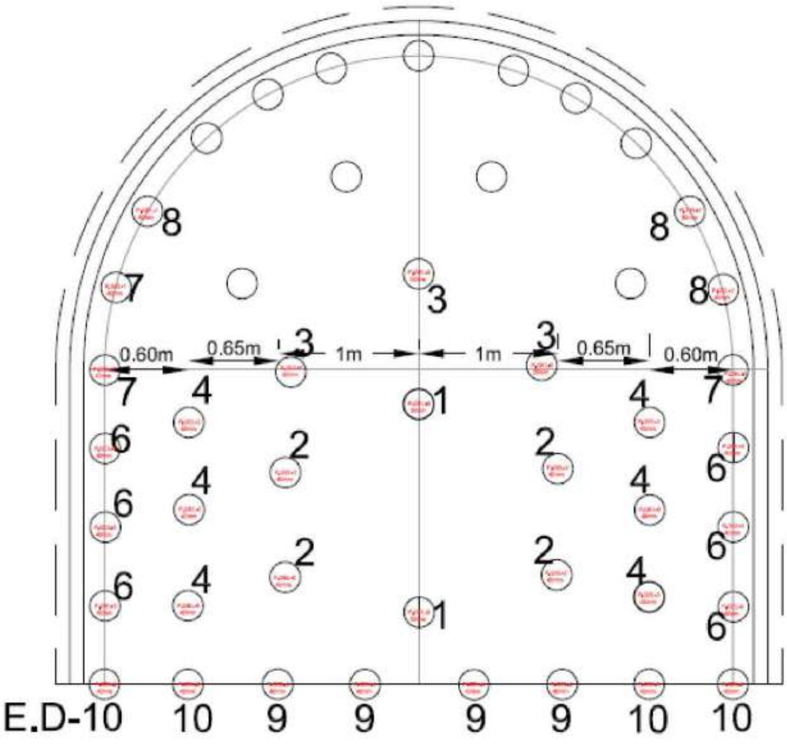
	Lateral	vertical	inclined
1.	212.374	293.37	362.172
2.	241.403	286.00	274.261
3.	267.276	281.97	388.514

Contd. Annexure –3

18. OBSERVATION

(a)	FRAGMENTATION	: Good
(b)	THROW	: Within limit
(c)	VIBRATION (IN TERMS OF PEAK PEAK PARTICLE VELOCITY) (mm/sec)	: Stn. A –0.102, 0.230 : Stn. B –0.284 : Stn. C –0.189
(d)	FREQUENCY (Hz)	: Stn. A – 2.19, 2.39 : Stn. B –104.0 : Stn. C – 40.9

19. SKETCH SHOWING THE PATTERN OF HOLES, PLACEMENT OF DETONATOR AND SEQUENCE OF DELAY.



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ANNEXURE -4

RECORDS OF TRIAL BLASTING AT FACE-6 RONGNICHU HEP, MBPCL, SIKKIM

SI No	PARTICULARS	
1.	DATE	: 09-02-2014
2.	TRIAL NO.	: 04
3.	NATURE OF FORMATION	: soft stone
4.	DIA. OF DRILL HOLES (mm)	: 45
5.	TOTAL NO. OF HOLES BLASTED	: 39
6.	PATTERN OF HOLES	: Wedge cut
a)	HOLE DEPTH (m) AT CROWN & BELOW	: 1.5
b)	HOLE DEPTH (m) AT SPRING LEVEL	: 2.2-2.5
7.	DIAMETER OF TUNNEL (meter)	: 4.5
8.	TYPE OF EXPLOSIVE USED	: Power Gel Capsule
9.	CHARGE PER DELAY (Kg)	: 2.34
10.	MAX. CHARGE/DELAY (Kg)	: 7.8
11.	TOTAL EXPLOSIVE USED PER ROUND (kg)	: 40.0
12.	WEIGHT OF POWER GEL CAPSULE (kg)	: 0.2 & 0.390
13.	LENGTH OF EXPLOSIVE (cm)	: 30
14.	DIAMETER OF EXPLOSIVE (mm)	: 32 & 40
15.	TYPE OF DETONATOR USED	: CED 1 to 10
16.	OBERVATION TAKEN NEAR	: 1. Miss Doma Bhutia 2. Footpath near house of Mr. Chejang Bhutia 3. near CMRHM building
17.	DISTANCE FROM OBSERVATION STATION TO BLASTING SITE (meter)	:

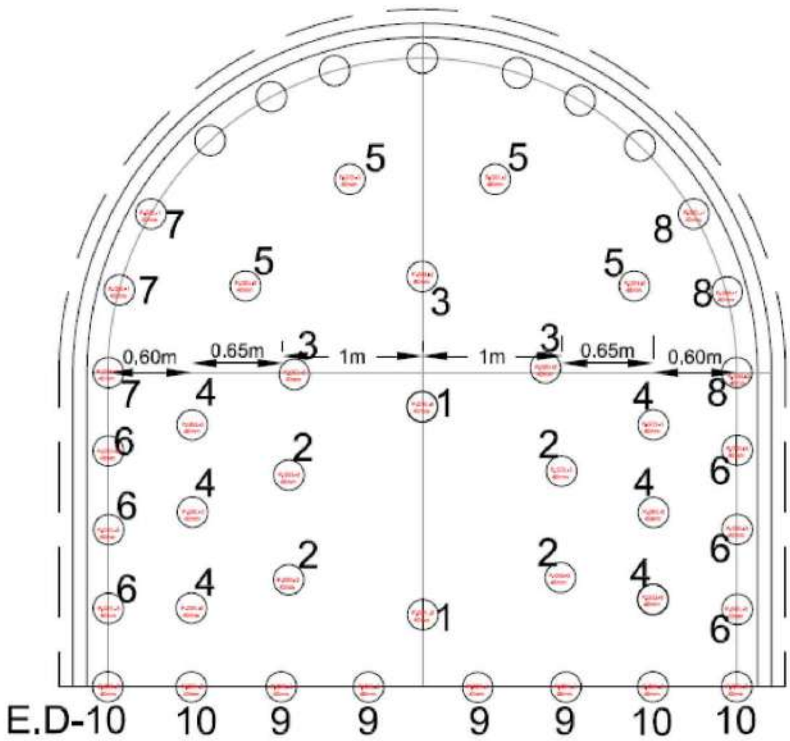
	Lateral	vertical	inclined
1.	172.260	276.37	325.659
2.	239.903	286.00	373.295
3.	265.961	277.37	384.277

Contd. Annexure –4

18. OBSERVATION

(a)	FRAGMENTATION	: Good
(b)	THROW	: Within limit
(c)	VIBRATION (IN TERMS OF PEAK PEAK PARTICLE VELOCITY) (mm/sec)	: Stn. A –0.637, 0.554 : Stn. B –0.186 : Stn. C – <0.13
(d)	FREQUENCY (Hz)	: Stn. A – 40.8, 95.1 : Stn. B – 60.1 : Stn. C –

19. SKETCH SHOWING THE PATTERN OF HOLES, PLACEMENT OF DETONATOR AND SEQUENCE OF DELAY.



ANNEXURE - 5

RECORDS OF TRIAL BLASTING AT FACE-6 RONGNICHU HEP, MBPCL, SIKKIM

Sl No	PARTICULARS	
1.	DATE	: 11-02-2014
2.	TRIAL NO.	: 05
3.	NATURE OF FORMATION	: soft stone
4.	DIA. OF DRILL HOLES (mm)	: 45
5.	TOTAL NO. OF HOLES BLASTED	: 39
6.	PATTERN OF HOLES	: Wedge cut
a)	HOLE DEPTH (m) AT CROWN & BELOW	: 1.5
b)	HOLE DEPTH (m) AT SPRING LEVEL	: 2.2-2.5
7.	DIAMETER OF TUNNEL (meter)	: 4.5
8.	TYPE OF EXPLOSIVE USED	: Power Gel Capsule
9.	CHARGE PER DELAY (Kg)	: 2.34
10.	MAX. CHARGE/DELAY (Kg)	: 9.36
11.	TOTAL EXPLOSIVE USED PER ROUND (kg)	: 45.0
12.	WEIGHT OF POWER GEL CAPSULE (kg)	: 0.2 & 0.390
13.	LENGTH OF EXPLOSIVE (cm)	: 30
14.	DIAMETER OF EXPLOSIVE (mm)	: 32 & 40
15.	TYPE OF DETONATOR USED	: CED 1 to 10
16.	OBERVATION TAKEN NEAR	: 1. Miss Leda & karma 2 Mr. Lobzang bhutia 3. Mr. Samten Bhutia
17.	DISTANCE FROM OBSERVATION STATION TO BLASTING SITE (meter)	:

	Lateral	vertical	inclined
1.	242.434	276.37	367.633
2.	241.786	272.37	364.205
3.	286.685	265.37	390.652

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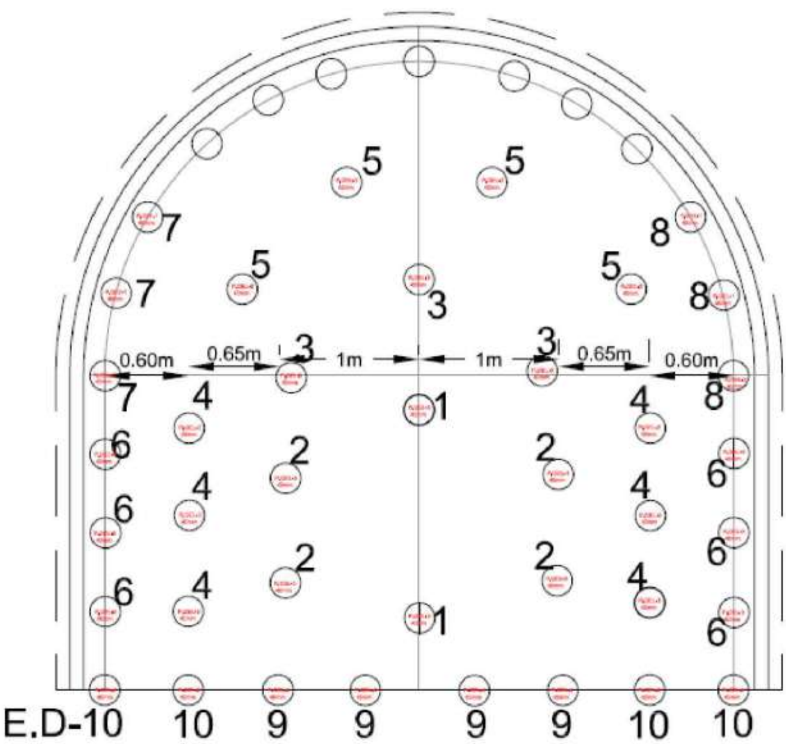
Contd. Annexure – 5

18. OBSERVATION

(a)	**FRAGMENTATION**	**: Good**
(b)	**THROW**	**: Within limit**
(c)	**VIBRATION (IN TERMS OF PEAK PEAK PARTICLE VELOCITY) (mm/sec)**	**: Stn. A –0.39** **: Stn. B –0.128,0.122** **: Stn. C – <0.13**
(d)	**FREQUENCY (Hz)**	**: Stn. A – 16.3** **: Stn. B – 33.4, 2.0** **: Stn. C –**

19. SKETCH SHOWING THE PATTERN OF HOLES, PLACEMENT OF DETONATOR AND SEQUENCE OF DELAY.



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ANNEXURE - 6

RECORDS OF TRIAL BLASTING AT FACE-6 RONGNICHU HEP, MBPCL, SIKKIM

Sl No	PARTICULARS	
1.	DATE	: 13-02-2014
2.	TRIAL NO.	: 06
3.	NATURE OF FORMATION	: soft stone
4.	DIA. OF DRILL HOLES (mm)	: 45
5.	TOTAL NO. OF HOLES BLASTED	: 40
6.	PATTERN OF HOLES	: Wedge cut
a)	HOLE DEPTH (m) AT CROWN & BELOW	: 1.5
b)	HOLE DEPTH (m) AT SPRING LEVEL	: 2.2-2.5
7.	DIAMETER OF TUNNEL (meter)	: 4.5
8.	TYPE OF EXPLOSIVE USED	: Power Gel Capsule
9.	CHARGE PER DELAY (Kg)	: 2.34
10.	MAX. CHARGE/DELAY (Kg)	: 8.97
11.	TOTAL EXPLOSIVE USED PER ROUND (kg)	: 50.0
12.	WEIGHT OF POWER GEL CAPSULE (kg)	: 0.2 & 0.390
13.	LENGTH OF EXPLOSIVE (cm)	: 30
14.	DIAMETER OF EXPLOSIVE (mm)	: 32 & 40
15.	TYPE OF DETONATOR USED	: CED 1 to 10
16.	OBERVATION TAKEN NEAR	: 1. Mr. karmaHisshey Lama 2 Mr. KarmaSanam 3. Mr. Norbu Bhutia
17.	DISTANCE FROM OBSERVATION STATION TO BLASTING SITE (meter)	:

	Lateral	vertical	inclined
1.	312.931	266.61	411.104
2.	89.630	290.37	303.888
3.	106.858	286.37	305.657

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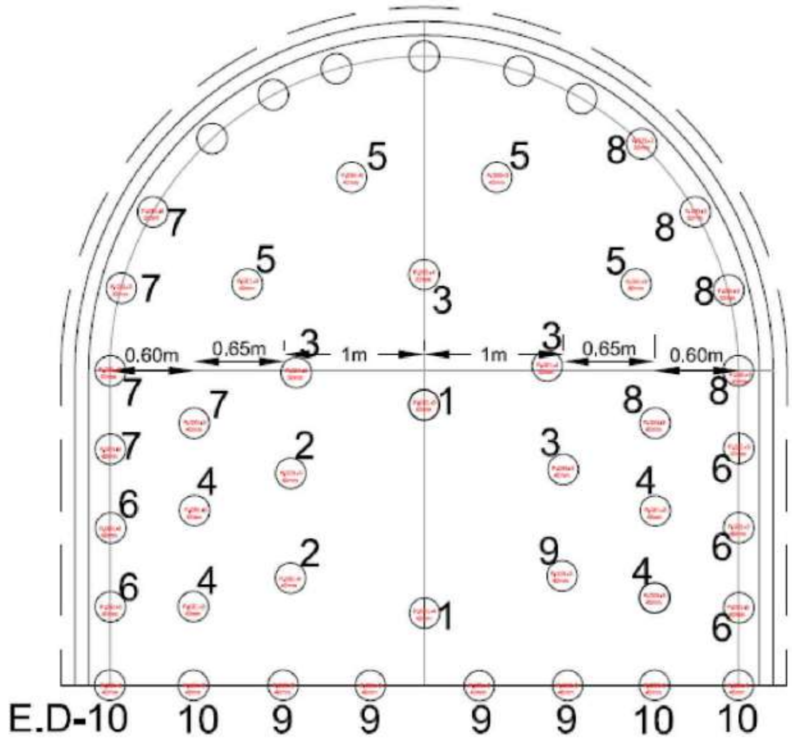
Contd. Annexure – 6

18. OBSERVATION

(a)	FRAGMENTATION	: Good
(b)	THROW	: Within limit
(c)	VIBRATION (IN TERMS OF PEAK PEAK PARTICLE VELOCITY) (mm/sec)	: Stn. A –0.172 : Stn. B –0.189, 0.137 : Stn. C – 0.65
(d)	FREQUENCY (Hz)	: Stn. A – 96.1 : Stn. B – 74.2, 27.8 : Stn. C – 108.0

19. SKETCH SHOWING THE PATTERN OF HOLES, PLACEMENT OF DETONATOR AND SEQUENCE OF DELAY.



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ANNEXURE - 7

RECORDS OF TRIAL BLASTING AT FACE-6 RONGNICHU HEP, MBPCL, SIKKIM

SI No	PARTICULARS	
1.	DATE	: 15-02-2014
2.	TRIAL NO.	: 07
3.	NATURE OF FORMATION	: soft stone
4.	DIA. OF DRILL HOLES (mm)	: 45
5.	TOTAL NO. OF HOLES BLASTED	: 39
6.	PATTERN OF HOLES	: Wedge cut
a)	HOLE DEPTH (m) AT CROWN & BELOW	: 1.7-2.0
b)	HOLE DEPTH (m) AT SPRING LEVEL	: 2.8-3.0
7.	DIAMETER OF TUNNEL (meter)	: 4.5
8.	TYPE OF EXPLOSIVE USED	: Power Gel Capsule
9.	CHARGE PER DELAY (Kg)	: 1.2
10.	MAX. CHARGE/DELAY (Kg)	: 10.92
11.	TOTAL EXPLOSIVE USED PER ROUND (kg)	: 55.0
12.	WEIGHT OF POWER GEL CAPSULE (kg)	: 0.2 & 0.390
13.	LENGTH OF EXPLOSIVE (cm)	: 30
14.	DIAMETER OF EXPLOSIVE (mm)	: 32 & 40
15.	TYPE OF DETONATOR USED	: CED 1 to 10
16.	OBERVATION TAKEN NEAR	: 1. Mr. Doma Bhutia 2 Mr. Ghytso Bhutia 3. Mr. Thinley Bhutia
17.	DISTANCE FROM OBSERVATION STATION TO BLASTING SITE (meter)	:

	Lateral	vertical	inclined
1.	166.831	276.37	322.820
2.	193.085	274.37	355.500
3.	226.569	271.37	353.518

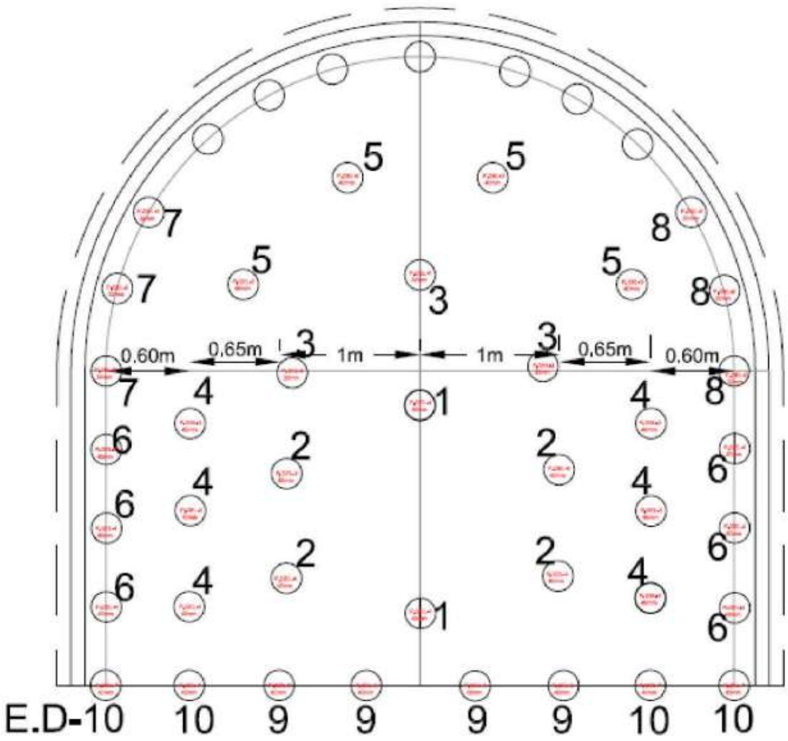
Job No. 281013144 35

Contd. Annexure – 7

18. OBSERVATION

(a)	FRAGMENTATION	: Good
(b)	THROW	: Within limit
(c)	VIBRATION (IN TERMS OF PEAK PEAK PARTICLE VELOCITY) (mm/sec)	: Stn. A –0.637 : Stn. B –0.237 : Stn. C – <0.13
(d)	FREQUENCY (Hz)	: Stn. A – 113.0 : Stn. B – 72.63 : Stn. C –

19. SKETCH SHOWING THE PATTERN OF HOLES, PLACEMENT OF DETONATOR AND SEQUENCE OF DELAY.



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ANNEXURE - 8

RECORDS OF TRIAL BLASTING AT FACE-6 RONGNICHU HEP, MBPCL, SIKKIM

Sl No	PARTICULARS	
1.	DATE	: 16-02-2014
2.	TRIAL NO.	: 08
3.	NATURE OF FORMATION	: soft stone
4.	DIA. OF DRILL HOLES (mm)	: 45
5.	TOTAL NO. OF HOLES BLASTED	: 39
6.	PATTERN OF HOLES	: Wedge cut
a)	HOLE DEPTH (m) AT CROWN & BELOW	: 1.7-2.0
b)	HOLE DEPTH (m) AT SPRING LEVEL	: 2.8-3.0
7.	DIAMETER OF TUNNEL (meter)	: 4.5
8.	TYPE OF EXPLOSIVE USED	: Power Gel Capsule
9.	CHARGE PER DELAY (Kg)	: 1.2
10.	MAX. CHARGE/DELAY (Kg)	: 10.92
11.	TOTAL EXPLOSIVE USED PER ROUND (kg)	: 55.0
12.	WEIGHT OF POWER GEL CAPSULE (kg)	: 0.2 & 0.390
13.	LENGTH OF EXPLOSIVE (cm)	: 30
14.	DIAMETER OF EXPLOSIVE (mm)	: 32 & 40
15.	TYPE OF DETONATOR USED	: CED 1 to 10
16.	OBERVATION TAKEN NEAR	: 1. Mr. Wongal Bhutia 2 Mr. Karma Bhutia
17.	DISTANCE FROM OBSERVATION STATION TO BLASTING SITE (meter)	:

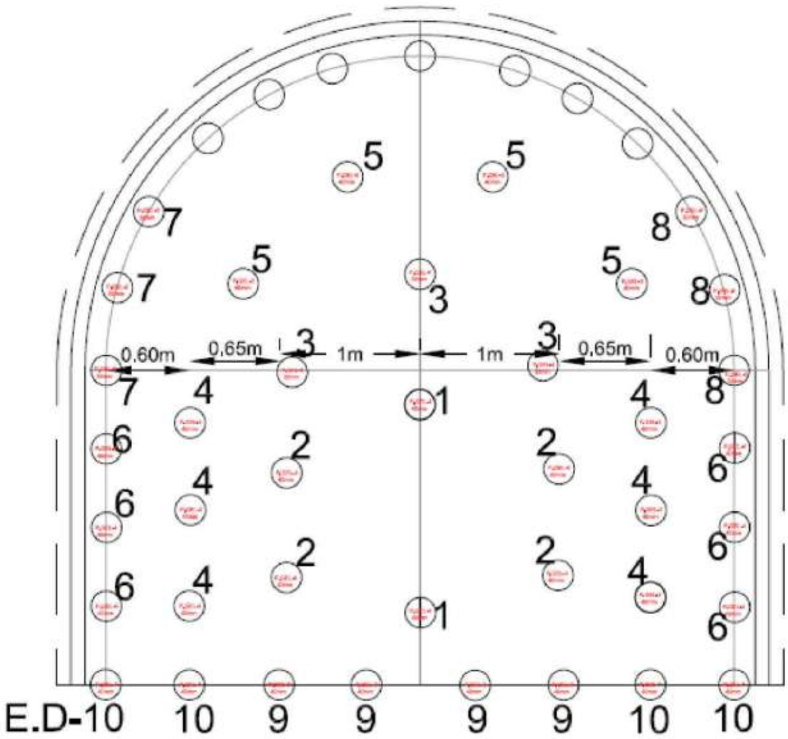
	Lateral	vertical	inclined
1.	141.247	332.37	361.137
2.	177.815	323.37	369.034

Contd. Annexure – 8

18. OBSERVATION

(a)	FRAGMENTATION	: Good
(b)	THROW	: Within limit
(c)	VIBRATION (IN TERMS OF PEAK PEAK PARTICLE VELOCITY) (mm/sec)	: Stn. A –0.16 : Stn. B –0.177,
(d)	FREQUENCY (Hz)	: Stn. A – 50.7 : Stn. B –2.13

19. SKETCH SHOWING THE PATTERN OF HOLES, PLACEMENT OF DETONATOR AND SEQUENCE OF DELAY.



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ANNEXURE - 9

RECORDS OF TRIAL BLASTING AT FACE-6 RONGNICHU HEP, MBPCL, SIKKIM

Sl No	PARTICULARS	
1.	DATE	: 18-02-2014
2.	TRIAL NO.	: 09
3.	NATURE OF FORMATION	: soft stone
4.	DIA. OF DRILL HOLES (mm)	: 45
5.	TOTAL NO. OF HOLES BLASTED	: 37
6.	PATTERN OF HOLES	: Wedge cut
a)	HOLE DEPTH (m) AT CROWN & BELOW	: 1.7-2.0
b)	HOLE DEPTH (m) AT SPRING LEVEL	: 2.8-3.0
7.	DIAMETER OF TUNNEL (meter)	: 4.5
8.	TYPE OF EXPLOSIVE USED	: Power Gel Capsule
9.	CHARGE PER DELAY (Kg)	: 1.2
10.	MAX. CHARGE/DELAY (Kg)	: 12.48
11.	TOTAL EXPLOSIVE USED PER ROUND (kg)	: 55.0
12.	WEIGHT OF POWER GEL CAPSULE (kg)	: 0.2 & 0.390
13.	LENGTH OF EXPLOSIVE (cm)	: 30
14.	DIAMETER OF EXPLOSIVE (mm)	: 32 & 40
15.	TYPE OF DETONATOR USED	: CED 1 to 10
16.	OBERVATION TAKEN NEAR	: 1. Mr. Chiden Bhutia 2. Mr. Gompa 3. Mr. Thakpa Bhutia
17.	DISTANCE FROM OBSERVATION STATION TO BLASTING SITE (meter)	:

	Lateral	vertical	inclined
1.	112.690m	356.37m	373.762m
2.	135.478m	376.37m	400.010m
3.	157.792m	378.37m	409.953m

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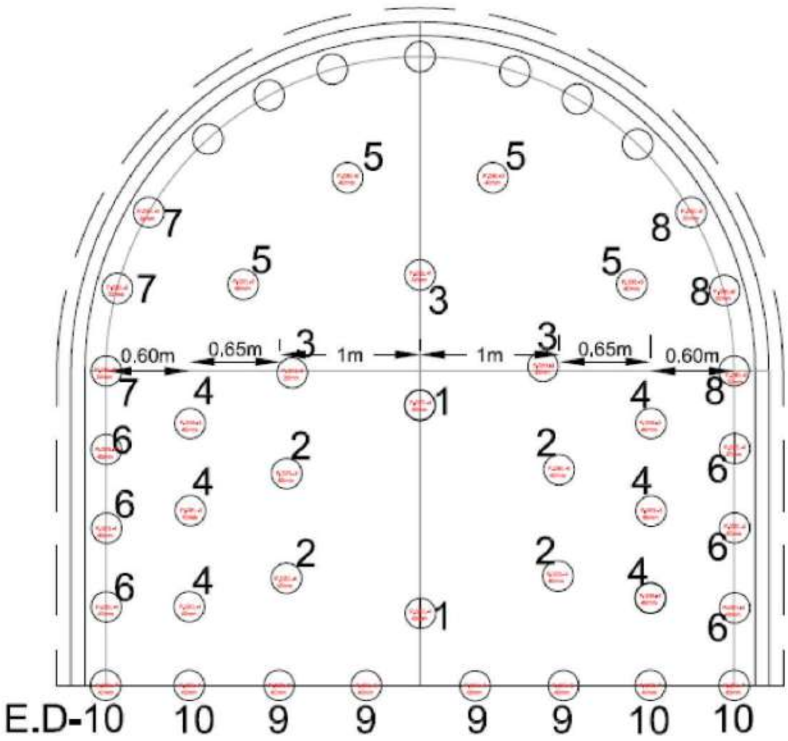
Contd. Annexure – 9

18. OBSERVATION

(a)	FRAGMENTATION	: Good
(b)	THROW	: Within limit
(c)	VIBRATION (IN TERMS OF PEAK PEAK PARTICLE VELOCITY) (mm/sec)	: Stn. A –0.176 : Stn. B –0.129 : Stn. C – 0.318, 0.282
(d)	FREQUENCY (Hz)	: Stn. A – 2.75 : Stn. B – 21.5 : Stn. C – 49.3, 46.0

19. SKETCH SHOWING THE PATTERN OF HOLES, PLACEMENT OF DETONATOR AND SEQUENCE OF DELAY.



ANNEXURE - 10

RECORDS OF TRIAL BLASTING AT FACE-6 RONGNICHU HEP, MBPCL, SIKKIM

SI No	PARTICULARS	
1.	DATE	: 20-02-2014
2.	TRIAL NO.	: 08
3.	NATURE OF FORMATION	: soft stone
4.	DIA. OF DRILL HOLES (mm)	: 45
5.	TOTAL NO. OF HOLES BLASTED	: 39
6.	PATTERN OF HOLES	: Wedge cut
a)	HOLE DEPTH (m) AT CROWN & BELOW	: 1.7-2.0
b)	HOLE DEPTH (m) AT SPRING LEVEL	: 2.8-3.0
7.	DIAMETER OF TUNNEL (meter)	: 4.5
8.	TYPE OF EXPLOSIVE USED	: Power Gel Capsule
9.	CHARGE PER DELAY (Kg)	: 1.2
10.	MAX. CHARGE/DELAY (Kg)	: 7.02
11.	TOTAL EXPLOSIVE USED PER ROUND (kg)	: 55.0
12.	WEIGHT OF POWER GEL CAPSULE (kg)	: 0.2 & 0.390
13.	LENGTH OF EXPLOSIVE (cm)	: 30
14.	DIAMETER OF EXPLOSIVE (mm)	: 32 & 40
15.	TYPE OF DETONATOR USED	: CED 1 to 10
16.	OBERVATION TAKEN NEAR	: 1. Mr. Tenzing Bhutia 2 Mr. Gompa 3. Mr. Thinley Bhutia
17.	DISTANCE FROM OBSERVATION STATION TO BLASTING SITE (meter)	:

	Lateral	vertical	inclined
1.	223.525m	345.37m	411.392m
2.	135.405m	376.37m	392.473m
3.	1053.5m	340.87m	376.37m

Contd. Annexure – 10

18. OBSERVATION

(a)	FRAGMENTATION	: Good
(b)	THROW	: Within limit
(c)	VIBRATION (IN TERMS OF PEAK PEAK PARTICLE VELOCITY) (mm/sec)	: Stn. A –0.106 : Stn. B – 0.316 : Stn. C –0.135
(d)	FREQUENCY (Hz)	: Stn. A – 2.25 : Stn. B – 2.38 : Stn. C – 2.06

19. SKETCH SHOWING THE PATTERN OF HOLES, PLACEMENT OF DETONATOR AND SEQUENCE OF DELAY.