CHAPTER-1
INTRODUCTION

1.1 GENERAL

Basin study for any river basin can be defined as its ability to provide optimum support for various natural processes and allow sustainable activities undertaken by its inhabitants. The same is determined in terms of the following:

- Inventorization and analysis of the existing resource base and its production, consumption and conservation levels.
- Determination of regional ecological fragility/sensitivity based on geo-physical, biological, socio-economic and cultural attributes.
- Review of existing and planned developments as per various developmental plans.
- Evaluation of impacts on various facets of environment due to existing and planned development.

The basin study involves assessment of stress/load due to varied activities covering, e.g. exploitation of natural resources, industrial development, population growth which lead to varying degree of impacts on various facet of environment. The basin study also envisages a broad framework of environmental action plan to mitigate the adverse impacts on environment which could be in the form of:

- Preclusion of an activity
- Infrastructure development
- Modification in the planned activity
- Implementation of set of measures for amelioration of adverse impacts.

Thus, basin study is a step beyond the EIA, as it incorporates an integrated approach to assess the impacts due to various developmental projects. The present study basically assesses impacts on terrestrial and aquatic ecology due to development of various hydroelectric projects in the area to be studied as a part of the present study.

1.2 CONCEPT OF SUSTAINABLE MANAGEMENT

Implementation of any developmental project requires sustainable management of natural resources. In order to ensure sustainable management of resources, an inventory of the existing resource base and its production and consumption pattern needs to be studied. This helps in developing conservation strategies for the resources and identification of intervention areas for conservation effort. Sustainable development is also assessed by determining the carrying capacity, which defines the upper limit of growth.

Sustainable development calls for keeping life-supporting ecosystems and interrelated socio-economic systems resilient for avoiding irreversibility, and for keeping the scale and impact of human activities within supportive and assimilative capacities.

Sustainable development is a process in which the utilization of resources, the direction of investments, and institutional changes are all made consistent with future as well as present needs. The sustainable development could be achieved through:

- Carrying capacity based developmental planning process
- Preventive environmental policy
- Structural change in economic sectors
- Enlarged and objective use of tools like
    - Environmental Impact and Risk Assessment
    - Environmental Audit
    - Natural Resource Accounting, and
    - Life Cycle Assessment.

Planning for sustainable development based on the premises of carrying capacity implies adoption of a normative, rationalist approach to planning, wherein planners subject both the ends and means of public policy to rational considerations. Sustainable development requires pragmatic management of natural resources through positive and realistic planning that balances human expectations with the ecosystems carrying capacity. It aims not only at environmental harmony, but also at long term sustainability of the natural resource base with economic efficiency in the utilization of non-renewable resources, and structural shifts to renewable resource utilization in economic processes.

1.3 NEED FOR THE STUDY

The Study of Lohit Basin in Arunachal Pradesh has been initiated at the instance of Ministry of Environment & Forests, Government of India while according prior Environmental Clearance to Demwe Lower hydroelectric project and Demwe Upper hydroelectric project being developed by M/s Athena Demwe Power Limited, New Delhi. Subsequently after series of discussions, the Expert Appraisal Committee reccomended the TOR for the Study of Lohit Basin. The cost of the study has been shared on pro-rata basis by various project developers who propose to commission hydroelectric projects on Lohit river.

The work for Basin study was awarded to M/s WAPCOS Limited, a Government of India undertaking under Ministry of Water Resources, vide letter no. J-12011/ 34/08-IA-I, dated 26/03/09. The letter of award is enclosed as Annexure-I.

1.4 STUDY AREA

The Basin Study will focuss on the various impacts resulting from implementation of hydro power projects in the Lohit basin. A total of 6 (six) hydroelectric projects are proposed to be developed on the main Lohit river upto Brahmakund in the Indian portion. The Lohit basin map is enclosed as Figure-1.1. The Study Area to be covered as a part of the Basin Study for Lohit Basin is enclosed as Figures-1.2 and 1.3. The list of the same has been tabulated below in Table 1.1.

TABLE-1.1
Projects Proposed on Lohit River (Cascade development)

Particulars	Unit	Demwe Lower	Demwe Upper*	Hutong-II	Hutong-I	Kalai-II	Kalai-I
Catchment Area	sq km	20174	18947	18450	17968	17846	16610
FRL	m	424.80	525	714.5	779.8	904.8	1065.25
Elevation of River Bed	m	~300	~440	~589.5	~755.8	~779.8	~915.25
Ht. of dam (From Deepest Foundation)	m	163.12 m	162.03	161	124	161	186
Installed capacity	MW	1750	1050	1250	750	1200	1450

Initially the Pre-Feasibility Report of Demwe Upper H.E. Project was proposed with installed capacity (1800 MW), between EL 440.00 m with FRL at EL 584.00 m, almost utilizing the entire allotted reach up to EL 589.00 m with the submergence area of 1440 ha. The free flow river stretch between Demwe Upper HEP and Hutong II HEP was only 500 m at that time.

However, during the site investigations and subsequent interactions with the Government of Arunachal Pradesh officials and local authorities, it was impressed upon by them that Demwe Upper HE Project which earlier envisaged FRL of EL 584.00 m will lead to submergence of a proposed hospital site of Swami Camp; part of Hayuliang town; some habitat areas and considerable road length of strategic importance. Accordingly, to avoid the large scale submergence as well as optimal utilization of the Power Potential of allotted reach, Project had been planned to be developed in two schemes/stages in consultation with MOEF, namely Demwe Upper HE Project with installed capacity of 1050 MW near Mompani at EL 440.00 m with FRL at EL 525.00 m bringing down submergence area to 749 ha and Anjaw HE Project, a Barrage toe power house scheme at EL 550 m with FRL at EL 580 m. The Ministry of Environment & Forests (MoEF), while granting revised TOR and Scoping approval for 1050 MW Demwe Upper HE Project vide letter dated 22-12-2010, (copy enclosed as Annexure-II) stated that the proposal for harnessing the hydropower potential of the allotted stretch up to EL 589 m wherein the proposal for a Barrage toe power house based project in the upstream reach is envisaged with provision of free flow river stretch of about 2 km between consecutive upstream and downstream projects.

1.5 STATUS OF ENVIRONMENTAL CLEARANCE OF THE PROJECTS IN STUDY AREA

The status of Environmental Clearance of the projects in Basin Area to be covered as a part of the study is given in Table-1.2.

TABLE-1.2
Status of Environmental Clearance of the projects in Basin Area to be covered as a part of the study

S. No.	Project Name	Project Proponent	Status of Environmental Clearance
1	Kalai HEP Stage –1	Mountain Fall India Private Limited	TOR Approved by EAC for River Valley Projects, Ministry of Environment and Forests
2	Kalai HEP Stage -2	Kalai Power Private Limited	TOR Approved by EAC for River Valley Projects, Ministry of Environment and Forests
3	Hutong HEP Stage –1	Project yet to be allotted	Not Applicable
4	Hutong HEP Stage –2	Mountain Fall India Private Limited	TOR Approved by EAC for River Valley Projects, Ministry of Environment and Forests
5	Demwe Upper HEP	Lohit Urja Limited	TOR Approved by EAC for River Valley Projects, Ministry of Environment and Forests
6	Demwe Lower HEP	Athena Demwe Power Private Limited	TOR Approved by EAC for River Valley Projects, Ministry of Environment and Forests

1.6 SCOPE OF WORK

In the present study emphasis is laid on terrestrial and aquatic ecology. The study envisages both primary as well as secondary data collection. The detailed Terms of Reference as approved by MoEF is enclosed as Annexure-III. The key features of the Terms of Reference for the basin study are presented in the following paragraphs.

Primary data collection is envisaged on following aspects:

- Water Quality
- Aquatic Ecology
- Terrestrial Ecology

Secondary data collection has been collected for the following aspects:

- Meteorology
- Water Resources
- Flora
- Fauna
- Aquatic Flora and Fauna

The following parameters shall be studied

- Modification in hydrologic regime due to diversion of water for hydropower generation.
- Depth of water available in river stretches during lean season and its assessment of its adequacy vis-à-vis various fish species.
- Length of river stretches with normal flow due to operation of various hydroelectric projects due to diversion of flow for hydropower generation.
- Impacts on discharge in river stretch during monsoon and lean seasons due to diversion of flow for hydropower generation.
- Impacts on water users in terms of water availability and quality
- Impacts on aquatic ecology including riverine fisheries due to diversion of flow for hydropower generation.
- Assessment of maintaining minimum releases of water during lean season to sustain riverine ecology maintain water quality and meet water requirements of downstream users.
- Impacts due to loss of forests
- Impacts on rare, endangered and threatened species
- Impacts on economically important plant species
- Impacts due to increased human interferences

The key outcomes of the study shall be to:

- Provide sustainable and optimal ways of hydropower development of Lohit river, keeping in view of the environmental setting of the basin.
- Assess requirement of environmental flow during lean season with actual flow, depth and velocity at different level.

1.7 LOHIT RIVER BASIN

The Lohit Basin is the eastern most river basins of India forming part of Brahamputra basin, with its catchment spreading across international border covering part of Tibet. River Lohit is a tributary of river Brahmaputra and originates at an EL 6190 m above mean sea level from the snow clad peaks in Eastern Tibet and enters India through Kibithoo area of the district. River Lohit in the upper reaches is known' as Krawnaon and after flowing westwards, joins tributary called Chalum Susning flowing from Indo-Burma Border. The combined flow is known as Tellu or Lohit river.

The Lohit basin lies between latitudes 27° 34′ N and 29° 36′ N and longitudes 95° 38′ E and 97° 44′ E.

River Lohit enters the state of Arunachal Pradesh after traversing through Tibet, and generally flows through Mishmi hills. Rivers Dau, Dalai and Tidding are its major tributaries on the right bank and river Lang is the major tributary on the left bank. After debouching from the gorges of Mishmi hills into the plains near Brahamkund, it flows in a westerly direction. It meets Noa-Dihing, Kamlang, Tabang and Tengapani River on the left bank and Digaru, Balijan and Kundli on the right bank. River Lohit is then joined by river Dibang, another important tributary of river Brahmaputra on its right bank and combined flow confluences with river Dihang near Kobo.

The catchment area experiences mostly tropical wet season and supports dense mixed forest. The area is characterized by hills with steep gorges and deep rugged valleys of dentritic pattern with streams feeding the tributaries of the Lohit river system. The rivers are turbulent with steep gradients. Water falls and rapids are very common in these rivers. The catchment area of river Lohit including Tibet region is 29,487 sq km. The catchment area in Tibet has been estimated as about 15,034 sq km and lies mostly in high altitude region.

River Lohit is perennial in nature, with its main source being snow melts of Himalayan glaciers and other small sreams. During lean season i.e. from November to March every year there is a drop in discharge. River Lohit offers good sites for hydro power development. For the optimal use of head and water, cascade development is envisaged to harness the natural river gradient of river Lohit.

1.7.1 Meteorology

The climate of Lohit basin is characterized by cool and highly humid conditions at lower elevations and in the valleys and intensively cold weather at higher elevations. The winter season commences from late November and continues up to March followed by monsoon season from May to September.

The rainfall in the basin is mainly received under the influence of south-west monsoons, which sets in by the second week of May and continues up to October. However major portion of the rainfall occurs during the period from June to August. The monsoon season is followed by a dry spell upto January. Subsequently, some rainfall is again received in the months of February and March. The average annual rainfall in the basin ranges from 2500- 5000 mm.

The India Meteorological Department has published Normal rainfalls for various important stations in the country. The location nearest to the study area is at Passighat where monthly normal rainfall data based on observed long term rainfall data w.e.f. 1951-2000 has been reported by Indian Meteorological Department (IMD) along with the mean number of rainy days. The average meteorological conditions in the study area as per the data observed at Passighat meteorological station are given in Table -1.3.

TABLE-1.3
Avearge meteorological conditions at Passighat

Month	**Mean monthly minimum temperature (°C)**	**Mean monthly maximum temperature (°C)**	**Mean Rainfall (mm)**	**No. of rainy Days**
January	12.3	22.5	53.1	4.3
February	14	23	93	6.4
March	16.8	26.2	124.2	8.9
April	19	28.1	234.6	11.9
May	21.2	29	400.4	15
June	23	30.4	866.5	18.5
July	23.5	30.5	1002.4	21.5
August	23.7	31.2	780.8	16.8
September	23	30.7	501.8	13.2
October	20.5	29.3	242.5	7.3

Month	Mean monthly minimum temperature (°C)	Mean monthly maximum temperature (°C)	Mean Rainfall (mm)	No. of rainy Days
November	16.6	26.9	35.3	2.4
December	13.4	24	22	1.9
Total			**4356.6**	**128.1**
Average	**18.92**	**27.65**		

Source : IMD

As per the DPR for Demwe Lower hydro electric project, rainfall data for following stations is available:

- Hawai 1972-73 to 1991-92
- Kibitoo 1972-73 to 1986-87
- Hayuliang 1972-73 to 1987-88
- Salangam 1972-73 to 1984-85
- Walong 1972-73 to 1985-86 and 1989-90
- Tidding 1979-80 to 1991-92

The locations of the above mentioned stations are shown in Figure-1.4. The mean monthly rainfall observed at these stations is given in Table-1.4.

TABLE-1.4
Mean monthly rainfall at various stations (mm)

Month	Hawai	Kibitoo	Havuliang	Salangam	Walong	Tidding
January	50	51	100	120	40	100
February	140	100	230	230	90	200
March	280	290	480	480	220	350
April	450	395	750	1020	355	800
May	250	90	480	490	130	400
June	265	170	550	700	280	520
July	290	95	490	650	95	750
August	200	70	260	480	81	420
September	170	85	300	390	83	430
October	142	75	250	380	100	410
November	40	40	70	120	46	50
December	55	54	90	100	48	90
Total	**2332**	**1515**	**4050**	**5160**	**1568**	**4520**

It can be observed from Table-1.4, that annual rainfall at various stations ranges from 1515 to 5160 mm. A large proportion of the rainfall is received under the influence of south-west monsoons, from June to September.

1.7.2 Geology

The region in and around Arunachal Pradesh exhibits tectonically distinct geological domains. In this region, two young belts E - W Eastern Himalayas and N - S Indo - Mayanmar mobile belts exist, which meet almost at right angles to each other. The distinctive techno - geological region of Arunachal Pradesh has been divided into four physiographic segments, with major tectonic features lineaments separating each segment as listed below:

- Eastern Himalayan Mobile Belt
- Mishmi Block
- Indo-Myanmar (Burmese) Mobile Belt
- Brahmputra Plain

Eastern Himalayan Mobile Belt

This belt rises abruptly from the Brahmaputra plain and merges with Tibetan plateau in the north. This belt covers about 350 km of Eastern part of Himalayas, known as the Arunachal Himalayas and extends from Eastern Nepal in the west to the West siang district of Arunachal Pradesh in the east terminating against N - W trending para-metamorphites and diorite - granodiorite complex of Mishmi block of Lohit district of Arunachal Pradesh. The eastern mobile belt embodies a succession of northerly dipping thrust sheets covering almost the whole of Arunachal Pradesh. Deep erosion along these thrust contact brings about the four well known E - W trending physiographic units of the eastern Himalayas namely Sub - Himalayas, Lesser Himalayas, Higher Himalayas and Tethyan belt or Tibetan Himalayas. North of it lies zone of Indus - Tsangpo suture.

Mishmi Block

The Mishmi block lies adjacent to the Naga - Patkai ranges of Arkan - Youma mountains to the south along another tectonic plate - the Mishmi thrust. The

Himalayas at the eastern end gets terminated along the Tidding suture and meets another chain of mountains - the Mishmi hills, which are the part of Mishmi block mobile belt. These mountain ranges, trending NW - SE are said to be a continuation of the hill ranges of northern Mayanmar (Burma), but are also considered to be in continuation of the Laddakh ranges lying to the north of Indus - Tsangpo suture. These are made up of diorite - granodiorite complex with a frontal belt of high grade schists and migmatites, and inner belt of low grade schist with crystalline limestone and serpentinite lenses. The important tectonic activities in this block are Mishmi thrust, Tidding Suture, Lohit thrust and Pochu fault.

Indo - Mayanmar (Burmese Belt) Mobile Belt

The Patkoi - Naga - Manipur - Chil Hills - Arkan Yoma region forms a westerly convex arcuate belt in the eastern part of the Arunachal Pradesh, which is an eastern portion of the Indo - Mayanmar (Burmese) mobile belt and is made up of Paleogene - Neogene sediments.

Brahmaputra Plains

This is an ENE - WSW trending relatively narrow valley bounded by two young mountain belts to the north and south east, Mishmi block to the north east and Meghalaya plateau to the south. The valley is filled by thick alluvium with a few inselbergs of basement rocks from Tezpur west wards. Almost flat lying tertiary shelf sediments overlie the basement whose thickness increases from south to north towards Himalayas.

1.7.3 Seismicity and Tectonics

Planar structures developed in the area are schistosity (foliation), joints, shears and thrusts. Out of these, foliation/bedding is the only primary structure and rest are secondary. Bedding is well developed in the limestone and quartzite of Tidding group of rocks. The general trend of this bedding is NW - SE with dip towards NE. Joints are well developed in the limestone at Tidding and along Lohit and Tidding rivers. Three sets of joints were observed, which trend in NW, NE and NS with moderate to steep dips. The rocks of Tidding group and Lohit group are highly sheared and fractured at a number of places.

The major thrusts that are present in the area are Tidding suture and Lohit. The general trend of the thrusts is NW - SE, which becomes almost N - S in the southern part. The area falls under seismic zone–V as per Seismic Zoning Map of the country given in IS 1983 (part I) : 2002. The seismic zoning map is enclosed as Figure-1.5. The important structural elements of the area are Lohit thrust, Tidding suture with dismembered ultra - mafic suite which mark the boundary between low grade sediments of Himalayan orogenic belt and moderately reworked metasedimentary belt and Mishmi thrust. These thrust systems trend NW - SE in contrast to NE - SE trend of Naga fold thrust belt. The historical record of important earthquake events in this region are during 1897 (Ms = 8.7) and 1950 (Mb =8.0, Ms = 8.6).

1.7.4 Physiography

The physiography extent of the basin area ranges from less than 300 m to almost 7000 m. An area of about 4400 sq. km. lies above an elevation of 4500 m (permanent snow line) and accounts for nearly 22% of the total basin area.

1.7.5 Drainage Network of river Lohit

The drainage network in the Lohit basin is complex being controlled by the structural features. Dendritic and rectangular drainage patterns are conspicuous. There are many rapids in the course of Lohit river. The tributaries of Lohit river and their catchment characteristics are given in Table-1.5. The drainage map of the study area is given in Figure-1.6.

TABLE-1.5
Drainage network of Lohit River in Indian Territory and the physiography of their catchment

Tributary	**Circle**	**Right Bank/ Left Bank**	**Streams joining the tributary**	**Confluences with Lohit near**	**Catchment Characteristics**
Di Chu	**Kibitoo**	Left bank	-	Upstream of Kibitoo	Upper part of its catchment is covered with grass lands, snowfields and wastelands. Pine forest is in the middle reaches

Tributary	Circle	Right Bank/ Left Bank	Streams joining the tributary	Confluences with Lohit near	Catchment Characteristics
Tho Chu		Right Bank	-	Kibitoo	It is a small stream. Upper part of its catchment is covered with dense pine forest. Arable lands are on the lower part.
Dunai River		Right Bank	-	Downstream of Kibitoo	This is a small stream the upper par of the catchment is covered with dense pine forest and arable lands are on the lower part.
Meshai River		Left Bank	-	Near Musai	It drains the slopes near Musai. Snowfields and grasslands are in the upper reaches, dense pine forest in the middle reaches and arable lands in the lower reaches.
Karo Ti		Right Bank	-	Downstream of Kibitoo	Originates from lakes. Upper catchment has grasslands and snowfields. Dense pine forests in the middle reaches and arable lands in the lower reaches.
Set Ti	**Walong**	Left Bank	Ir Ti, Yirchik Ti	Dong in the upstream of Walong	It drains the slopes near Dong. Grass lands have wide coverage. Dense forests are on the left bank. Some lands have been subjected to shifting cultivation in the middle part. Arable lands are in lower reaches.

Tributary	Circle	Right Bank/ Left Bank	Streams joining the tributary	Confluences with Lohit near	Catchment Characteristics
Tamun Ti		Left Bank	-	Tinal in the upstream of Walong	It drains the slopes around Tinal. Originates from snowfields and lakes. Grasslands and thick pine vegetation cover most part of its catchment. Arable lands are on the lower reaches.
Dan Ti		Left Bank	-	downstream Walong	It originates from lakes and snowfields and drains the slopes upstream of Setati camp. Middle and most part of upper catchment is covered with dense forest. Chunks of lands with shifting cultivation in the lower reaches.
Yabak Ti or Yerbi Ti		Right Bank	-	downstream Walong near Bish point L. camp	It originates from snowfields. Grass lands and dense forests are in the middle reaches. In the lower reaches, some lands are under shifting cultivation and others are arable.
Shet Ti		Right Bank	-	Near Setati camp	It drains the slope around Setul. It originates from a lake and passes through a18 m fall. Grasslands are present in the upper catchment and dense mixed forest in the lower and middle reaches.

Tributary	Circle	Right Bank/ Left Bank	Streams joining the tributary	Confluences with Lohit near	Catchment Characteristics
Sal Ti		Right Bank	-	Near Selti	It is a small stream with headwater regions in the snowfields. The middle reaches are covered with dense mixed vegetation. Shifting cultivation and arable lands are in the lower part.
Klang Ti		Right Bank	-	downstream of Sarti L. Camp	It is a small stream which mostly flows through dense mixed forest.
Chik Ti		Left Bank	-	upstream of Yashong L. Camp	It is a small stream. Its upper catchment is covered with dense mixed forest. Lands with shifting cultivation are in the lower part.
Kamun Ti		Left Bank	-	Near Khampti Pani	Upper part of the catchment is covered with snowfields and waste lands. Dense mixed jungle mainly of pine occurs in middle part and arable lands in the lower part.
Kram Nala		Right Bank	-	Near Krill	Upper part of the catchment is snow covered. Its catchment has dense mixed jungle in the middle part and arable lands in the lower part. There is a 10 m high waterfall in its course.
Chiral Nala	**Hawaii**	Right Bank	-	Near Machong	It is a small stream. The upper catchment is covered with dense mixed forest. Arable lands are in the lower part.

Tributary	Circle	Right Bank/ Left Bank	Streams joining the tributary	Confluences with Lohit near	Catchment Characteristics
Ghalum or Kulung River		Left Bank	Pungla Ti, Thacechi Ti, Hau Ti, Samblam Ti, Rati River, Kunglung Ti/Nom Ti (Top Ti and Galong Ti), Cha Ti	Hawaii Block	It originates from dense forest and drains the slopes around Matkrong, Hunung and Bhaw. Most part of its catchment is under shifting cultivation. Arable lands are present in the lower reaches.
See Ti		Left Bank	-	Near Kheyong	It is a small stream. Most part of its catchment is covered with thick vegetation.
La Ti		Left Bank	Dothi Nala, Chenu Nala, Klathi Nala, Tawa Nala, Krang Nala, Lap Ti, Kaithang Ti	upstream Hawaii, near Mla	It originates from snow covered land and flows through dense cane and bamboo forest region and grass lands. Drains the slope around Krosam, Halaikrong, Lapkrong, Kamlat, Nukung, Kunung. In the lower reaches there are patches under shifting cultivation and at the bottom level there are some arable lands.
Samdi Ti		Left Bank	-	Near Chunyu	It is a springfed stream which drains the slopes around Walla, Kamdi and Chegung. Its catchment is covered with dense vegetation.

Tributary	Circle	Right Bank/ Left Bank	Streams joining the tributary	Confluences with Lohit near	Catchment Characteristics
Wal Nadi		Left Bank	-	Near Perho	It is a springfed stream which drains the slopes around Longling, Marbo and Perho. Its catchment is covered with dense vegetation in the upper part. In the middle and lower reaches shifting cultivation is in practice.
Chowa Ti		Right Bank	-	Near Kalai	It is a springfed stream which drains the slopes of Chowagong, Kritong, Tamblu and Kalai. Shifting cultivation is in practice in its middle and lower reaches.
Hali R./ Gudun Nala		Right Bank	Kawai Nala, Hali Nala, Sirun Nala. The tributaries of Hali namely Lan Nala, Lang Nala and Gudin Nala are in Manchal circle	Downstream of Lautul	It drains the slopes of Yealiang, Thalla, Tapang and Lautul, There are thick forest and grass lands in the upper catchment. Some of the slopes are subjected to shifting cultivation. There are arable lands in the lower reaches. It confluences with Lohit river at 713 m.
Shangti River	**Manchal**	Left Bank	-	Near Chambab	It is a springfed stream which drains the slopes around Sungung, Loliang, Chamukh, Kanji and Chambab. Dense forest is present in the upper part of its catchment and arable lands are in the lower reaches.

Tributary	Circle	Right Bank/ Left Bank	Streams joining the tributary	Confluences with Lohit near	Catchment Characteristics
Towang River		Left Bank	Tuiyul Nala	Near Hutong	It is a springfed stream which drains the slopes around Khamblighat, Kherewe, Phanglonglat. Thick pine forest is present in its upper catchment. In the lower reaches arable lands area present along either side of the stream.
Halong Ti		Right Bank	-	Near Changrelang	It is a small springfed stream. Dense forest is present in its upper catchment. The lower catchment near the confluence has arable lands.
Gabgonia nala		Left Bank	-	Near Manchal	It is a small springfed stream which drains the slopes around Gnnog and Manchal. Its upper catchment is covered with dense vegetation. There are extensive arable lands in the lower reaches near its confluence with the Lohit.
Hangam nala		Left Bank	-	Near Kombing	It is a springfed stream which drains the slopes around Ikalang, Kumbing and Gathong. Dense vegetation cover is present in Its upper catchment and arable lands are in the lower reaches.

Tributary	Circle	Right Bank/ Left Bank	Streams joining the tributary	Confluences with Lohit near	Catchment Characteristics
Ul Nala		Right Bank	Halong Nala, Vaj Nala	Near Plutung	It is a springfed stream which drains the slopes around Long jam, Eliang, Ghowaliang, Pirah, and Plongnung. Its upper catchment is covered with dense mixed forest. In the middle reaches at 1512 m there are clusters of arable lands and settlements. Arable lands are also present in the lower reaches and alongside the Haling Nala.
Tawig Nala		Left Bank	Hotang Nala	Near Kholiang	It is a springfed stream which drains the slopes of Chutong, Kanthuliang, Gong, Qunboo, Khapma, Zong, Chiliang, Krosam, Kundong, Ratong, Chikulang and Kombo. There area arable lands and settlements in the lower reaches.
Dau River	**Goiliang**	Right Bank	Thusbi R.,Changai Nala, Tastor Tasi Nala, Aniyoi Nala, Biringko K, Beri R. (Jang Nala), and Lang N.	Upstream of Hayuliang	It is a springfed and lakefed stream which drains the slopes around Bringkong, Nilang, Room, Challang, Goiliang, Brailiang, Kaniliang, and Goiliang. The lower and middle parts of its catchment have arable lands and settlements where shifting cultivation is in practice.
Dalai River	**Changlangam**	Right Bank	Kalang River, Kazi Miyu, Kayom N.,	Downstream of Hayuliang	It is a snowfed and lakefed stream which drains the slopes around Chaglagam and in lower

Tributary	Circle	Right Bank/ Left Bank	Streams joining the tributary	Confluences with Lohit near	Catchment Characteristics
			Tamlon River, Kajap river, Katsa R., Duren River, Kuran Machi, Hara Machi, Doring R., Hamang R.		elevational regions like Tablaiko, Chipura, Tegamna, Chaipuliang, Doringko, and Hamangko. Most part of its catchment in the middle and lower reaches is covered with arable lands and settlements. Shifting cultivation is in practice in this stretch.
Nangdh Nala	**Hayuliang**	Left Bank	-	Near Kongra	It is a springfed stream which drains the slopes around Milling. Dense vegetation is present in most part of its catchment.
Din Pong Nala		Right Bank	Am Nala	Near Ampani Camp	It is a springfed stream which drains the slopes around Matiliang, Hoiliang, Chunga and Tafraliang. Most part of its catchment is covered with dense vegetation.
Am Nala		Right bank	Haningklay Nala, Shiv Nala, and Grey Nala, Chikung Nala, and Taku Nala, Dinpong Nala and Cheru Nala	Near Koupe	It is a springfed stream. This valley is spread between 3824 m to 495 m. Most part of its catchment is covered with dense mixed jungle. It confluences with Lohit river near Roupe.

Tributary	Circle	Right Bank/ Left Bank	Streams joining the tributary	Confluences with Lohit near	Catchment Characteristics
Tallua Nala		Right Bank	-	Near Chirang	It is a small stream which flows from 3558 m and confluences at 490 m. Most part of its headwater region is barren rocky land. Below 1000 m there are numerous small old landslide scars along its tributary streams. It drains the slopes around Chirang. Lower part of its catchment is covered with fairly dense mixed jungle.
Mahui Nala		Left Bank	-	Near Mahikong	It is a small springfed stream which drains the slopes around Huiliang, Chingraliang and Mahikong. Most part of its catchment is covered with dense mixed jungle. It confluences with Lohit river at 480 m.
Mam Nala		Right Bank	-	Near Chillang	It is a small springfed stream. In its headwater region the right bank slopes are barren while the left bank slopes are covered with dense mixed jungle.
Dura nala		Left Bank	-	Near Sapalding	It is a small springfed stream which confluences with Lohit at 470 m near Sapaliong.

Tributary	Circle	Right Bank/ Left Bank	Streams joining the tributary	Confluences with Lohit near	Catchment Characteristics
Paya Nala		Right Bank	-	Near Tayabjal	It originates on the southeastern slopes of 3220 peak. It drains the slopes around Sagurnla and Takallang and confluences with Lohit river on its right bank at 450 m. There are old landslide scars in the upper reaches of Paya Nala.
Taka Nala		Right Bank	-	Near Paya	It is a small tributary stream. Its catchment is covered with dense mixed jungle.
Mazang Pani		Left Bank	-	Near Namalong	It flows westward from 2901 m peak and confluences with Lohit at 420 m. Most part of its catchment is covered with dense mixed forest. On the southern slope of Lamatong village there are a number of landslide scar. Landslide scars are also on the right bank of one of the tributary streams of Mazang pani.
Tidding River		Right Bank	Ito Nala, Gome Nala, Chakring River, Wa Nadi; Tributaries in Tezu circle are Tinning R., Omane R.	Near Tidding	It is a large tributary stream of Lohit which has its headwater region in moraine fields in Tibet. Its upper catchment is thickly vegetated. Its lower catchment has settlements and arable lands at many places. Shifting cultivation is in practice in this stretch.

Tributary	Circle	Right Bank/ Left Bank	Streams joining the tributary	Confluences with Lohit near	Catchment Characteristics
Lang River	**Wakro**	Left Bank	Tamblung	Near Lakao	It is a springfed stream which drains the slopes of Kamlang wildlife sanctuary and slopes near Lakao. It drains the dense mixed sal and bamboo forest and grass lands.
Tacha Pani		Left Bank	-	downstream of Dumla	It is a small springfed stream which flows through dense mixed jungle on the northern slope of Shamphu Mamphun ridge. It confluences with Lohit river at 316 m.
Kamlang River		Left Bank	Lai Nala, Krasam	Near Nagar-II, downstream of Wakro	It is a springfed stream which drains the slopes of Kamlang wildlife sanctuary around Kalai, Cherang, Towam, Towan, Kamja, Mining Nagar, Kamlang Nagar, and Wakro.
Digaru River	**Tezu C.D. Block**	Right Bank	Reena River, Tebang River	Near Alubari, downstream of Danglat	It is a springfed streams which drains the slopes around Lohitpur, Tafra Gam, Lolliang and Danglat.
Hazo River		Right Bank	Balljan River	downstream of Sunpura	It is a springfed stream which drains the slopes around Sunpura. Its upper catchment has thick mixed jungle of bamboo.
Tengapani River	**Chowkham**	Left Bank	Champani Nala, Tamba Nala, Ligaun H ka,	downstream of Chowkham	It is a springfed stream which drains the slopes around Namliang, Guna Nagar-II, and Chawkham. Its upper catchment is covered

Tributary	Circle	Right Bank/ Left Bank	Streams joining the tributary	Confluences with Lohit near	Catchment Characteristics
			Mathang H ka, Kalpet H Ka, Lunga H ka, Namkahi Nala		with dense vegetation.
Nao Dihing River	**Namsai**	Left bank	Sanglai H ka, Jamga H ka, Dirak Nala	downstream of Mengkenmiri	It is a springfed stream which drains the slopes around Piyong, Mahadevpur, Kaupata and Lekang. Most part of its upper catchment has thick forest.

Source: CEIA Report, Demwe Lower Hydroelectric Project

1.7.6 Vegetation

The following types of forests are found in the study area.

Pine Forests

Pine forest in the study area starts from Quibang on the left hill hillock and extend beyond Wallang. The forest is dominated by pine and few individuals of *Quercus* sp. are seen scattered within pine trees. The ground vegetation is thick and is dominated by grasses.

Tropical Forests

These are essentially evergreen and dense in nature. *Albizia* sp., *Altingia excelsa, Ficus* spp., *Macaranga denticulata, Callicarpa arborea, Duabanga grandiflora, Dalbergia sissoo, Meliosma simplicifolia, Pterospermum acerifolium, Terminalia myriocarpa,* etc. are the dominant tree species on the left and inaccessible areas. Some sub-tropical species were also observed such as *Litsea citrate*, *Wendlandia* sp., *Syzygium tetragonum, Bauhinia* spp. and *Quercus* spp.

Tropical Secondary Forests

The secondary forests have grown along the West bank of the river where primary forests have been cleared in the past for timber or shifting cultivation. The secondary forests are dominated by trees belonging to species *Macaranga denticulate, Dalbergia sissoo* and *Callicarpa arborea.*

Riverine Semi-Evergreen Forests

This class of forest occurs along riverbanks and riverine plains. The trees in these forests are mostly deciduous and lack a dense closed canopy. The trees are generally buttressed. *Pterospermum acerifolium, Duabanga grandiflora*, *Bombax cieba, Terminalia myriocarpa*, *Altingia excelsa, Ficus cunia, Ficus hirta,* and *Macaranga denticulata* are the dominant trees of this forest.

Plantations

The plantations have been raised along the left bank of the rivers where primary forests have been cleared in the past for timber. The plantation that represents secondary forests is dominated by trees belonging to species like *Bombax ceiba*, *Emblica officinalis*, *Albizia chinensis* and *Kydia calycina*.

1.7.7 Fauna

The biogeographic classification includes this region under the Eastern Himalaya - Province 2D (Rodger et al., 2002). The fauna of eastern Himalaya is mainly governed by the species of southern China, Indo-China and Indo-Malaya regions. The fauna of Eastern Himalaya also have affinities with the Mediterranean, Ethiopian and Turkmenian regions. Species, viz. *Elaphus maximus, Babalus bubalis, Bos gaurus*, horlbill species, Pittas species, Cobras etc. inhabit the monsoon forest below 1000 m, and have close affinity with that of the Indo-Malayan region. The northern part of Eastern Himalaya is close to palaearctic region in the faunal composition. It includes animal species - *Uncia uncia, Ursus arctos*, *Canis lupus* and many species of alpine ungulates. A large numbers of mammals, birds, reptiles and fish species of Arunachal Pradesh, easternmost part of Himalaya are similar to the North-East states of India.

1.8 OUTLINE OF THE REPORT

The report is presented in two volumes listed as below:

Volume-I : Main Report

Volume-II : Annexures

The outline of Volume-I (Main Report) is given as below:

Chapter-1 covers the need for the basin study, study area to be covered as a part of the study. The scope of work and brief profile of the study area is also summarized in the Chapter.

Chapter-2 includes description of various projects proposed to be developed in the study area.

Chapter-3 outlines the methodology adopted for conducting the Basin study. The information has been collected mainly from secondary data sources viz. the data available in the PFR and DPRs of various projects. The secondary data was provided by various project developers.

Chapter-4 presents information on hydrological aspects of Lohit river Basin.

Chapter-5 covers the findings of the water quality survey conducted as a part of the study. As a part of the basin study, water quality sampling as conducted once per month for six months. The findings of the same have been presented in this Chapter.

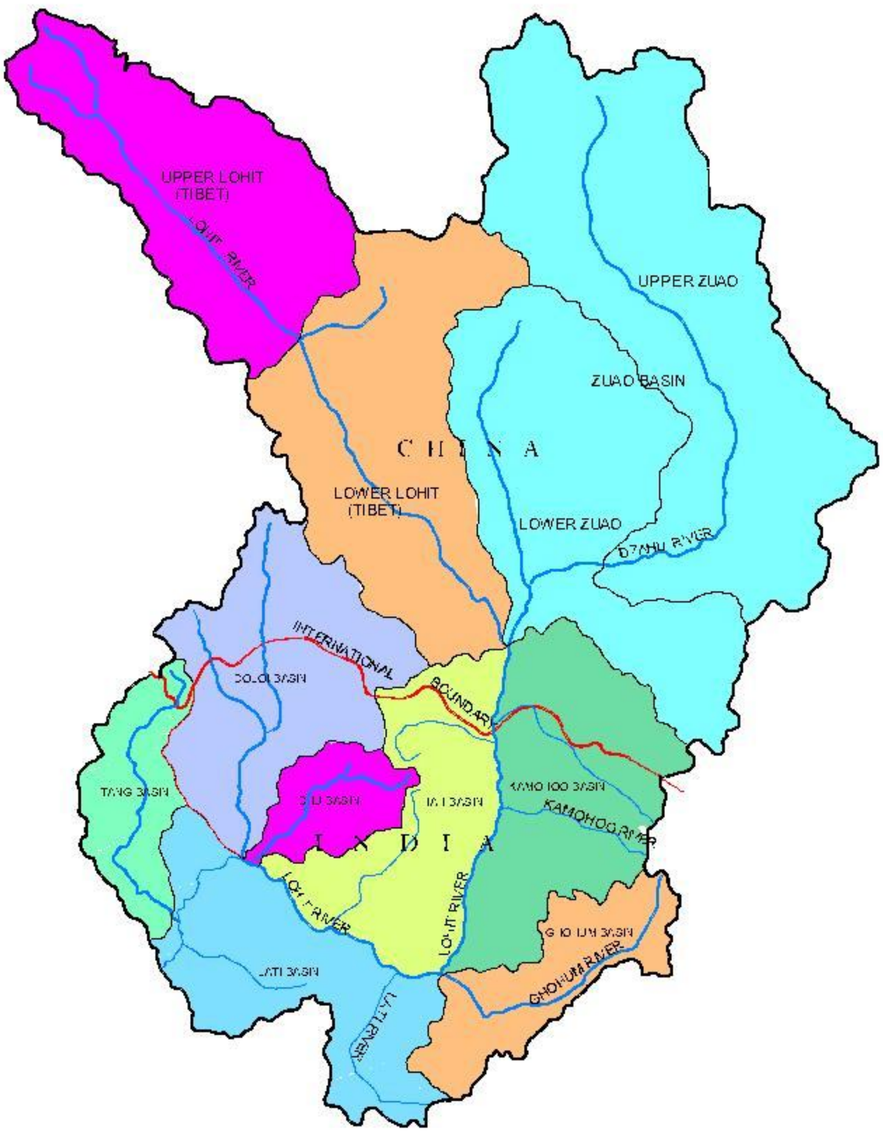
Chapter-6 presents the aquatic ecological aspects of environment. The findings of the chapter are based on collection of data from primary as well as secondary data sources. As a part of the basin study, detailed ecological survey was conducted once per month for six months. The findings of the aquatic ecological survey were analysed and ecological characteristics of the study area have been covered in this Chapter.

Chapter-7 presents the findings the terrestrial ecological survey conducted for two seasons as a part of the study. The survey was conducted in the month of April 2009 and July 2009. The information collected through secondary sources has also been presented in this chapter.

Chapter-8 : describes the anticipated positive and negative impacts as a result of the commissioning of various projects in Lohit Basin (study area). The emphasis was mainly on water environment including water availability, water quality and aquatic ecology including riverine fisheries. Impact prediction is essentially a process to forecast the future environmental conditions of the project area that might be expected to occur as a result of commissioning of various projects in the study area. An attempt has been made to forecast future environmental conditions quantitatively to the extent possible. But for certain parameters, which cannot be quantified, qualitative assessment has been done so that planners and decision-makers are aware of their existence as well as their possible implications.

Chapter-9 presents the Environmental Flows to be released for sustaining the riverine ecology.

Chapter-10 delineates an Environmental Management Plan (EMP) for amelioration of anticipated adverse impacts likely to accrue as a result of commissioning of various projects in the study area. The approach adopted for formulation of the Environmental Management Plan (EMP) has been to maximize the positive environmental impacts and minimize the negative ones.



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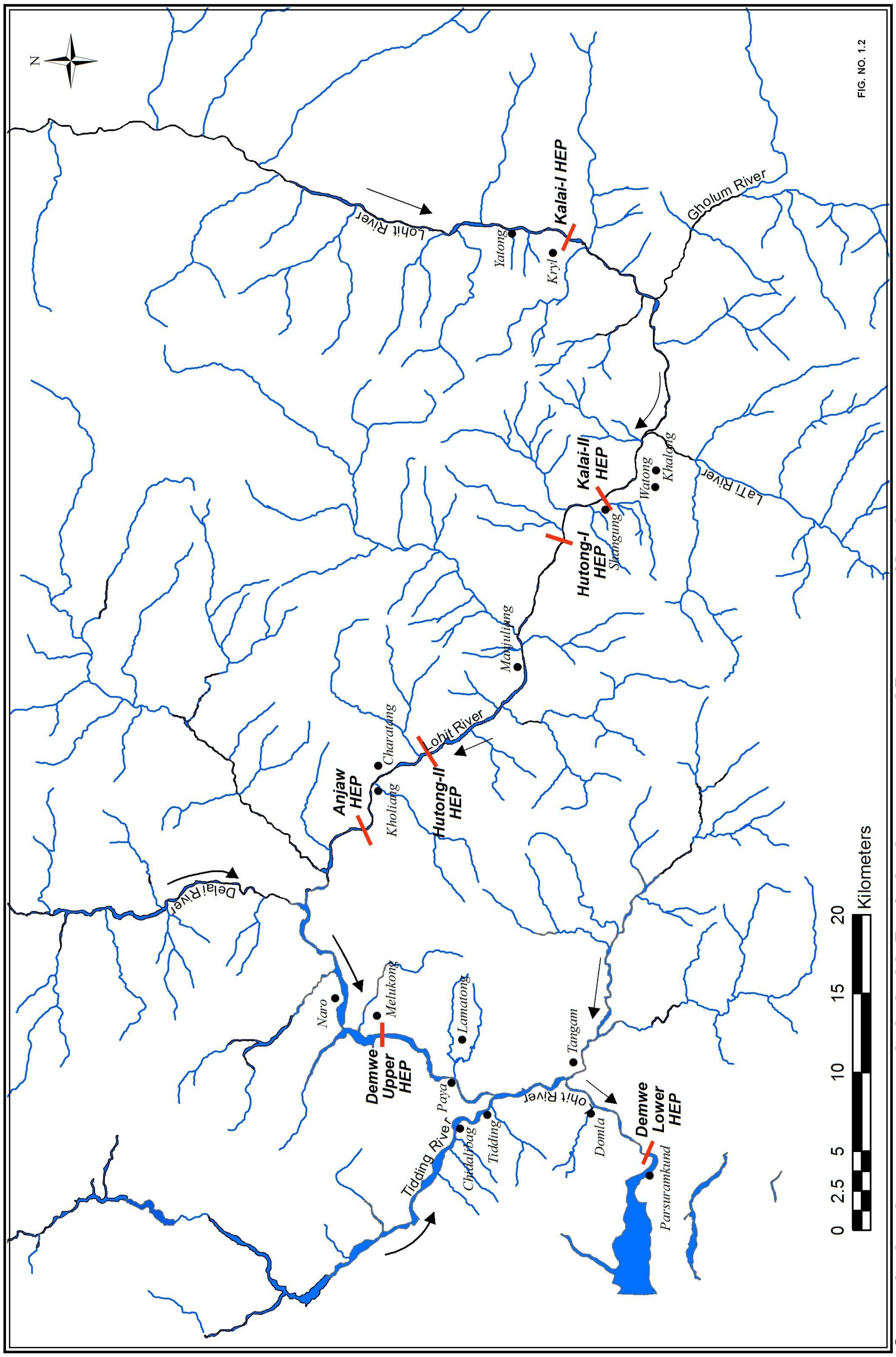
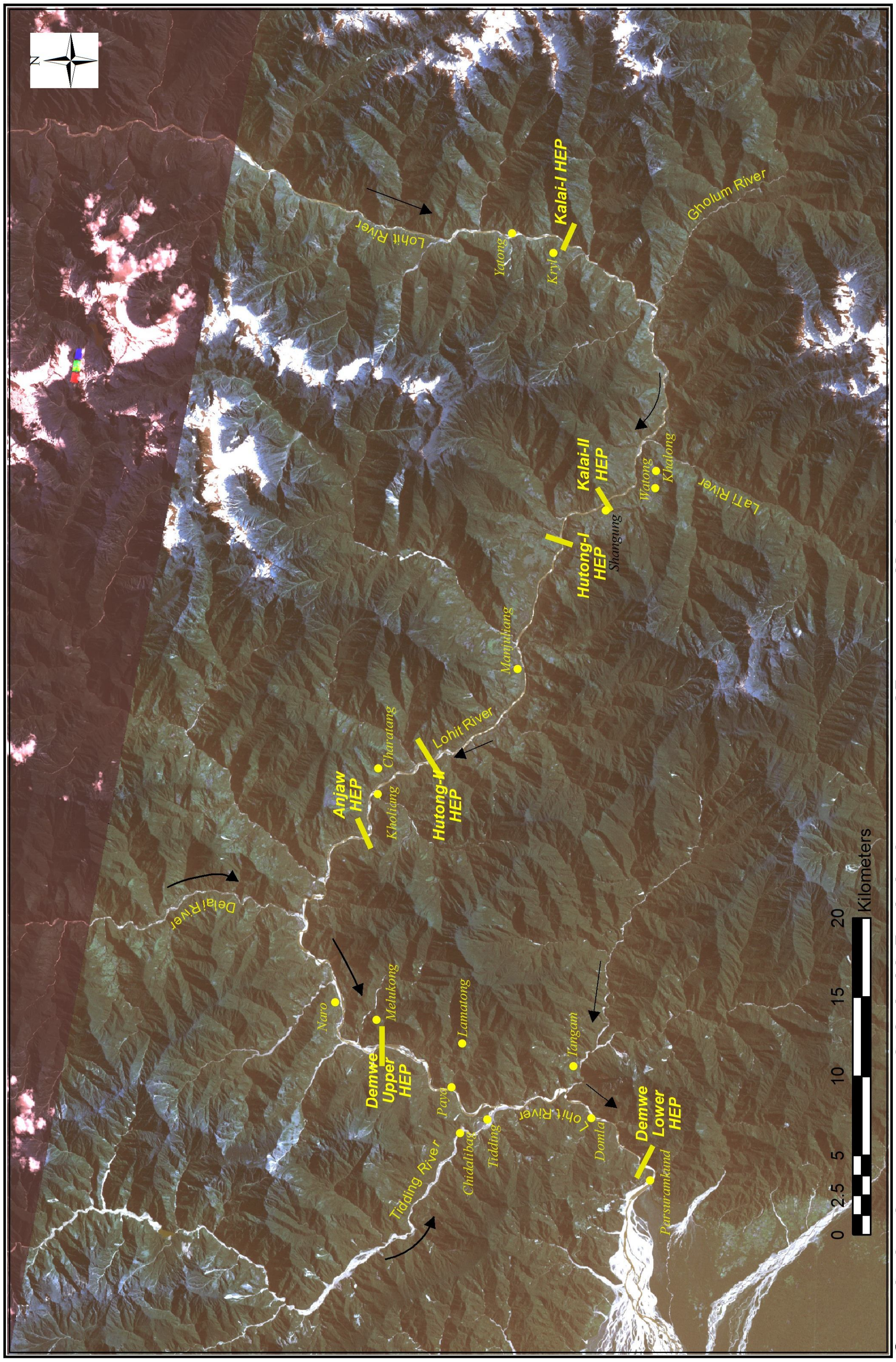
PROJECT:	LOHIT BASIN STUDY
TITLE:	LOHIT BASIN AREA MAP
	FIG. NO. 1.1

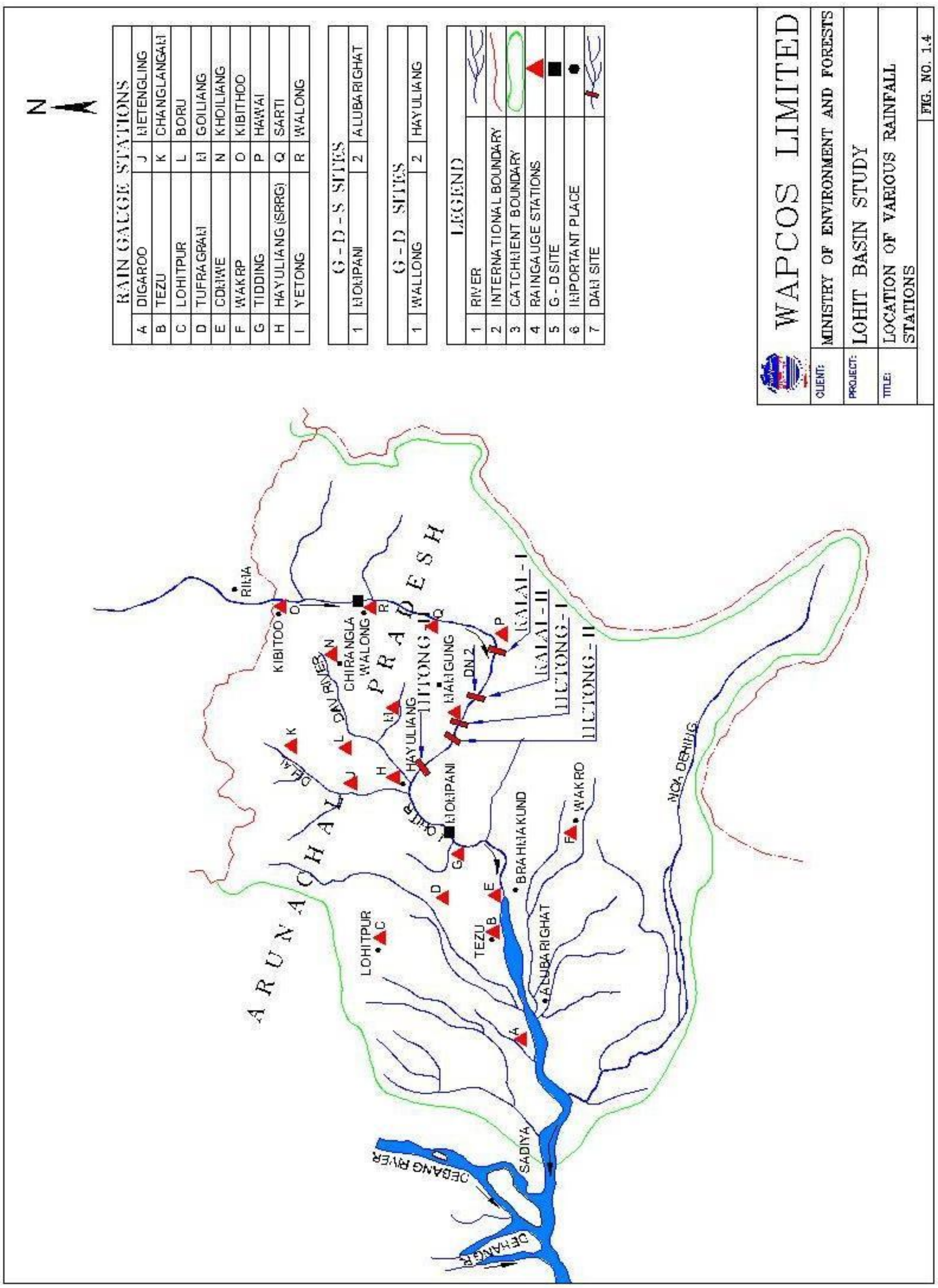


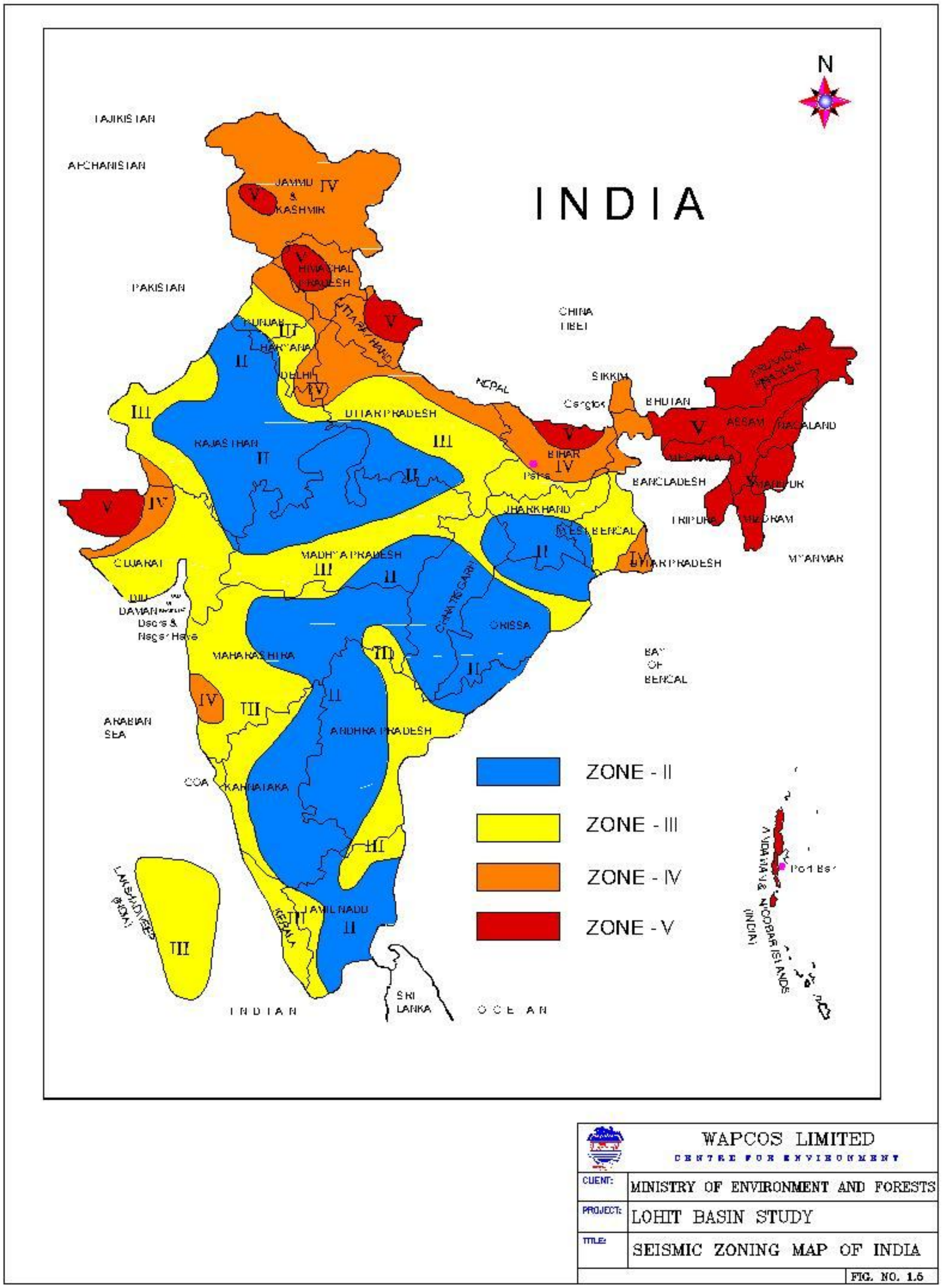
Cascade development scenario in Lohit Basin in the upstream of Parasuram Kund



Cascade development scenario in Lohit Basin in the upstream of Parasuram Kund

FIG. NO. 1.3


N
RAIN GAUGE STATIONS
A DIGAROO
B TEZU
C LOHITPUR
D TUFRAGRAM
E CDMWE
F WAKRP
G TIDDING
H HAYULIANG (SRRG)
I YETONG
J METENGLING
K CHANGLANGAM
L BORU
M GOILIANG
N KHOILIANG
O KIBITHOO
P HAWAI
Q SARTI
R WALONG
G - D - S SITES
1 MOMPANI
2 ALUBARIGHAT
G - D SITES
1 WALLONG
2 HAYULIANG
LEGEND
1 RIVER
2 INTERNATIONAL BOUNDARY
3 CATCHMENT BOUNDARY
4 RAINGAUGE STATIONS
5 G - D SITE
6 IMPORTANT PLACE
7 DAM SITE
WAPCOS LIMITED
CLIENT: MINISTRY OF ENVIRONMENT AND FORESTS
PROJECT: LOHIT BASIN STUDY
TITLE: LOCATION OF VARIOUS RAINFALL STATIONS
FIG. NO. 1.4
ARUNACHAL PRADESH
RIMA
KIBITOO
WALONG
CHIRANGLA
DAU RIVER
HAYULIANG
MOMPANI
BRAHMAKUND
WAKRO
LOHITPUR
TEZU
ALUBARIGHAT
SADIYA
DEBANG RIVER
NOA DEHING
KALAI - I
KALAI - II
HUTONG - I
HUTONG - II
DN 2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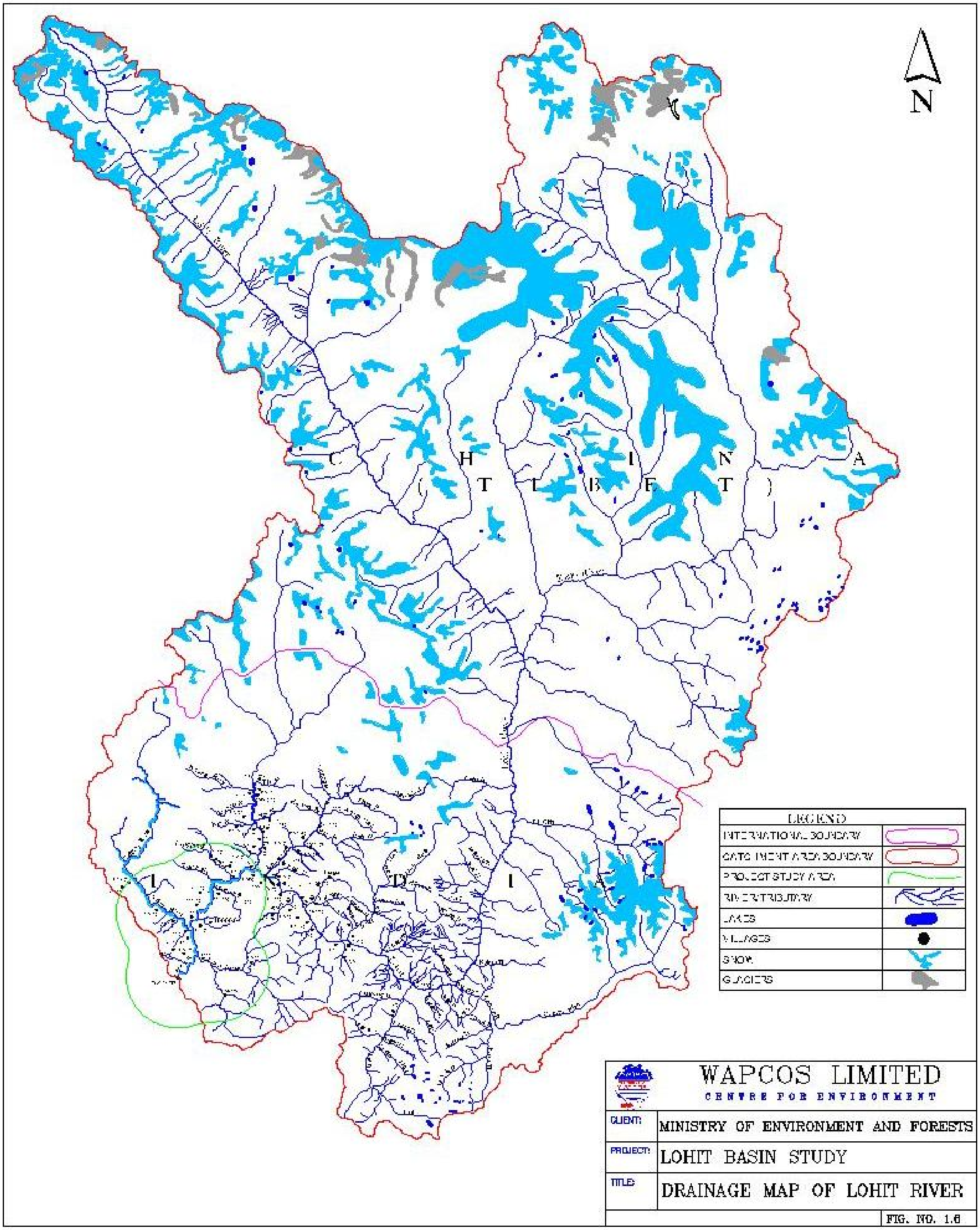
NEPAL
SIKKIM
BHUTAN
BANGLADESH
MYANMAR
JAMMU & KASHMIR
HIMACHAL PRADESH
PUNJAB
HARYANA
DELHI
UTTAR PRADESH
RAJASTHAN
BIHAR
JHARKHAND
WEST BENGAL
ASSAM
NAGALAND
TRIPURA
MIZORAM
GUJARAT
MADHYA PRADESH
ORISSA
MAHARASHTRA
ANDHRA PRADESH
KARNATAKA
GOA
KERALA
TAMIL NADU
ARABIAN SEA
BAY OF BENGAL
INDIAN OCEAN
SRI LANKA
LAKSHADWEEP (INDIA)
ANDAMAN & NICOBAR ISLANDS (INDIA)
ZONE - II
ZONE - III
ZONE - IV
ZONE - V
WAPCOS LIMITED
CENTRE FOR ENVIRONMENT
CLIENT: MINISTRY OF ENVIRONMENT AND FORESTS
PROJECT: LOHIT BASIN STUDY
TITLE: SEISMIC ZONING MAP OF INDIA
FIG. NO. 1.6


N
LEGEND
INTERNATIONAL BOUNDARY
CATCHMENT AREA BOUNDARY
PROJECT STUDY AREA
RIVER TRIBUTARY
LAKES
VILLAGES
SNOW
GLACIERS
WAPCOS LIMITED
CENTRE FOR ENVIRONMENT
CLIENT:
MINISTRY OF ENVIRONMENT AND FORESTS
PROJECT:
LOHIT BASIN STUDY
TITLE:
DRAINAGE MAP OF LOHIT RIVER
FIG. NO. 1.6

CHAPTER-2

DESCRIPTION OF PROJECTS IN THE STUDY AREA

2.1 GENERAL

The following projects are envisaged in the study area to be covered as a part of the Lohit basin study. The list of the projects is given as below:

- Kalai hydroelectric project stage-1
- Kalai hydroelectric project stage-2
- Hutong hydroelectric project stage-1
- Hutong hydroelectric project stage-2
- Demwe Upper hydroelectric project
- Demwe Lower hydroelectric project

The location of various hydroelectric projects on river Lohit is given in Figure-1.2 enclosed in Chapter-1. A brief description of the above referred projects is given in the following sections.

2.2 KALAI HYDROELECTRIC PROJECT STAGE-1

The Kalai hydroelectric Project Stage-1 envisages creation of a storage reservoir on river Lohit, a left bank tributary of river Brahmaputra with a view to utilise flows of river Lohit over large head available for hydro power generation. The coordinates of the dam site are 27° 54' 55" N and 96° 57' 30" E.

The gross and live storage of the Kalai Stage-1 reservoir are 429.31 Mm^3 and 336 Mm^3 respectively. The FRL and lower spillway crest level are envisaged as 1065.25 m and 989.25 m respectively. The dam on river Lohit shall be concrete dam with spillway and a separate diversion structure for diverting a regulated discharge of 1033.05 cumec through 4 nos. each 0.75 km long with 8.0 m dia. Head Race Tunnel to the 7.5 m dia vertical shafts bifurcating to 5.3 m dia leading to the turbine generating 1450 MW power (8 x 181.50 MW) in underground power stations located on the right bank of the Lohit river.

A brief description of project components is given in the following paragraphs.

DAM AND RIVER DIVERSION WORKS

The width of the valley at dam site varies from 137 m at the river bed to 379 m at EL 1070.25 m. The average bed level at the dam site is EL+ 915.25 m. The FRL is proposed to be fixed at EL 1065.25m and MDDL at 1061.35 m keeping in view the inflow of water in river Lohit during lean period. The top of the dam has been proposed at EL 1070.25 m and seat of the dam is proposed to be kept at EL 884.25 m after removal of approximately 30 m thick overburden.

The spillway for concrete gravity dam is proposed to be designed for a probable maximum flood (PMF) of 13526 cumec. Keeping in view large quantum of silt being carried by river Lohit and high PMF, two level spillway are proposed. Five lower level sluice type spillway are proposed with crest at EL 989.25.0 m with an opening of size 7.0 x 16 m. Two upper level orifice type spillways are proposed with crest at 1048.25 m with an opening of size of 10.5 m x 17 m. The total length of the spillway structure is 132 m. Three concrete lined 10.0 m diameter D- shaped, 1200m long diversion tunnel has been proposed on each bank of the river to divert a flood of 3700 cumec of river Lohit.

POWER INTAKES

The power intake systems are proposed on both the banks of river Lohit and consist of 4 nos. power intakes each. The invert level of the intake structure has been kept at EL 1039.25 m taking into consideration the water seal requirement to prevent the vortex formation and air entertainment. The intake structure shall be provided with trash racks to prevent entry of trash in the water conductor system.

HEAD RACE TUNNEL

It is proposed to provide 4 no. of 8.0 m diameter horse shoe shaped concrete lined tunnels of about 750 m length to pass the design discharge of 1033.05 cumec.

PRESSURE SHAFT

4 nos. of 7.5 m diameter steel lined, vertical, circular pressure shafts are proposed. The above shafts shall be divided into 8 no. penstocks to feed water to 8 no. Francis turbines of 181.25 MW capacity each. A separate Valve House cavity of 15 m width and 20 m height shall be provided to accommodate the MIVs. The valve house shall be connected to machine hall cavern through access tunnel.

POWER HOUSE COMPLEX AND TAIL RACE TUNNEL

The underground power house is proposed to utilise the maximum head for generation of power. Based on the power potential studies, installed capacity of 1450 MW (8 nos. machine of 181.25 MW each) has been proposed. The size of the machine hall cavern is 205 m(L) X 22m(W) x 49.26 m(H).

4 nos. 8.0 diameter horse shoe shaped Tail Race Tunnel is proposed in the downstream of draft tube for outfalling the tailrace discharge in river Lohit. The length of tailrace tunnel (TRT) is 750 m. The invert of the TRT shall be kept at 896.50 m.

The salient features of the Kalai hydroelectric project stage-1 are given in Table-2.1. The project layout map is enclosed as Figure-2.1.

TABLE-2.1

Salient features of Kalai hydroelectric project stage-1

River	
Name of River	Lohit
Catchment Area	16610 sq.km
Annual Average Inflow	967 cumec
Reservoir	
Maximum Water Level (MWL)	1065.25 m
Full Reservoir Level (FRL)	1065.25 m
Minimum Drawdown Level	1061.35
Available Drawdown	5.0 m

Sedimentation Level (NZE at 70 yrs)	989.00 m
Gross Storage Capacity	429.31 Mm^3
Reservoir Area	745 ha
Dam	
Type	Concrete Gravity Dam
Elevation of Upper Spillway Crest	1048.25 m
Elevation of river bed	915.25 m
Height of Dam (from foundation)	186 m
Length at top of Dam	403 m
Spillway (Lower)	
Design Flood	13526 cumec
Type	Sluice
Crest Elevation	989.25m
Width of Overflow Crest	56m
Energy Dissipator	Trajectory type
Type of Gate	Radial
Number of Gate	5
Size of Gate	7m (W) x 16m (H)
Intake	
Type	Inclined
Number	4
Elevation of Inlet Sill	1039.25 m
Type of Gate	Fixed Wheel
Number of Gate	4
Size of Gate	6.4m (W) x 7.0m (H)
Headrace Tunnel	
Type	Horse Shoe
Number	4
Max. Discharge	258.3 cumec
Inner Diameter	8.0 m
Length	0.75 km
Pressure Shaft	
Type	Circular Steel Lined
Number	4
Inner Diameter	7.5 m
Total length	220 m
Powerhouse Cavern	
Type	Underground
Size	205 x 22 x 49.26 m
Transformer Cavern	
Type	Underground
Size	214.6 x 16 x 23.1 m
Development Plan	

Maximum Tail Water Level	904.8m
Gross Head	159.15m
Rated head	156.15m
Maximum Discharge	1033.05 cumec
Number of Unit	8
Installed Capacity	1450 MW (8 x 181.25)
Lean Period Avg. Power	370.57 MW
Turbine/Generator	
Type	Francis
Number	8
Speed	176.47 rpm
Frequency	50 Hz
Voltage	11 kv
Power Factor	0.9
Annual Energy Production	
Total Energy (GWh)	6863
Construction Period	7 years Main Project Components
Project Cost (Rs. in Crores)	
Excluding IDC	5525.28
IDC (Rs. Crores)	1210.41
Total Project Cost (Rs. Crores)	
Including IDC	6735.69

2.3 KALAI HYDROELECTRIC PROJECT STAGE-2

The Kalai hydroelectric Project Stage-2 envisages creation of a storage reservoir on river Lohit with a view to utilize large head available for hydro power generation. The coordinates of the dam site are 27° 54' 20" N and 96° 47' 57" E. The project envisages construction of a 161 m high concrete dam (from deepest foundation level). The gross storage of the Kalai Stage-2 reservoir is 315.94 Mm^3 at an FRL of 904.8 m. The live storage capacity shall be 108.52 Mm^3. The proposed dam shall have a spillway and a separate diversion structure for diverting regulated discharge of 289.66 cumec through 4 nos. each 0.75 km long 8.4 m dia Head Race Tunnel to the 7.5 m dia vertical shafts bifurcating to 5.3 m dia leading to the turbine generating 1200 MW power (8 x 150 MW) in underground power stations located on the right bank of river Lohit.

A brief description of project components is given in the following paragraphs.

DAM AND RIVER DIVERSION WORKS

The project envisages construction of a 161 m high concrete dam across river Lohit considering 4 to 6 hours of peaking. The reservoir formed by construction of Dam has a gross storage pre-sedimentation capacity for about 315.94 Mcum and live storage capacity of about 108.52 Mcum.

The average bed level at dam site is EL 779.80 m. The top of the dam has been proposed at EL 909.80 m and seat of the dam is proposed to be kept at EL 748.80 m.

The spillway for concrete gravity dam is proposed to be designed for a probable maximum flood (PMF) of 14273 cumec. Keeping in view large quantum of silt being carried by river Lohit and high PMF, two level spillways are proposed. Six lower level orifice type spillways are proposed with crest at EL 845.00 m having spillway opening size of 7.0 x 16 m. Two upper level orifice type spillways are proposed with crest at EL 887.80 m with opening size of 10.5 m x 17 m. The total length of the spillway structure is 121.3 m.

Three concrete lined 10.0 m diameter D-shaped, 1200m long diversion tunnels are proposed on each bank of the river to divert a flood of 3700 cumec.

POWER INTAKES

The power intake systems are proposed on both the bank of river Lohit and consist of 5 no. power intakes each. The invert level of the intake structure has been kept at EL 878.80 m.

HEAD RACE TUNNEL

The proposed project envisages 4 nos. of 8.4 m diameter horse shoe shaped concrete lined tunnel of about 750 m length to pass the design discharge of 1158.61 cumec.

SURGE SHAFT

The restricted orifice type surge tank shall be provided to reduce the height of surge shafts. The top of the surge shaft has been kept at 915 m, keeping adequate freeboard above the maximum upsurge level. The bottom of the surge shaft is 83 m below the maximum down surge level.

PRESSURE SHAFT

4 nos. of 7.85 diameter steel lined, vertical, circular pressure shafts are proposed. The above shafts shall be divided into 8 nos. penstocks to feed water to 8 nos. Francis turbines of 150 MW each. A separate Valve House cavity 15 m wide and 20 m high can be created to accommodate the Main Inlet Valve (MIV). The valve house shall be connected to machine hall cavern through access tunnel.

POWER HOUSE COMPLEX AND TAIL RACE TUNNEL

The underground power house is proposed to the maximum head for generation of power. Based on the power potential studies the installed capacity of 1200 MW (8 machines of 150 MW each) has been proposed.

4 no. 8.4 diameter horse shoe shaped tail race tunnel is proposed downstream of draft tube for disposal of tailrace discharge into Lohit river. The length of tail race tunnel is about 750 m.

The salient features of Kalai hydroelectric project stage-2 are given in Table-2.2. The project layout map is enclosed as Figure-2.2.

TABLE-2.2

Salient features of Kalai hydroelectric Project Stage-2

River	
Name of River	Lohit
Catchment Area	17846 sq.km
Annual Average Inflow	1039 cumec
Reservoir	
Maximum Water Level (MWL)	904.8 m
Full Reservoir Level (FRL)	904.8 m
Minimum Drawdown Level	898.87 m
Available Drawdown	5.93 m
Sedimentation Level (NZE at 70 yrs)	844.15 m
Gross Storage Capacity	315.94 Mm^3
Reservoir Area	660 ha
Dam	
Type	Concrete Gravity Dam
Elevation of Upper Spillway Crest	887.8 m
Elevation of river bed	779.8 m
Height of Dam (from foundation)	161 m
Length at top of Dam	396 m
Diversion Tunnel	
Design Flood	3700 cumec
Type	D-shaped
Number	3
Inner Diameter	10 m
Length	1.2 km
Spillway (Lower)	
Design Flood	14273 cumec
Type	Sluice
Crest Elevation	845.00 m
Width of Overflow Crest	63 m
Energy Discipator	Trajectory type
Type of Gate	Radial
Number of Gate	6
Size of Gate	7m (W) x 16m (H)
Intake	
Type	Inclined
Number	5
Elevation of Inlet Sill	878.80 m
Type of Gate	Fixed Wheel

Number of Gate	5
Size of Gate	6.4m (W) x 7.0m (H)
Headrace Tunnel	
Type	Horse Shoe
Number	4
Max. Discharge	289.66 cumec
Inner Diameter	8.4 m
Length	0.75 km
Surge Shaft	
Type	Restricted Orifice
Number	4
Size	26 m dia, 6.0 m orifice
Pressure Shaft	
Type	Circular Steel Lined
Number	4
Inner Diameter	7.85 m
Total length	250 m
Powerhouse Cavern	
Type	Underground
Size	205 x 22 x 49.26 m
Transformer Cavern	
Type	Underground
Size	214.6 x 16 x 23.1 m
Annual Energy Production	
Total Energy (GWh)	5673
Construction Period	7 years Main Project Components
Project Cost (Rs. Crores)	
Excluding IDC	5049.70
IDC (Rs. Crores)	1106.23
Total Project Cost (Rs. Crores)	
Including IDC	6155.93
Unit Construction Cost Per MW(Rs. Crores)	
Without IDC and transmission cost	4.2

2.4 HUTONG HYDROELECTRIC PROJECT STAGE-1

The Hutong hydroelectric Project Stage-1 envisages creation of a storage reservoir on river Lohit, a left bank tributary of river Brahmaputra with a view to utilize flows of river Lohit over large head available for hydro power generation. The coordinates of the barrage site are 28° 57' 38" N and 96° 43' 40" E.

The gross and live storage of the Hutong hydroelectric project Stage-1 are 6.69 Mm^3 and 0.06 Mm^3, respectively. The FRL is envisaged at El 779.8 m. The reservoir area at FRL is 51 ha. The barrage on river Lohit shall, be of concrete with a separate diversion structure for diverting a regulated discharge of 1423.02 cumec through 3 nos. each 5.75 km long 10.9 m dia Head Race Tunnel to the 7.20 m dia vertical shaft leading to the turbine generating (6 units of 125 MW each) 750 MW in underground power house located on the right bank of river Lohit.

A brief description of project components is given in the following paragraphs.

DAM AND RIVER DIVERSION WORKS

A 24 m high barrage has been proposed as a part of the project across river Lohit considering 4 to 6 hours peaking. The reservoir formed by construction of dam shall have a gross storage pre-sedimentation capacity for about 6.69 Mm^3.

Average bed level at dam site is El $\pm$755.80 m. The FRL and MDDL are proposed at EL 779.80 m and El 777.80 m respectively. The top of the barrage has been proposed at EL 784.80 m.

POWER INTAKES

The power intake systems are proposed on both the banks of river Lohit and consist of 5 power intakes. The invert level of the intake structure has been kept at El 753.8 m. The intake structure shall be provided with trash racks to prevent the entry of trash in the water conductor system.

HEAD RACE TUNNEL

It is proposed to provide 3 nos. 10.9 m diameter horse shoe shaped concrete lined tunnels of approximate 5.75 km length to convey the design discharge of 1423.02 cumec.

SURGE SHAFT

A restricted orifice type surge tank shall be provided to reduce the height of surge shafts. The top of the surge shaft has been kept at 860 m keeping adequate freeboard above the maximum upsurge level. The bottom of the surge shaft is 736.8 m below the maximum downsurge level. The proposed diameter of surge shaft and orifice is 26 m and 6 m respectively.

PRESSURE SHAFT

6 nos. of 7.2 diameter steel lined, vertical, circular pressure shafts are proposed. A separate Valve House cavity 15 m wide and 20 m high shall be created to accommodate the Main Inlet Valves (MIV). The valve house shall be connected to machine hall cavern through access tunnel.

POWER HOUSE COMPLEX

The underground power house is proposed to utilize the maximum head for generation of power. Based on the power potential studies the installed capacity of 750 MW (6 machines of 125 MW each) has been proposed. The size of the machine hall cavern is 165 m(L) X 22m(W) x 49.26 m(H).

TAIL RACE DISPOSAL

3 nos. 10.9 diameter horse shoe shaped tail race tunnel are proposed in the downstream of draft tube for conveying tail race discharge into river Lohit. The length of tailrace tunnel is 750 m. The tailrace channel shall be made at the end of the tunnel to check the erosion of the river bed. The invert of the TRT shall be kept at 706.05 m.

The salient features of the Hutong hydroelectric project stage-1 are given in Table-2.3. The project layout map is enclosed as Figure-2.3.

TABLE-2.3

Salient features of the Hutong Hydroelectric Project Stage-1

River	
Name of River	Lohit
Catchment Area	17968 sq.km
Annual Average Inflow	1046 cumec
Reservoir	
Maximum Water Level (MWL)	779.8 m
Full Reservoir Level (FRL)	779.8 m
Minimum Drawdown Level	777.8 m
Available Drawdown	2.0 m
Sedimentation Level (NZE at 70 yrs)	
Gross Storage Capacity	6.69 Mm^3
Reservoir Area	51 ha
Dam	
Type	Barrage
Elevation of river bed	755.8 m
Height of Dam (from foundation)	24 m
Length at top of Dam	160 m
Spillway (Lower)	
Design Flood	11976 cumec (SPF)
Type	Sluice
Crest Elevation	756.80 m
Width of Overflow Crest	56m
Energy Discipator	Stilling Basin
Type of Gate	Radial
Number of Gate	6
Size of Gate	15m (W) x 19m (H)
Intake	
Type	Inclined
Number	5
Elevation of Inlet Sill	753.8 m
Type of Gate	Fixed Wheel
Number of Gate	5
Size of Gate	6.4m (W) x 7.0m (H)
Headrace Tunnel	
Type	Horse Shoe
Number	3
Max. Discharge	474.34 cumec
Inner Diameter	10.9 m

Length	5.75 km
Surge Shaft	
Type	Restricted orifice
Number	3
Size	26 m dia, 6.0 m orifice
Pressure Shaft	
Type	Circular Steel Lined
Number	6
Inner Diameter	7.2 m
Total length	80 m
Powerhouse Cavern	
Type	Underground
Size	165 x 22 x 49.26 m
Annual Energy Production	
Total Energy (GWh)	2977
Construction Period	7 years Main Project Components
Project Cost (Rs. in Crores)	
Excluding IDC	4191.83
IDC (Rs. in Crores)	918.30
Total Project Cost (Rs. in Crores)	
Including IDC	5110.13

2.5 HUTONG HYDROELECTRIC PROJECT STAGE-2

The Hutong hydroelectric Project Stage-2 envisages creation of a storage reservoir on river Lohit, a left bank tributary of Brahmaputra river with a view to utilise flows of Lohit river over large head available for hydro power generation. The coordinates of the dam site are 27° 54' 55" N and 96° 57' 30" E.

The Gross and Live Storage of the Hutong stage-2 Storage reservoirs are 424.24 Mm^3 and 336 Mm^3 with FRL at EI 714.5m and Lower Spillway Crest Level at EI 989.25 m respectively. The dam on river Lohit shall be concrete dam with spillway and a separate diversion structure for diverting a regulated discharge of 1033.05 cumec through 4 nos. each 0.75 km long 8.4 m dia Head Race Tunnel to the 7.5 m dia vertical shafts bifurcating to 5.3 m dia leading to the turbine generating 1250 MW power (8 x 156.25 MW) in underground power stations located on the right bank of the Lohit river.

A brief description of project components is given in the following paragraphs.

DAM AND RIVER DIVERSION WORKS

The project envisages construction of a 161 m high concrete across river Lohit considering 4 to 6 hours peaking. The reservoir formed by construction of dam shall have a gross storage capacity of about 424.24 Mm^3 and live storage capacity of about 23.04 Mm^3.

The average bed level at dam site is EL$\pm$ 589.50 m. FRL is proposed to be fixed at EL 714.50 m and MDDL at EL 710.50 m keeping in view the inflow of water in Lohit during lean period. The top of the dam has been proposed at EL 719.50 m and seat of the dam is proposed to be kept at EL 558.50 m after removal of approximately 30 m thick overburden. The spillway for concrete gravity dam is proposed to be designed for a probable maximum flood (PMF) of 14635 cumec.

Keeping in view large quantum of silt being carried by river Lohit and high PMF, two level spillway are proposed. Five Lower level Radial type spillways are proposed with crest at EL 638.50 m having spillway opening size of 7.0 x 16 m. Two upper level orifice type spillways are proposed with crest at 697.50 m with opening size of 10.5 m x 17 m. The total length of the spillway structure is 121.3 m.

POWER INTAKES

The power intake systems are proposed on both the bank of river Lohit and consist of 4 nos. power intakes each. The invert level of the intake structure has been kept at EL 643.50 m.

HEAD RACE TUNNEL

It is proposed to provide 4 nos of 8.4 m diameter horse shoe shaped concrete lined tunnels of approximate 750 m length to pass the design discharge of 1151.23 cumec.

SURGE SHAFT

The top of the surge shaft has been kept at 725 m keeping adequate freeboard above the maximum upsurge level. The bottom of the surge shaft is 640 m below the maximum down surge level. The proposed diameter of surge shaft and orifice is 26 m and 6 m respectively.

PRESSURE SHAFT

4 no. of 7.85 diameter steel lined, vertical, circular pressure shafts are proposed. The above shafts shall be divided into 8 no. penstocks to feed water to 8 no. Francis turbines of 156.25 MW. A separate Valve House cavity 15 m wide and 20 m high can be created to accommodate the Main Inlet Valves. The valve house shall be connected to machine hall cavern through access tunnel.

POWER HOUSE COMPLEX AND TAIL RACE TUNNEL

Based on the power potential studies the installed capacity of 1250 MW (8 nos. machine of 156.25 MW each) has been proposed. 4 nos. 8.4 diameter horse shoe shaped tail race tunnel is proposed in the downstream of draft tube for discharge of tail race outfall in river Lohit. The length of tail race tunnel shall be about 750 m.

The salient features of Hutong hydroelectric project stage-2 are given in Table-2.4. The project layout map is enclosed as Figure-2.4.

TABLE-2.4
Salient features of Hutong Hydroelectric Project Stage-2

River	
Name of River	Lohit
Catchment Area	18450 sq.km
Annual Average Inflow	1071 cumec
Reservoir	
Maximum Water Level (MWL)	714.5 m
Full Reservoir Level (FRL)	714.5 m
Minimum Drawdown Level	710.5
Available Drawdown	3.62 m
Sedimentation Level (NZE at 70 yrs)	629.5 m
Gross Storage Capacity	424.24 Mm^3
Reservoir Area	651 ha
Dam	
Type	Concrete Gravity Dam

Elevation of Upper Spillway Crest	697.5 m
Elevation of river bed	589.5 m
Height of Dam (from foundation)	161 m
Length at top of Dam	675 m
Spillway (Lower)	
Design Flood	14635 cumec
Type	Sluice
Crest Elevation	638.50 m
Energy Dissipator	Trajectory type
Type of Gate	Radial
Number of Gate	5
Size of Gate	7m (W) x 16m (H)
Intake	
Type	Inclined
Number	4
Elevation of Inlet Sill	643.50 m
Type of Gate	Fixed Wheel
Number of Gate	4
Size of Gate	6.4m (W) x 7.0m (H)
Headrace Tunnel	
Type	Horse Shoe
Number	4
Max. Discharge	287.8 cumec
Inner Diameter	8.4 m
Length	0.75 km
Surge Tank	
Type	Restricted Orifice
Number	4
Size	26 m dia, 6.0 m orifice
Pressure Shaft	
Type	Circular Steel Lined
Number	4
Inner Diameter	7.85 m
Total length	250 m
Powerhouse Cavern	
Type	Underground
Size	205 x 22 x 49.26 m
Annual Energy Production	
Total Energy (GWh)	5905
Construction Period	7 years Main Project Components
Project Cost (Rs.in Crores)	
Excluding IDC	6259.30
IDC (Rs. in Crores)	1371.21

Total Project Cost (Rs. in Crores)	
Including IDC	7630.51

2.6 DEMWE UPPER HYDROELECTRIC PROJECT

As discussed in Chapter – 1 to avoid the submergence of proposed hospital site of Swami Camp; part of Hayuliang town; some habitat areas and considerable road length of strategic importance, the project is being developed in two stages i.e. Demwe Upper Hydroelectric Project with installed capacity of 1050 MW near Mompani at EL 440.00 m with FRL at EL 525.00 m and Anjaw Hydroelectric Project a Barrage toe power house scheme at EL 550 m with FRL at EL 580 m.

1050 MW Demwe Upper H.E. Project has been contemplated as a Run-of-River scheme with diurnal pondage situated in the Anjaw district of Arunachal Pradesh. Dam site is located on Lohit river at about 12.8 km d/s of confluence of Delai river with Lohit River.

Demwe Upper hydroelectric project is proposed on river Lohit at Mompani, at EL - 440 with FRL at 525 m. The coordinates of the dam site are 28° 01' 56" N and 96° 27' 0" E. The gross and live storage of the Demwe Upper Storage reservoir are 216 Mm^3 and 99 Mm^3. The FRL and MDDL are envisaged as 525.0 m and 510 m respectively. The water spread shall be 749 ha at FRL. The dam on river Lohit shall be concrete dam with a height of 162.03 m from deepest foundation level. The dam-toe, under ground cavern powerhouse is proposed to be located at about 100 m downstream of dam axis in the right bank of Lohit river. The power generation envisaged is (5 x 205+ 1x25) 1050 MW.

CONCRETE GRAVITY DAM

The proposed dam site is located in a moderately narrow valley, where the river channel is about 170 m wide. Detailed studies and sub-surface explorations were carried out earlier for alternative sites for dam and it has been revealed that the dam site at Mompani is most suitable. Accordingly the layout of dam axis and other project components has been tentatively fixed. Different alternatives to select the type of the dam were considered and the site topography is suited for a concrete dam.

TEMPORARY RIVER DIVERSION

River diversion during construction of dam has been planned through diversion tunnels along with coffer dams on upstream and downstream of the concrete dam. 5 nos., 14.00m diameter with an average length of about 1500m long each Horse shoe shaped diversion tunnels have been provided on the left bank and right bank to pass a maximum diversion flood of 12,000 cumec. This diversion discharge corresponds to a flood of 1 in 25 years return period.

SEDIMENT MANAGEMENT

Due to substantial storage capacity, the Demwe Upper reservoir will have high sediment retention capacity and a large proportion of sediments carried by the Lohit River will get settled in the reservoir. In addition to this, low level crest for the sluice spillway bays have been provided for better silt management.

INTAKE STRUCTURE AND PRESSURE SHAFT

The proposed project is a dam-toe power house scheme. Since Topography of the powerhouse site does not permit to locate a surface powerhouse due to steep hill slope, an underground power house is proposed. Due to high design discharge of 1400 cumec five numbers individual intakes and penstocks are provided to feed each unit of turbine.

All five intakes are proposed upstream of dam axis on the right bank. The intakes are proposed in one line side by side to facilitate the use of common trash cleaning machine and stoplog hoisting arrangement for all the units. Due to short length of the Pressure Shafts (290.00m, average length) Surge Shaft is not required.

POWERHOUSE COMPLEX

The powerhouse complex comprises mainly of three caverns, viz; machine hall cavern, transformer cavern and tail water collection gallery. Apart from these caverns, there will be access tunnels, ventilation/ construction tunnels, cable tunnel etc. The dam-toe, underground cavern powerhouse is proposed to be located at about 50 m downstream of dam axis in the right bank of Lohit River. Presently, a motorable road is passing through project area, which will provide access to the power house complex sites. The caverns will be accessed through access tunnels of shorter lengths.

The three caverns are located bounded within an area of 275m X 200m. The powerhouse is oriented suitably to minimize the problems that may be encountered during the excavation of the cavern. However orientation will be finalised after completion of drifts exploration and in-situ rock mechanic testing in the power house drift.

Spacing between machine hall and transformer caverns is kept a clear distance of 55m. A clear spacing of 42 m is kept between transformer cavern and tail water collection gallery.

TAILRACE TUNNELS

All 6 draft tubes have been extended by (5 nos. 9.4 m dia and 1 no. 5.4m dia) 113 m long circular tail race tunnels to the tail water collection gallery, where gates will be provided. Finally, three tail race tunnels of 13.40m dia tunnels are provided from tail water collection gallery to the tail race out fall to discharge back into the Lohit River. The length of each tailrace tunnel varies from 375.00 m to 487.00m. At the tailrace outfall each tunnel will have a gate to isolate the TRT from river.

The salient features of Demwe Upper hydroelectric project are given in Table-2.5. The project layout map is enclosed as Figure-2.5.

TABLE-2.5
Salient features of Demwe Upper Hydroelectric Project

Location	
State	Arunachal Pradesh
District	Anjaw
Village	Mompani
Hydrology	
Catchment Area	18,947 sq. km
Design Flood	27500 cumec (PMF) + 3989 (GLOF)
Reservoir	
Maximum Water Level	525.00 m
Full Reservoir Level	525.00 m
Minimum Drawdown Level	510.00 m
Water Spread at FRL	749 ha
Storage at FRL	216 Mm^3
Storage at MDDL	117 Mm^3
Live Storage	99 Mm^3
Dam	
Type	Concrete Gravity
Length at top	345.48 m
Overflow	187.0 m
Non-overflow	158.48 m
Top Width	6.00m
Top Elevation	527.00 m
Maximum Height above	162.03 m
deepest foundation	
River Bed Level (average)	440.00 m
Spillway	
Type	Surface Ogee
Capacity	31,489 cumec (PMF + GLOF)
No. of Gates	1 No. Surface Ogee, 10 No. Sluice type
Size of Gates	Surface: 15.00 m(W) X 20 m(H) Sluice: 10.60 m(W) X 13.00 m(H)
Crest Level	Surface – EL 505.00 m Sluice EL – 483.00 m
Diversion Tunnels	
Nos, Size & Shape	5 Nos., 14.0 m dia Horse Shoe
Length	1500 m (Average)
Discharge	12000 cumec
Invert Level at Tunnel Inlet	EL 441.00 m
Invert level at Tunnel outlet	EL 434.00 m
Pressure Shaft	

Nos., Diameter and type	5 Nos. 9.4 m Dia, underground with a vertical shaft of 58.5 m height reduced to 5.95 m dia near Power house
Length	9.4 m dia: 290 m (average)
	5.95 m dia: 20.0 m (average)
Power House	
Type and location	Underground powerhouse on right bank
No. of caverns	Three viz., Machine Hall cavern, Transformer Cavern and Tail Water Collection Gallery
Design Head	73.5 m (net)
Machine Hall Cavern	
Size	236 m (L) x 24 m (W) x 57 m (H)
Type of Turbine and no. of units	Vertical Francis, 5 units of 205 MW each and one unit of 25 MW
Installed Capacity	1050 MW
Minimum Tail Water level	EI. 444.00 m
Transformer Cavern	
Facilities	Transformer and Draft tube gates
Size	179.4 m (L) x 16 m (W) x 28.5 m (H)
Invert level	El 4451.40
Tailrace Tunnel	
Details	5 Nos. Horse shoe 9.4 m dia, 113 m long and one horse shoe 5.4 m diameter upto Tail water collection gates Gallery
	3 Nos. Circular 13.4m dia, 375 to 487 m long each from Tail water Collection Gallery to outfall
Design discharge	1400 cumec
Rated net head at Design	73.5 m
Discharge	
Installed Capacity	5 X 205 MW + 1 X 25 MW = 1050 MW
Annual generation in 90%	3944 Million Units
Cost	
Hard Cost at PL Sep 2010	Rs. 6429.59 Crore
Capitalized Cost with IDC and	Rs. 11057 Crore

2.7 ANJAW HYDRO ELECTRIC PROJECT

Anjaw HEP is proposed on Lohit River in the Anjaw District of Arunachal Pradesh at latitude 28^{0} 02′ 31′′ N and longitude 96^{0} 35′ 04′′ E. The river bed level at the Barrage site is about at EL 550.00 m and FRL is proposed at EL 580.00 m. The

catchment area of Lohit River at the barrage site is 16430 sq km. The gross storage at FRL and live storage of the project reservoir will be 10 MCM and 1.17 MCM respectively. The FRL and MDDL are envisaged as 580 m and 578 m respectively. The diversion structure on Lohit River for Anjaw project shall be barrage with height of 26 m above the crest level. The surface power house is proposed on right bank of river with net design head of 27.04 m.
A brief description of project component is given in the following paragraphs

BARRAGE

The site for barrage has been selected after the topographical survey, field reconnaissance and preliminary geological and hydrological condition. Limitations kept in mind while selecting the suitable locations of the Barrage were:-

- Sufficient width of barrage available to accommodate design flood.
- To ensure adequate length of virgin river flows both upstream and downstream of Anjaw HEP
- Favorable Hydraulic conditions
- Suitable location of Intake to draw silt free water
- Suitable location for sitting a surface power house at the barrage toe.

The proposed Barrage axis is aligned in S 67°W – N 67°E direction, where the river bed is about 83.00 m wide, flanked on the right bank by about 240 m wide area covered with two levels of river terraces . In the upstream and downstream of the Anjaw Barrage site the river is flanked by steeply rising mountainous terrain constituting Mishmi Hills made up of metasediments, amphibolite and the Lohit Complex of Precambrian age with younger mafic and acidic intrusive. The river in the upstream of the proposed site flows from N 80°E to S 80°W and takes a bend towards N 63°W. Afterwards the river flows in a straight course from 200 m upstream of the Barrage axis for considerable distance from S 14°E to N 14°W direction.

The deepest river bed level at barrage site is about EL 550.00 m. A 26 m high barrage above crest level with spillway comprising of 7 bays controlled by radial gates.

POWER INTAKE

The water is led to the penstock through intake structures located in the right bank of Lohit River. Seven separate intakes and penstocks are provided to feed each unit of turbine independently. All intakes are proposed in one line and side by side to each other in order to facilitate the use of common trash cleaning machine and stop- log hoisting arrangement for all the units.

Rectangular forebay type intake with inclined trash rack is provided for smooth entry of clear water from the reservoir to penstock. The trash rack sill level of intake is kept at EL 560.00 m. As the difference between FRL and MDDL is less, the trash rack is provided upto the top i.e. EL 582.00 m.

PENSTOCKS

Since the total discharge for power generation is high, seven numbers of 40 MW generating units of power house shall be fed through seven independent penstocks. Each penstock is of 7.0 m diameter and centre to center distance between the penstocks is 24.00 m. Length of each penstock is kept 48.5 m from transition end at power intake to power house.

POWER HOUSE

A terrace of about 300-350 m long and 25 to 30 m width is available just 60 m down-stream of barrage axis on the right bank. This terrace is being utilized for locating surface power house on the right bank. The power house in oriented / proposed such that the length of the water conductor system (WCS) is least so as to avoid surge tank. The size of the proposed power house is 168.15 m long, 25.00 m wide and 50.0 m high. The floor of the transformer hall has been kept EL 559.30 m. The service bay provided for facilitating erection and maintenance of the various electro-mechanical and other equipments is proposed at EL 559.30 m.

TAILRACE CHANNEL

The draft tube of each unit will be extended to the draft tube gate, which is located at about 19.38 m downstream of B-Line. After the gate, a rectangular channel tail race of 163.60 m width will discharge the water back into the Lohit River. Length of tailrace channel would be around 165 m up to the River channel. The tail race shall be of Rectangular section. The water from the draft tube of the units will be taken to the tailrace channel the draft tube of each unit has been provided with 2 numbers of 6.225 m (w) x 6 m (h) draft tube gates. The gates will be operated from platform at EL 561.00 m

Normally the gates will remain open and will be docked in the grooves below the gate operating floor level. A gantry crane has been proposed for operating the gates.

SWITCH YARD

220 kV switchyard with double bus scheme (high level type) is proposed for the project, the switchyard shall consist of seven numbers of generator incomer bays, two numbers of 220 kV feeder bays, one station auxiliary transformer bay and one bus coupler bay. Size of the switch Yard shall be 30 m wide and 180 m long on the right bank of Lohit River near the power house.

The Salient features based on PFR of Anjaw HEP are given in Table-2.6. The project layout is enclosed as Figure-2.6.

TABLE-2.6

Salient Features of the Anjaw Hydroelectric Project

Location	
State	Arunachal Pradesh
District	Anjaw
Village	Supliyang
Hydrology	
Catchment Area	16,430 sq. km
Design Flood	12944 cumecs (1 in 100 years)
Reservoir	

Maximum Water Level	580.00 m
Full Reservoir Level	580.00 m
Minimum Drawdown Level	578.00 m
Water Spread at FRL	115 ha
Storage at FRL	10 MCM
Storage at MDDL	8.83 MCM
Live Storage	1.17 MCM
Barrage	
Barrage bridge deck level	El. 582.00 m
Height of the Barrage above crest level	26 m
River Bed Level (average)	550.00 m
Barrage Bay	
Capacity	12944 cumecs (1 in 100 Year Flood)
No. of Gates	7 Nos.
Size of Gates	13.00 m (W) X 24.00 m (H)
Crest Level	556.00 m
Penstock	
Nos, Diameter	7 nos. and 7m dia, steel lined
Length	Appox. 48.5 m each
Power House	
Type and Location	Surface powerhouse on right bank
Design Head	27.04 m (net)
Machine Hall Cavern	
Size	25 m (W) x 168.15 m (L) x 50 m (H)
Type of Turbine and no. of units	Vertical Kaplan, 7 units of 40 MW each
Installed Capacity	280 MW
Minimum Tail Water Level	EL. 550.90 m
Transformer Hall	
Facilities	Transformer
Size	18 m (W) x 168.15 m (L) x 15.2 m (H)
Floor Level	EL 559.30m
Tailrace Channel	
Details	163.6 m wide and 165 m long rectangular Tailrace Channel
Power Generation	
Design Discharge	1141.15 cumecs
Rated net head at Design discharge	27.04 m
Installed capacity	7 X 40 MW= 280 MW
Design Energy in 90% dependable year	1145.97 Million Units
Cost	
Hard Cost at PL Sep, 2010	Rs. 1632.70 Cr
Capitalized Cost with IDC and	Rs. 2233.91 Cr

escalation	

2.8 DEMWE LOWER HYDROLECTRIC PROJECT

The project is located at the foothill of Lohit basin. The project is located about 800m upstream of Brahamkund bridge on NH 52 and falls in Lohit district with reservoir extending into Anjaw district of the state of Arunachal Pradesh. The project area can be accessed from Dibrugarh airport, which is about 550 km from Guwahati airport. The project site is about 215 km from Dibrugarh and about 160 km from Tinsukia, the nearest rail head. The district head quarter Tezu is about 40 km on hill road from the project site. The project Demwe Upper HEP, a cascade development of Demwe HEP is located about 80 km upstream of proposed Demwe Lower HE Project.

After approval from CEA/CWC for the Water Availability Studies in July, 2008, M/s ADPPL approached MOEF for continuance of same ToR for EIA/EMP studies with an installed capacity of 1630 MW and received approval from MOEF vide letter dated 12-1-2009. Subsequently, M/s ADPPL finalized Detailed Project Report (DPR) and submitted to CEA for Techno-economic appraisal. During appraisal CEA recommended that the FRL and MWL of Demwe Lower should be kept at EL 424.8m as against the earlier considered FRL of EL 420m and MWL of EL 423.5m respectively. This change in elevation levels has resulted in enhancement of installed capacity to 1750 MW for which the MOEF has also accorded approval with the same TOR as earlier approved during the appraisal for 2 stage development (i.e Demwe Lower and Demwe Upper HEP)s. The project has obtained Techno-Economic Clearance from Central Electricity Authority in November-2009, Environment Clearance from Ministry of Environment & Forests in February-2010.

Demwe Lower HE Project envisages construction of concrete gravity dam of 163.12 m height above deepest foundation level, the maximum water level and full reservoir level of the project are proposed at an elevation of 424.8 m and the

Minimum drawdown level will be at elevation 408 m with live storage of about 171.20 Mcum. A surface power house is proposed on the right bank of Lohit river to accommodate five numbers of vertical Francis turbines of 342 MW each to generate 1710 MW power and one unit of 40 MW to generate total installed capacity of 1750 MW. The water after power generation will be discharged at an elevation of 297.9 m in the main course of river through a 130m long tail race channel. The design discharge of the project is 1729 cumec with a design head of 112.00m. The project will generate 6322 million units in a 90% dependable year at 95% machine availability.

The Layout plan of Demwe Lower is given as Figure-2.7. The salient features of the project are given in Table-2.7.

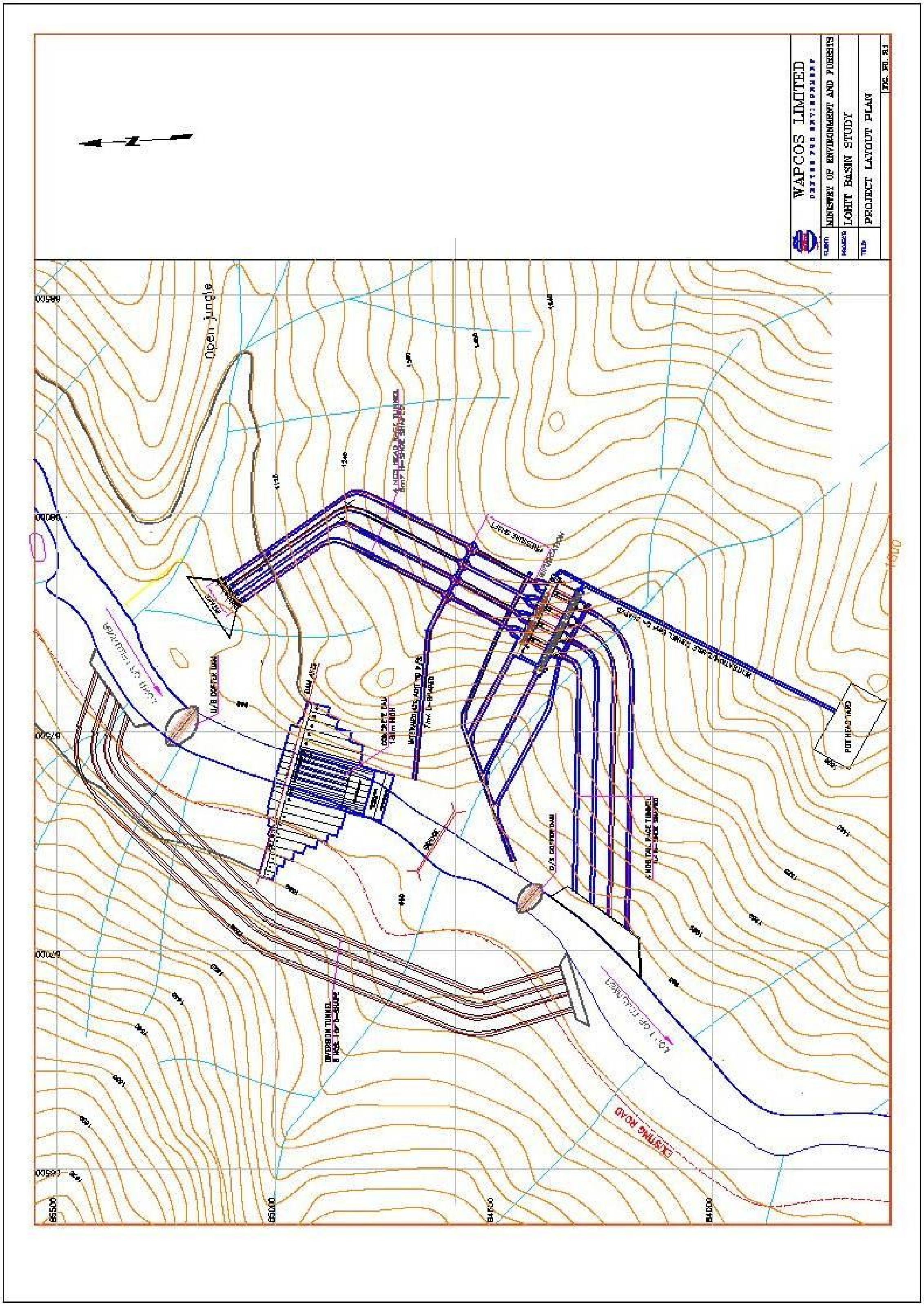
TABLE-2.7

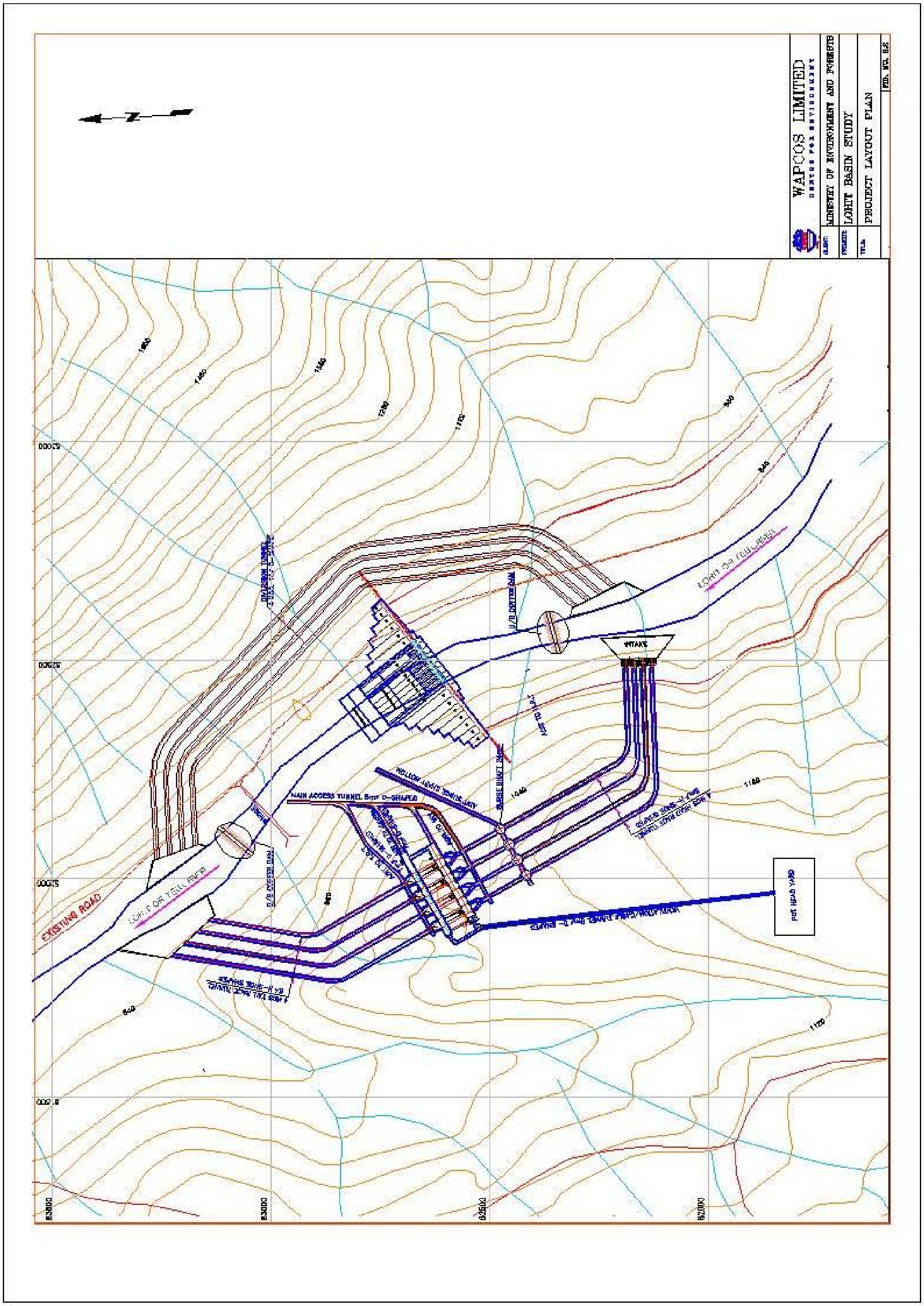
Salient Features of the Demwe Lower Hydroelectric Project

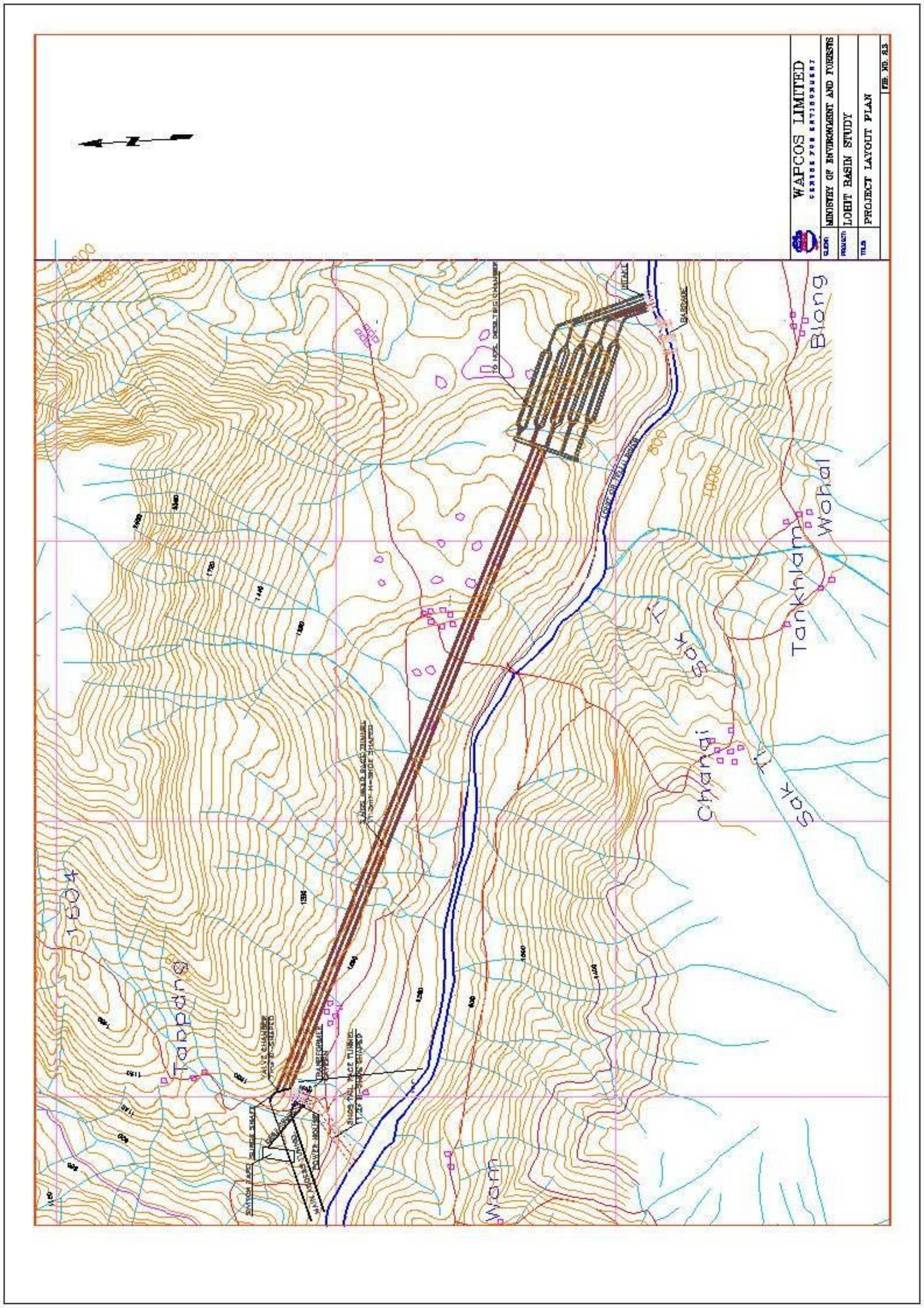
Location	
State	Arunachal Pradesh
District	Lohit
River	Lohit
Access	
Airport	Dibrugarh - 215 km (Guwahati to Dibrugarh = 550 Km)
Rail Head	Tinsukia - 160 km
Road Head	Parasuram Kund – 1 km
Co-ordinates of the Dam Site	
Latitude (N)	27^{0} 52′ 48′′
Longitude (E)	96^{0} 22′ 39′′
Map reference	Survey of India topo-sheet 92A/5
Meteorology	
Average Rainfall	3000 mm
Maximum Rainfall	5000 mm
Minimum Rainfall	2500 mm
Atmospheric Temperature	
Average Maximum Temp.	39^{0}C (at Tezu)
Average Minimum Temp.	8^{0} C (at Tezu)
Hydrology	
Catchment Area	20,174 sq. km
PMF	28,500cumecs

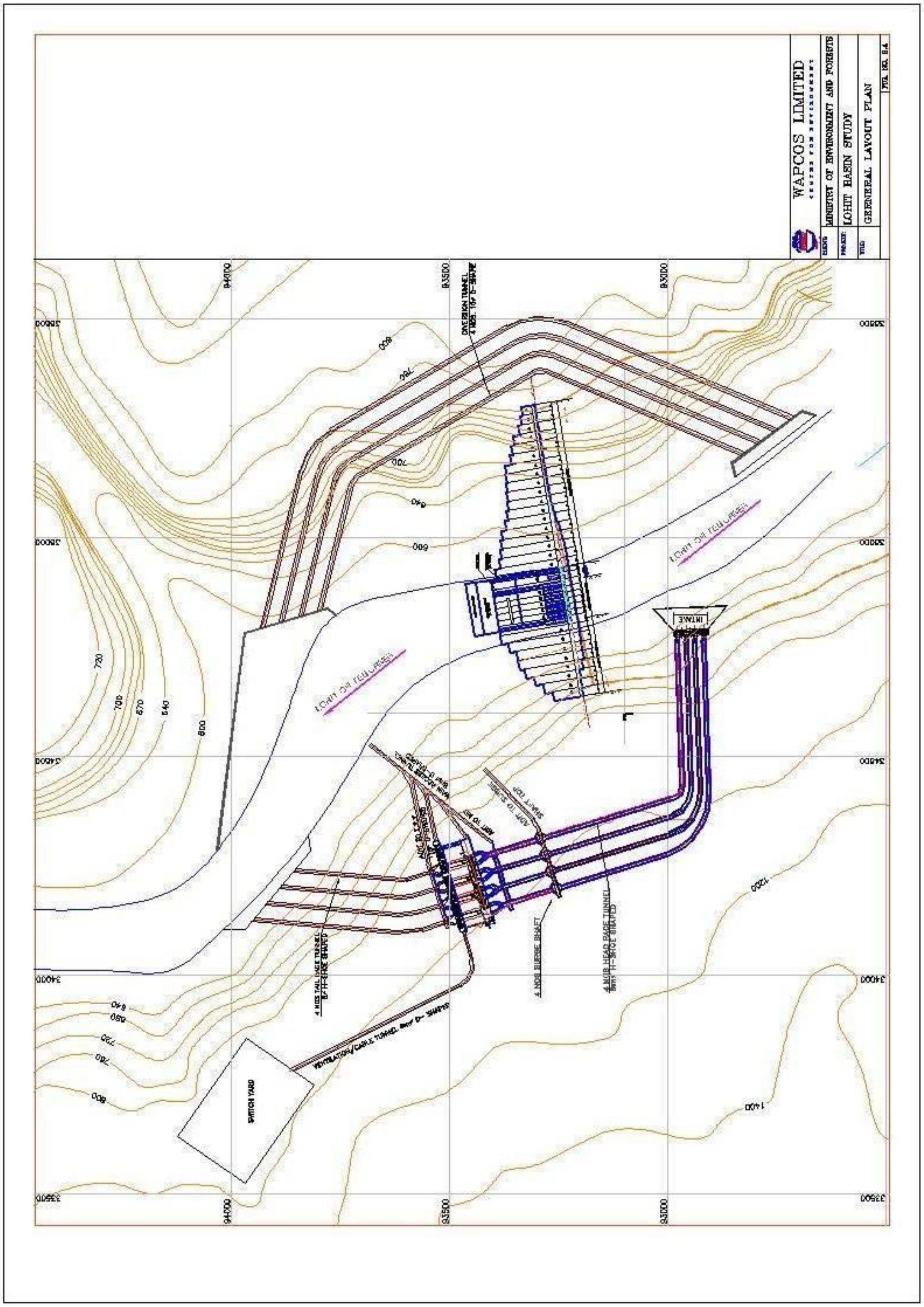
Reservoir	
Maximum Water Level	424.80 m
Full Reservoir Level	424.80 m
Minimum Drawdown Level	408.00 m
Water Spread at FRL	1131 ha
Storage at MWL	516.38 MCM
Storage at FRL	516.38 MCM
Storage at MDDL	345.18 MCM
Live Storage	171.20 MCM
Dam	
Type	Concrete Gravity
Length at top	474.35 m
Overflow	219.70 m
Non-overflow	254.65 m
Top Width	6.00 m
Top Elevation	426.80 m
Maximum Height above deepest foundation	163.12 m
Spillway	
Type	Sluice /Surface Ogee spillway type
Capacity	32300.00cumecs
No. Of Gates	Surface Ogee type– 1No. Sluice spillway – 12 Nos.
Size of Gates	Surface Ogee -12.5m(W)X18.0 m(H) Sluice spillway -8.6m (W) X 11.0 m(H)
Crest Level	Surface Ogee type -406.80 m Sluice spillway -360.00 m
Diversion Tunnels	
Nos, Size & Shape	5Nos.-14.0 m Horse Shoe shaped on right bank and 1No.-6.00m Horse Shoe shaped on left bank,
Length	14.0 m – average length of 1025 m 6.0 m – 900 m length
Design Discharge	12600.00 cumecs
Invert Level at Tunnel Inlet	EL 300.00 m
Power Intake	
Type and Location	Rectangular forebay type with inclined trash rack on right bank of Lohit River inclined at 105° to dam axis
Size	160 m long, 32.57m wide and 48.8 m high
Design Discharge	2085 cumec during monsoon
Pressure Shafts	
Nos., Diameter and type	5 Nos. 10.0 m Dia, underground

	parallel @ 36m c/c
Length	Length varying from 550.0 m to 640.0 m and the average length is 602.0 m
Liner	Steel liner of varying thickness of 28 mm to 36 mm
Power House	
Type and Location	Surface powerhouse on right bank of Lohit River about 650 m downstream of dam axis
Design Discharge	1729 cumec at design head
Design Head	112.00 m (net)
Size	PH Hall: 200.57 m (l) x 28m (w) x 50 m (h)
Type of Turbine and no. of units	Vertical Francis, 5 units of 342 MW each + 1 unit of 40.0 MW
Installed Capacity	1750 MW
Turbine Centre Line Level	El. 291.90 m
Service Bay Level	El. 306.60 m
Minimum Tail Water Level	El. 297.90 m
Tailrace	
Details	Open channel, 165.0 m wide, 130 m long
Power Generation	
Installed Capacity	5 X 342 MW +1 X 40 MW = 1750 MW
Design Energy: Annual generation in 90% Dependable Year at 95% plant availability	6322 Million Units


WAPCOS LIMITED
MINISTRY OF ENVIRONMENT AND FORESTS
LOHIT BASIN STUDY
PROJECT LAYOUT PLAN
Open jungle
EXISTING ROAD
POT HEAD YARD
DIVERSION TUNNEL
U/S COFFER DAM
D/S COFFER DAM


WAPCOS LIMITED
MINISTRY OF ENVIRONMENT AND FORESTS
LOHIT BASIN STUDY
PROJECT LAYOUT PLAN
INTAKE
EXISTING ROAD
POT HEAD YARD


WAPCOS LIMITED
MINISTRY OF ENVIRONMENT AND FORESTS
LOHIT BASIN STUDY
PROJECT LAYOUT PLAN
Blong
Wohal
Tankhlam
Changi
Sak
Tappang
Wam
1604
INTAKE


WAPCOS LIMITED
MINISTRY OF ENVIRONMENT AND FORESTS
LOHIT BASIN STUDY
GENERAL LAYOUT PLAN
INTAKE
SWITCH YARD
LOHIT RIVER

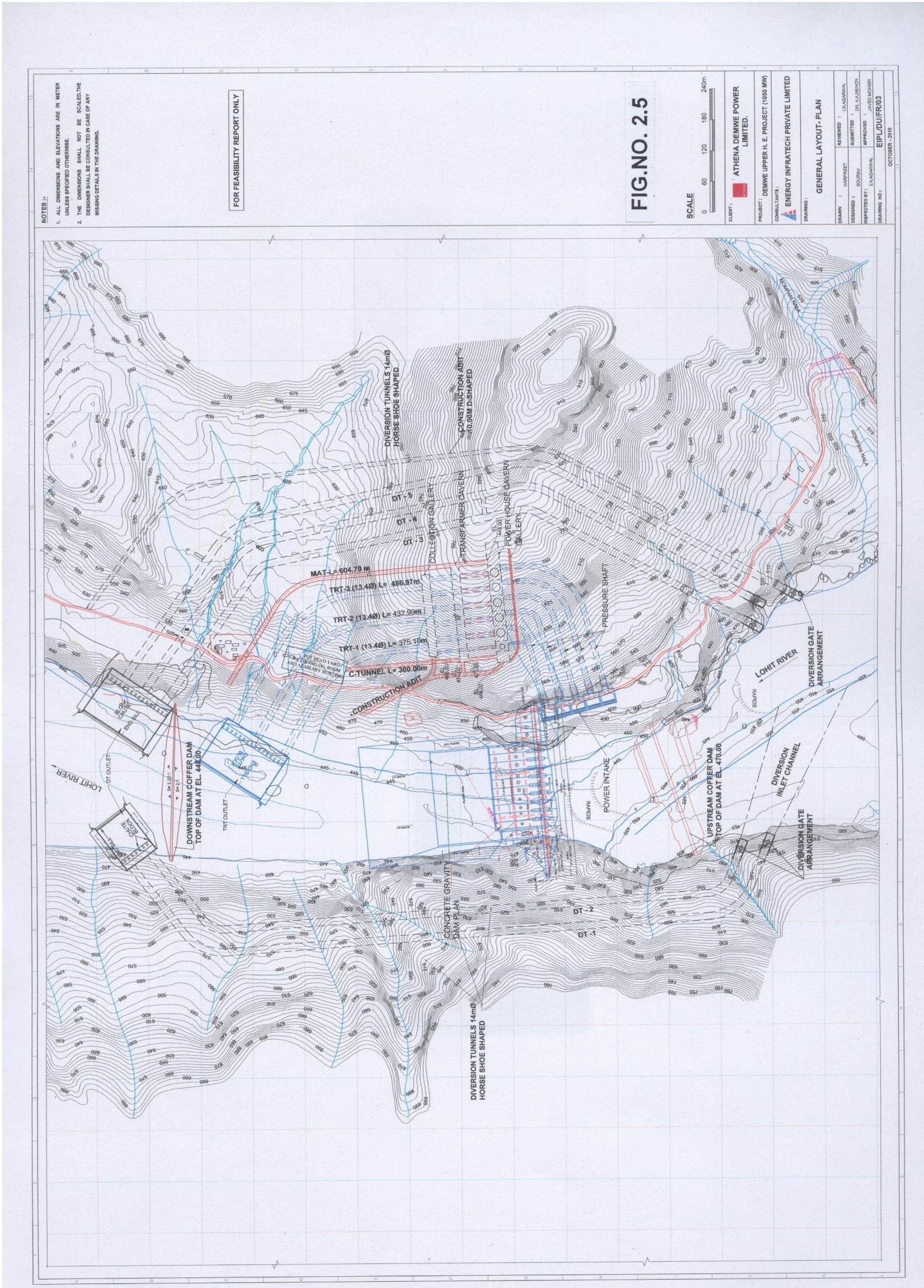
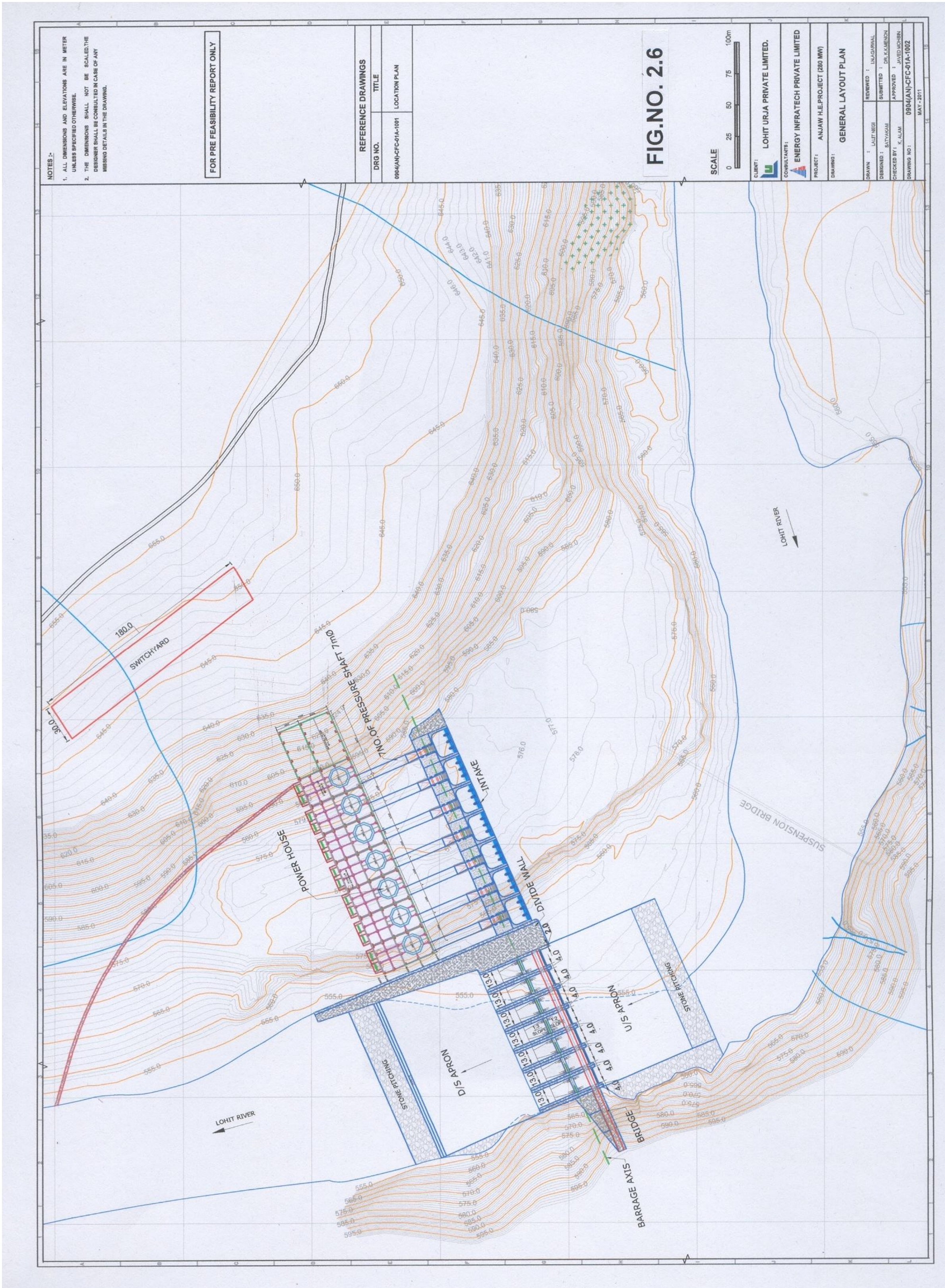


FIG.NO. 2.5
FOR FEASIBILITY REPORT ONLY
NOTES :-
ATHENA DEMWE POWER LIMITED.
DEMWE UPPER H. E. PROJECT (1050 MW)
ENERGY INFRATECH PRIVATE LIMITED
GENERAL LAYOUT- PLAN
EIPL/DU/FR/03
OCTOBER - 2010
LOHIT RIVER
DIVERSION TUNNELS 14mØ HORSE SHOE SHAPED
CONSTRUCTION ADIT
TRANSFORMER CAVERN
POWER HOUSE CAVERN
COLLECTION GALLERY
MAT-L= 604.70 m
TRT-3 (13.4Ø) L= 486.97m
TRT-2 (13.4Ø) L= 432.99m
TRT-1 (13.4Ø) L= 375.10m
C-TUNNEL L= 300.00m
PRESSURE SHAFT
POWER INTAKE
DOWNSTREAM COFFER DAM TOP OF DAM AT EL. 448.00
UPSTREAM COFFER DAM TOP OF DAM AT EL. 470.00
DIVERSION INLET CHANNEL
DIVERSION GATE ARRANGEMENT
CONCRETE GRAVITY DAM PLAN
DT - 1
DT - 2
DT - 3
DT - 4
DT - 5
TRT OUTLET
DT OUTLET


NOTES :-
FOR PRE FEASIBILITY REPORT ONLY
REFERENCE DRAWINGS
LOCATION PLAN
FIG.NO. 2.6
SCALE
LOHIT URJA PRIVATE LIMITED.
ENERGY INFRATECH PRIVATE LIMITED
ANJAW H.E.PROJECT (280 MW)
GENERAL LAYOUT PLAN
0904(AN)-CFC-01A-1002
MAY - 2011
SWITCHYARD
180.0
30.0
7NO.OF PRESSURE SHAFT 7m0
INTAKE
POWER HOUSE
DIVIDE WALL
U/S APRON
D/S APRON
STONE PITCHING
STONE PITCHING
BRIDGE
BARRAGE AXIS
SUSPENSION BRIDGE
LOHIT RIVER
LOHIT RIVER


FOR DETAILED PROJECT REPORT ONLY.
REF. DRAWING
FIG.NO. 2.7
ATHENA DEMWE POWER PRIVATE LIMITED.
DEMWE LOWER H. E. PROJECT (1750 MW)
ENERGY INFRATECH PRIVATE LIMITED
GENERAL LAYOUT PLAN
EIPL/DL/DPR/02
LOHIT RIVER
FLOW
SWITCH-YARD
POWER HOUSE
5 Nos. PENSTOCKS 10.00 m Ø
5 NOS. DIVERSION TUNNELS 14.00 m HORSE SHOE SHAPED
DT - 5
DT - 4
DT - 3
DT - 2
DT - 1
6m D-SHAPED ADIT TO DIVERSION TUNNELS
D/S COFFER DAM TOP EL - 306.00
PROTECTION WALL
TAIL RACE CONDUIT
INTAKE STRUCTURE
MAIN U/S COFFER DAM TOP EL - 331.10
GATE SHAFTS
RIGHT BANK
LEFT BANK
PRE - COFFER DAM
HILL NOSE CUTTING
DIVERSION TUNNEL (DT-6) - 6.00 m HORSE SHOE SHAPED

CHAPTER-3

METHODOLOGY ADOPTED FOR THE STUDY

3.1 GENERAL

The Basin Study is based on collection of relevant data from primary and secondary sources on environmental and baseline parameters. The parameters covered as a part of the study include meteorology, water quality, terrestrial & aquatic ecology. Based on the baseline setting and input loads due to the proposed hydroelectric projects to be developed in the study area, impacts on various facets of environment have been predicted. Environmental management measures have been recommended for amelioration of anticipated impacts. The present chapter describes the methodology adopted for conducting the Basin Study for the Lohit Basin.

3.2 SAMPLING FREQUENCY

The frequency of sampling for various aspects to be covered under primary data collection as a part of the study is given as below:

- Water Quality : Once per month for six months
- Aquatic Ecology : Once per month for six months
- Terrestrial Ecology : Once per season for two seasons

3.3 PRIMARY DATA COLLECTION

As a part of the study, field studies have been conducted for water quality, aquatic and terrestrial ecology. As a part of aquatic ecology, phytoplanktons, zooplanktons, periphyton, benthic invertebrates, primary productivity, fisheries, etc. has been monitored. Physico chemical parameters of water have been monitored for assessing the water quality. Survey of floral and faunal elements was carried out for the terrestrial ecology. The methodology adopted for estimation of various parameters is given in the following sections.

3.3.1 Sampling stations

For water quality and aquatic ecological monitoring, the following five sites were selected at each hydroelectric project and the same are listed as below:

- 5000 m upstream of dam site
- 3000 m upstream of dam site

- Dam site
- 3000 m downstream of dam site
- 5000 m downstream of dam site

For terrestrial ecological monitoring, five sites were covered for each hydroelectric project.

3.3.2 Estimation of density and diversity of Phytoplankton and Zooplanktons in River water

Phytoplanktons are the autotrophic component of the plankton community and play an important role in the primary production process in the stream ecosystems. They serve as a base of the aquatic food web, providing essential ecological function for all aquatic life. In terms of numbers, the important groups of phytoplanktons comprises of diatoms, dinoflagellates, cyanobacteria, and other groups of unicellular algae. In the present study, the density and diversity of phytoplanktons in river water was estimated by collecting the samples from various sites listed in Section 3.3.1.

Methodology

For enumeration of phytoplankton and zooplankton population, 100 lit composite water samples were collected from the river surface up to 60 cm depth and were filtered through a 20 μm net to make 1 lit of bulk sample. The bulk samples so collected were preserved in 5% formalin solution and were brought to the laboratory for analysis. Ten replicate water samples each of 15 ml were made out of the preserved 1 lit bulk sample and were centrifuged at 1500 rpm for 10 minutes. After centrifuging, volume of aliquot concentrate was measured. 1 ml of aliquot concentrate was used for enumeration of phytoplankton population in each replicate. A plankton chamber of 1 ml capacity was used for counting of plankton under a light microscope.

The total number of planktons present in a litre of water sample was calculated using the following formula:

$$N = (n \times v \times 100) / V$$

Where, N= Number of phytoplankton per litre n = average number of plankton cells in 1 ml of aliquot concentrate

v = volume of plankton concentrate (aliquot)

V= volume of water from bulk sample centrifuged

3.3.3 Estimation of density and diversity of Periphytons in River water

Periphytons are a complex mixture of algae, cyanobacteria, heterotrophic microbes, and detritus that is attached to submerged surfaces in most aquatic ecosystems. They serves as an important food source for invertebrates, tadpoles, and some fish. They can also absorb contaminants; removing them from the water column and limiting their movement through the environment. The periphytons are also an important indicator of water quality; responses of this community to pollutants can be measured at a variety of scales representing physiological to community-level changes.

In the present study, periphytic algal component were sampled at various project sites. Samples of periphytic algae were collected by scraping 1 cm^2 area of the substratum on which they were growing. The scraped algae were then put in a small container and brought to the laboratory for identification. Density of the periphytic algae has been expressed in terms of no. per cm^2.

3.3.4 Estimation of density and diversity of Benthic invertebrates in River water

Benthic invertebrates are organisms that live on the bottom of a water body (or in the sediment) and have no backbone. Their size spans 6 to 7 orders of magnitude and they range from microscopic (e.g. micro-invertebrates, <10 microns) to a few tens of centimetres or more in length (e.g. macro-invertebrates, >50 cm). Benthic invertebrates live either on the surface of bed forms (e.g. rock, coral or sediment - epibenthos) or within sedimentary deposits (infauna), and comprise several types of feeding groups e.g. deposit-feeders, filter-feeders, grazers and predators. The abundance, diversity, biomass and species composition of benthic invertebrates can be used as indicators of changing environmental conditions. Construction of dams can impact the benthic invertebrates by alteration of the physical characteristics of the river which includes substratum, current velocity, food availability, water temperature, dissolved oxygen concentration, and water chemistry. Prior to commissioning of power projects on a river an enumeration of the benthic invertebrates in the proposed site is necessary. In the present study, an enumeration of benthic invertebrates was done in order to know their composition, density and diversity in different reaches of the river.

Methodology

Benthic invertebrates were collected from the sampling stations by stirring an area of 1 m^2 and dislodging the substrate to catch the dislodged organisms in a net (0.5 mm mesh) held downstream following Davis (1938). Three replicates were collected at each site. The species were then brought to the laboratory and sorted order-wise for identification and enumeration. The identification was done under stereo-microscope to the lowest possible taxonomic levels following Pennak (1978) and Thirumalai (1989, 1994).

3.3.5 Estimation of Indices

Phytoplankton species diversity indices were calculated using PAST. The following formulas were used in the PAST implementation.

- Simpson index = 1 - dominance (D). Measures 'evenness' of the community from 0 to 1.
- Shannon index. A diversity index taking into account the number of individuals as well as number of taxa. Varies from 0 for communities with only a single taxon to high values for communities with many taxa, each with few individuals. $\overline{H} = -\Sigma \frac{ni}{N} ln\left(\frac{ni}{N}\right)$
- Equitability. Shannon diversity divided by the logarithm of number of taxa. This measures the evenness with which individuals are divided among the taxa present.

3.3.5 Diversity of Ichthyofauna in the Study area

The state of Arunachal Pradesh is the largest in terms of geographical as well as river drainage. It harbors many rivers, streams and streamlets which supports diverse fish species. Recently, Bagra *et al*. (2009) prepared a checklist of 213 species of fishes for Arunachal Pradesh of which 138 species were first hand collections from 35 rivers in the state. Construction of dams might affect the migratory route of the fishes to an extent, but then the entire river course is regularly drained by numerous inlets in forms of small rivers, seasonal nallahs, channels, rivulets and like water sources where these fishes can get refuge during course of their migration to carry out their annual spawning/breeding activity. However there will be some ecological changes in the river course, which will affect the fish composition. Hence, a survey of the fish diversity & important spawning/breeding grounds was made as a part of the study.

Random sampling in selected areas in the river basin was carried out using a cast net at morning (6:00 — 8:00) hours. The sampled fishes were identified using the taxonomic keys (Nath & Dey 2000, Bagra *et al*. 2009, Viswanath NBFGR).

3.3.6 Estimation of Primary productivity in River water

Phytoplanktons are autotrophic, prokaryotic or eukaryotic algae that live near the water surface where there is sufficient light to support photosynthesis. Among the more important groups are the diatoms, cyanobacteria, dinoflagellates and coccolithophores. Phytoplankton accounts for half of all photosynthetic activity on Earth and contribute significantly to primary production process in aquatic ecosystems. Phytoplankton primary productivity is defined as the rate of organic matter production by the growth of planktonic plants.

Methodology

The primary productivity was determined by light and dark bottle method (Wetzel and Likens 1991). The water samples were collected in light and dark BOD bottles. Three replicates were maintained for each sample. The experimental bottles were kept for 6 hours in the river from where the water samples were collected. Winkler’s method was used for determination of oxygen in the light and dark bottles. Following formula was used for calculation of phytoplankton primary productivity.

Gross Primary productivity (GPP) (mgC/m^3/hr) =

$$\frac{(O_2 \text{ content of light bottle} - O_2 \text{ content of dark bottle}) \times 0.375 \times 1000}{1.2 \times \text{Incubation hour}}$$

Net Primary productivity (NPP) (mgC/m^3/hr) =

$$\frac{(O_2 \text{ content of light bottle} - O_2 \text{ content of control bottle}) \times 0.375 \times 1000}{1.2 \times \text{Incubation hour}}$$

3.3.7 Vegetation Survey

Considering the difficult terrain, quadrat method was used for vegetation sampling. The phyto-sociological data for trees and shrubs were collected from random quadrats of 10 x 10 m size laid at the project site. Random quadrats of 1 x 1 m size were laid for the study of herb component at each site.

During survey, number of plants of different species in each quadrat was identified and counted. The height of individual trees was estimated using an Abney level/ Binocular and the DBH of all trees inside the quadrat having height more than 8 m was measured.

Based on the quadrat data, frequency, density and cover (basal area) of each species were calculated. The importance value index (IVI) for different tree species were determined by summing up the Relative Density, Relative Frequency and Relative Cover values. The Relative Density and Relative Frequency values were used to calculate the IVI of shrubs and herbs.

The volume of wood for trees was estimated using the data on DBH (measured at 1.5 m above the ground level) and height. The volume was estimated using the formula: $\pi r^2 h$, where r is the radius and h is the estimated height of the bole of the tree. The data on density and volume were presented in per ha basis.

Two species diversity indices viz., Shannon index of general diversity (H) and Evenness index (e) were computed using PAST software:

- Shannon index. A diversity index taking into account the number of individuals as well as number of taxa. Varies from 0 for communities with only a single taxon to high values for communities with many taxa, each with few individuals. $\overline{H} = -\Sigma\frac{ni}{N}\ln\left(\frac{ni}{N}\right)$

- Buzas and Gibson's evenness index was calculated using the formula: $e^{H}\ /\ S$, where H is the Shannon's index and S represents the number of species.

During the vegetation survey, herbaria were prepared for the plants those had flowers. Rare and endangered species were identified referring to the Red Data Book of India and other available literature, flora and herbarium pertaining to the rare/ endangered species of Arunachal Pradesh.

3.3.8 Faunal Survey

In order to collect the information on the fauna (mammals, birds, herpetofauna) in the study area, primary as well as secondary sources were utilized. Following methods were adopted and referred during the survey of fauna.

I. The Forest Working Plans of the Forest Divisions falling in the respective project areas for secondary information on the wildlife.

II. Interviews of local villagers for ascertaining the presence and relative abundance of various animal species within each locality.

III. Direct sighting and indirect evidences such as calls, signs, tracks and fecal pellets of mammals were recorded along the survey routes taking aid from Prater (1980).

V. A detailed survey of birds was carried out in the project sites using the literatures of Ali & Ripley (1983), Grewal et al. (2002) and Dutta and Basu (2006) as field guides.

VI. The criteria of IUCN (2008), Wildlife Protection Act (1970) and Zoological Survey of India (1994) were followed to describe the conservation status of the species.

3.4 SECONDARY DATA COLLECTION

The following reports/ documents were reviewed and the data as reported in these reports was used as basis for the present report:

- Preliminary Feasibility Report. Main report: Kalai H.E. Project stage I (1450 MW). Arunachal Pradesh.
- Preliminary Feasibility Report. Main report: Kalai H.E. Project stage II (1200 MW). Arunachal Pradesh.
- Preliminary Feasibility Report. Main report: Hutong H.E. Project stage I (750 MW). Arunachal Pradesh.
- Preliminary Feasibility Report. Main report: Hutong H.E. Project stage II (1250 MW). Arunachal Pradesh.
- Pre- Feasibility Report, Demwe Upper Electric Project. 1050 MW (5X205 MW+ 1x 25 MW) Arunachal Pradesh.
- Detailed Project Report and EIA/EMP report of Demwe Lower Hydro Electric Project. 1750 MW (5X342 MW + 1x 40 MW) Arunachal Pradesh.

The meteorological data for the study area was collected from Indian Meteorological Department (IMD) and respective Project Reports. Similarly data on geology was collected from Project Reports. For terrestrial and aquatic ecology both primary as well as Secondary data as available with the Forest Department and other sources was collected.

3.5 SUMMARY OF DATA COLLECTION

The summary of the data collected from various sources is outlined in Table-3.1.

TABLE-3.1
Summary of data collected from various sources

Aspect	Mode of Data collection	Parameters monitored	Frequency	Source
Meteorology	Secondary	Temperature, humidity, rainfall, etc.	-	Indian Meteorological Department (IMD) and Project Reports

Aspect	Mode of Data collection	Parameters monitored	Frequency	Source
Water Resources	Secondary	Flow, Design hydrograph and design flood hydrograph	-	Project Reports
Water Quality	Primary	Physico-chemical and bacteriological parameters	Once per month for six months	Field studies
Geology	Secondary	Geological characteristics of study area	-	Project Reports
Terrestrial Ecology	Primary and secondary	Floral and faunal diversity	Two seasons	Field studies for Summer and Monsoon seasons. Secondary data as available with the Forest Department
Aquatic Ecology	Primary and Secondary	Presence and abundance of various species	Once per month for six months	Field studies and secondary data sources

3.6 IMPACT PREDICTION

Prediction is essentially a process to forecast the future environmental conditions of the study area that might be expected to occur because of implementation of various project. In the present context impact of project activities on existing environment has been predicted using mathematical models and overlay technique (super-imposition of activity on environmental parameter). For intangible impacts qualitative assessment has been done. The following impacts have been studied as a part of the present study:

- Modification in hydrologic regime due to diversion of water for hydropower generation.
- Depth of water available in river stretches during lean season and its assessment of its adequacy vis-à-vis various fish species.

- Length of river stretches with normal flow due to commissioning of various hydroelectric projects due to diversion of flow for hydropower generation.
- Impacts on discharge in river stretch during monsoon and lean seasons due to diversion of flow for hydropower generation.
- Impacts on water users in terms of water availability and quality
- Impacts on aquatic ecology including riverine fisheries as a result of diversion of flow for hydropower generation.
- Assessment of maintaining minimum releases of water during lean season to sustain riverine ecology, maintain water quality and meet water requirements of downstream users.
- Impacts due to loss of forests
- Impacts on RET species & Economically important plant species
- Impacts due to increased human interferences

3.7 OUTCOMES OF THE STUDY

The key outcomes of the study shall be to:

- Provide sustainable and optimal ways of hydropower development of Lohit River, keeping in view of the environmental setting of the basin.
- Assess requirement of environmental flow during lean season with actual flow, depth and velocity at different level.

CHAPTER -4

HYDROLOGY

4.1 INTRODUCTION

The Lohit river basin is the easternmost river basin of India in Arunachal Pradesh with its catchment spreading across international border covering part of Tibet and India. The basin is bounded by China and part of Dibang valley district of Arunachal Pradesh in the north, Changlang district (Burhi Dibang sub basin) in the south, China and hills of Myanmar in the east and Assam state in the west. The Lohit basin is situated between latitude 27° 34′ 00″ N and 29 36′ 00″ N and longitude 95° 38′ 00″ E and 97° 44′ 00″ E. Lohit river passes through deep valleys, narrow gorges and deep green lush forest with high hydropower potential. It is a major component of the Brahmaputra river system. It rises from the snow covered peaks in the eastern Tibet at elevation of 6190 m above msl and has a total length of about 413 km from its source in Tibet to its confluence point with Siang/Dihang near Kobo (WAPCOS, 2005).

4.2 REVIEW OF AVAILABLE INFORMATION

The following reports/ documents were reviewed and the data as reported in these reports was used as basis for the present report:

1. Preliminary feasibility report. Main report: Kalai H.E. Project stage I (1450 MW). Arunachal Pradesh.
2. Preliminary feasibility report. Main report: Kalai H.E. Project stage II (1200 MW). Arunachal Pradesh.
3. Preliminary feasibility report. Main report: Hutong H.E. Project stage I (750 MW). Arunachal Pradesh.
4. Preliminary feasibility report. Main report: Hutong H.E. Project stage II (1250 MW). Arunachal Pradesh.
5. Pre-feasibility report. Demwe Upper Electric Project. Arunachal Pradesh. 1050 MW (5X205 MW+ 1x25MW).

6. Detailed Project Report. Demwe Lower Hydro Electric Project. Arunachal Pradesh, 1750 MW (5X342 MW + 1x40MW).

4.3 DATA AVAILABILITY

The long term gauge & discharge (G&D) observations were collected from two sites: Hayuliang and Mompani. Hayuliang G&D site is located 67 km downstream of Kalai HEP Stage-1 and 18 km downstream from Hutong HEP Stage-2 site. At this site, the observed ten daily flows are available from 1984-85 up to 1994-95 (11 years). Mompani G&D site is located 98 km downstream of Kalai HEP Stage-1 and 49 km downstream from Hutong HEP Stage-2 site and the observed ten daily flows are available from 1984-85 up to 2002-03 (19 years). The location of proposed project sites along Lohit River and the G&D stations is shown in Figure-4.1. In both G&D stations, data available is "Ten daily data", with some missing values in different years. The gaps were filled by interpolation from the discharges for the adjacent 10-daily data for the same month. The consistency of data was checked based on double mass curve technique on annual basis. Correlation studies between these two sites were carried out and the data was found to be consistent (WAPCOS, 2005).

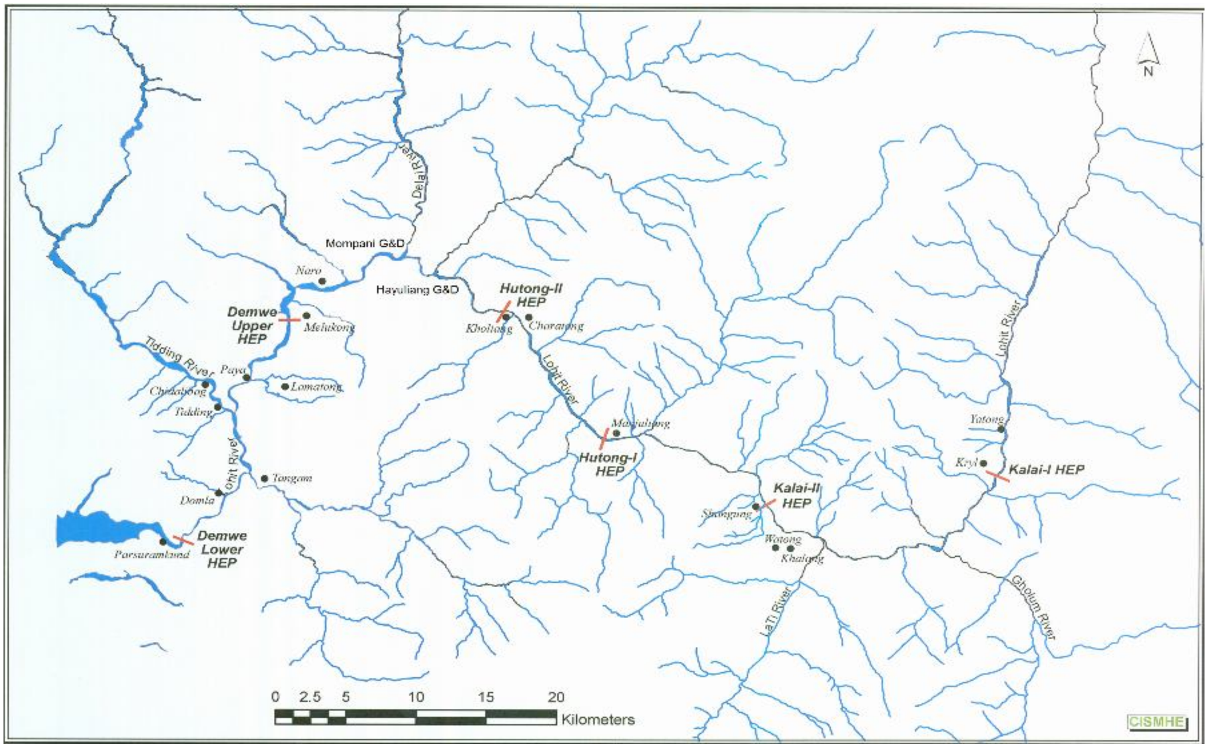


Figure-4.1: Location of proposed project sites along Lohit River and G&D stations

4.4 DATA GENERATION

In order to have stage discharge data at all the sites for a uniform period of time, following interpolations were carried out:

For Discharge data at Kalai & Hutong Projects

Hayuliang G&D station is nearest to these places. However, it has only 11 years (1984-85 to 1994-95) of records. In order to have data for 19 years, a series having the observed data from Hayuliang G & D site and data derived from 1995-96 to 2002-03 using observed data at Mompani G & D site, is prepared. This integrated series is used for preparing series of discharges at Kalai and Hutong projects is shown in Figure-4.2. The series of data for Kalai HEP Stage-1, Kalai HEP Stage-2, Hutong HEP Stage-1 and Hutong HEP Stage-2 are prepared using catchment area-proportion technique from May 1984 to April 2003.

For Discharge data at Demwe Projects

The observed discharge data of Mompani G & D site, which is available from 1984-85 to 2003-04 with some missing months, is used for these projects. For this site, the continuous data available is from 1987-88 to 2003-04 with some interpolated filled up data. In order to estimate the rainfed contribution in Mompani data, snow melt by a rate of 5 mm/day for the period of April to September is subtracted. After this, a new reduction was made to the entire series using a correction factor of 0.8275 in order to take care of the higher specific yield at Mompani as comapred to Hayuliang.

In order to obtain the discharge at Demwe Upper project site, snow melt contribution is added to the reduced Mompani discharges.. The schematic diagram adopted for estimation of discharges at various project sites is enclosed as Figure 4.2.

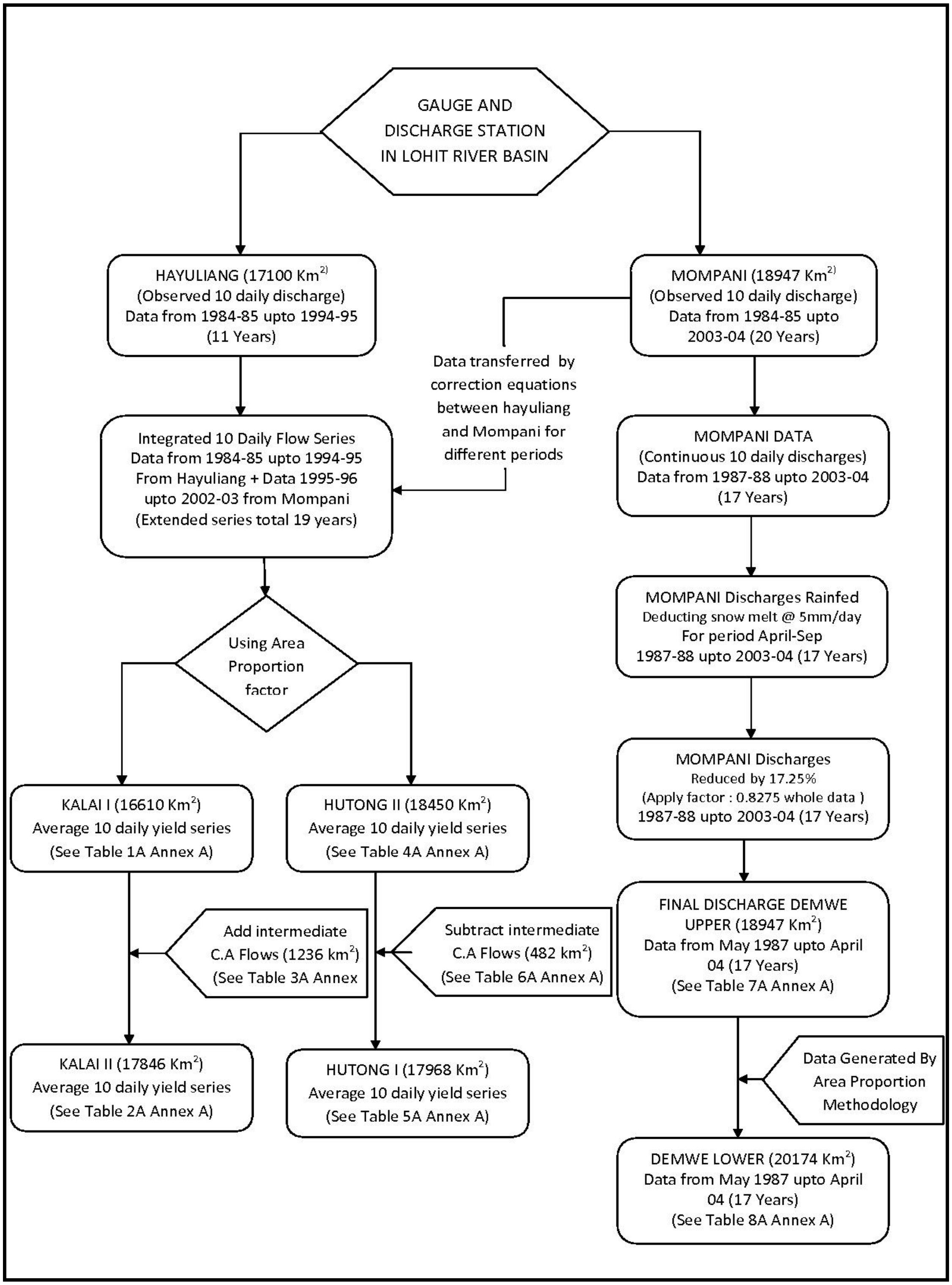


Figure-4.2 Data generation from different sites

4.5 DATA ANALYSIS

Data at different sites do not have the same base years. Hence, data analysis for three different cases was carried out. These are listed in the following paragraphs.

CASE I: Dependable flow analysis using flow series without any arrangement. That means data series with different length of years. For example, Kalai HEP Stage-1, Kalai HEP Stage-2, Hutong HEP Stage-1 and Hutong HEP Stage-2 data for 19 years (instead of 20 as 2003-04 data is not complete) has been used. For Demwe Upper and Demwe Lower Hydroelectric project sites, 17 years data is used. These are shown as Tables-1 to 8 with "Average Ten Daily Flow Series" in Annexure-IV for this case.

CASE II: Data series with common years (1987-1988 to 2002-2003) and 16 years only was used. The "Average Ten Daily Flow Series" for this case are shown in Tables-9 to 16 of Annexure-V.

CASE III: This case consider the data series for 20 years (from 1984-1985 to 2003-2004) in all proposed hydroelectric projects. The series are extended using area-proportion method. The "Average Ten Daily Flow Series" for this case are shown in Tables-17 to 24 of Annexure-VI.

In all three cases, using these 10-daily flow values, following is estimated:

- 10 daily average, maximum, minimum, and corresponding standard deviation values are estimated.
- Annual average (cumec-day) and Annual volume (MCM).
- Total Annual Average discharge in cumec.

The summary of this information for the three cases is given in Tables-4.1 to 4.3 respectively.

TABLE-4.1
Total Annual Average Discharge at proposed sites (Case I)

Proposed Site	C.A. (km^2)	Total Annual Average Discharge (cumec)	Maximum Discharge (cumec)	Minimum Discharge (cumec)	Standard Deviation of Discharge (cumec)
Kalai HEP Stage-1	16610	967	3603	156	360
Kalai HEP Stage-2	17846	1039	3871	176	386
Hutong HEP Stage-1	17968	1046	3897	169	389
Hutong HEP Stage-2	18450	1074	4002	173	400
Demwe Upper HEP	18947	1176	4070	251	417
Demwe Lower HEP	20174	1234	4273	263	438

TABLE-4.2
Total Annual Average Discharge at proposed sites(Case II)

Proposed Site	C.A. (km^2)	Total Annual Average Discharge (cumec)	Maximum Discharge (cumec)	Minimum Discharge (cumec)	Standard Deviation of Discharge (cumec)
Kalai HEP Stage-1	16610	1024	3603	156	346
Kalai HEP Stage-2	17846	1100	3871	176	371
Hutong HEP Stage-1	17968	1107	3897	169	374
Hutong HEP Stage-2	18450	1137	4002	173	384
Demwe Upper HEP	18947	1206	4070	251	408
Demwe Lower HEP	20174	1266	4273	263	429

TABLE-4.3
Total Annual Average Discharge at proposed sites(Case III)

Proposed Site	C.A. (km^2)	Total Annual Average Discharge (cumec)	Maximum Discharge (cumec)	Minimum Discharge (cumec)	Standard Deviation of Discharge (cumec)
Kalai HEP Stage-1	16610	947	3603	156	363
Kalai HEP Stage-2	17846	1017	3871	176	390
Hutong HEP Stage-1	17968	1024	3897	169	393
Hutong HEP Stage-2	18450	1051	4002	173	404
Demwe Upper HEP	18947	1122	4070	239	425
Demwe Lower HEP	20174	1180	4273	254	445

4.6 DEPENDABILITY OF FLOW

Further, in order to know the dependability of flow, the following exercises were carried out for the three cases being studied as a part of the study:

- 90% dependability year among corresponding years.
- 90% dependable flow from 90% dependable year.
- Flow duration curve with the original data series for each proposed site

4.6.1 CASE-I: Dependable flow analysis using flow series without any arrangement

he Dependability years for Case-I for Kalai HEP Stage-1 and Stage-2 are given in Table-4.4.

TABLE-4.4

Dependability year for Kalai HEP Stage-1 and Stage-2 (Case I)

Rank	Year	Calcs for 90% Dependable year Kalai I		Calcs for 90% Dependable year Kalai II	
		A.V.Discharge (cumec)	% Time	A.V.Discharge (cumec)	% Time
1	1986-87	423	95	455	95
2	2002-03	553	90	594	90
3	1992-93	701	85	753	85
4	1984-85	759	80	816	80
5	1985-86	812	75	872	75
6	2001-02	812	70	872	70
7	1994-95	885	65	951	65
8	1987-88	934	60	1003	60
9	1990-91	964	55	1036	55
10	1989-90	967	50	1039	50
11	1991-92	1023	45	1099	45
12	1993-94	1034	40	1111	40
13	1995-96	1091	35	1172	35
14	1999-00	1151	30	1237	30
15	1988-89	1185	25	1273	25
16	1998-99	1189	20	1278	20
17	2000-01	1239	15	1331	15
18	1997-98	1285	10	1380	10
19	1996-97	1368	5	1470	5

The Dependability years for Case-I for Hutong HEP Stage-1 and Stage-2 are given in Table-4.5.

TABLE-4.5

Dependability year for Hutong HEP Stage-1 and Stage-2 (Case I)

Rank	Year	Calcs for 90% Dependable year Hutong I		Calcs for 90% Dependable year Hutong II	
		A.V.Discharge (cumec)	% Time	A.V.Discharge (cumec)	% Time
1	1986-87	458	95	470	95
2	2002-03	598	90	615	90
3	1992-93	758	85	778	85
4	1984-85	821	80	843	80
5	1985-86	878	75	902	75
6	2001-02	878	70	902	70
7	1994-95	958	65	983	65
8	1987-88	1010	60	1037	60
9	1990-91	1043	55	1071	55
10	1989-90	1046	50	1074	50
11	1991-92	1107	45	1136	45
12	1993-94	1119	40	1149	40
13	1995-96	1180	35	1212	35
14	1999-00	1246	30	1279	30
15	1988-89	1282	25	1316	25
16	1998-99	1287	20	1321	20
17	2000-01	1340	15	1376	15
18	1997-98	1390	10	1427	10
19	1996-97	1479	5	1519	5

The Dependability years for Case-I for Demwe Upper HEP and Demwe Lower HEP are given in Table-4.6.

TABLE-4.6

Dependability year for Demwe Upper HEP and Lower HEP (Case I)

Rank	Year	Calcs for 90% Dependable year Demwe Upper		Calcs for 90% Dependable year Demwe Lower	
		A.V.Discharge (cumec)	% Time	A.V.Discharge (cumec)	% Time
1	2002-03	666	94.44	699	94.44
2	2003-04	689	88.89	724	88.89
3	1994-95	846	83.33	888	83.33

Rank	Year	Calcs for 90% Dependable year Demwe Upper		Calcs for 90% Dependable year Demwe Lower	
		A.V.Discharge (cumec)	% Time	A.V.Discharge (cumec)	% Time
4	1992-93	942	77.78	989	77.78
5	2001-02	960	72.22	1008	72.22
6	1987-88	1071	66.67	1125	66.67
7	1989-90	1141	61.11	1198	61.11
8	1995-96	1159	55.56	1217	55.56
9	1993-94	1160	50.00	1218	50.00
10	1990-91	1245	44.44	1307	44.44
11	1988-89	1360	38.89	1428	38.89
12	1991-92	1365	33.33	1433	33.33
13	1999-00	1368	27.78	1437	27.78
14	2000-01	1441	22.22	1513	22.22
15	1998-99	1445	16.67	1518	16.67
16	1997-98	1504	11.11	1579	11.11
17	1996-97	1622	5.56	1703	5.56

The summary of Dependability years for Case-I for the six hydroelectric projects in the study area are given in Table-4.7.

TABLE-4.7

Different flow dependability at each proposed site for Case-I

Proposed Site	Flow for different dependability (cumec)		
	90 %	75 %	50 %
Kalai HEP Stage-1	301	401	693
Kalai HEP Stage-2	323	430	744
Hutong HEP Stage-1	325	433	753
Hutong HEP Stage-2	334	445	770
Demwe Upper HEP	371	512	918
Demwe Lower HEP	389	537	964

4.6.2 CASE II: Data series with common years (1987-1988 to 2002-2003)

The Dependability years for Case-II for Kalai HEP Stage-1 and Stage-2 are given in Table-4.8.

TABLE-4.8

Dependability year for Kalai HEP Stage-1 and Stage-2 (Case -II)

Rank	Year	Calcs for 90% Dependable year Kalai I		Calcs for 90% Dependable year Kalai II	
		A.V.Discharge (cumec)	% Time	A.V.Discharge (cumec)	% Time
1	2002-03	553	94.12	594	94.12
2	1992-93	701	88.24	753	88.24
3	2001-02	812	82.35	872	82.35
4	1994-95	885	76.47	951	76.47
5	1987-88	934	70.59	1003	70.59
6	1990-91	964	64.71	1036	64.71
7	1989-90	967	58.82	1039	58.82
8	1991-92	1023	52.94	1099	52.94
9	1993-94	1034	47.06	1111	47.06
10	1995-96	1091	41.16	1172	41.16
11	1999-00	1151	35.29	1237	35.29
12	1988-89	1185	29.41	1273	29.41
13	1998-99	1189	23.53	1278	23.53
14	2000-01	1239	17.65	1331	17.65
15	1997-98	1285	11.76	1380	11.76
16	1996-97	1368	5.88	1470	5.88

The Dependability years for Case-II for Hutong HEP Stage-1 and Stage-2 are given in Table-4.9.

TABLE-4.9

Dependability year for Hutong HEP Stage-1 and Stage-2 (Case -II)

Rank	Year	Calcs for 90% Dependable year Hutong I		Calcs for 90% Dependable year Hutong II	
		A.V.Discharge (cumec)	% Time	A.V.Discharge (cumec)	% Time
1	2002-03	598	94.12	615	94.12
2	1992-93	758	88.24	778	88.24
3	2001-02	878	82.35	902	82.35

Rank	Year	Calcs for 90% Dependable year Hutong I		Calcs for 90% Dependable year Hutong II	
		A.V.Discharge (cumec)	% Time	A.V.Discharge (cumec)	% Time
4	1994-95	958	76.47	983	76.47
5	1987-88	1010	70.59	1037	70.59
6	1990-91	1043	64.71	1071	64.71
7	1989-90	1046	58.82	1074	58.82
8	1991-92	1107	52.94	1136	52.94
9	1993-94	1119	47.06	1149	47.06
10	1995-96	1180	41.16	1212	41.16
11	1999-00	1246	35.29	1279	35.29
12	1988-89	1282	29.41	1316	29.41
13	1998-99	1287	23.53	1321	23.53
14	2000-01	1340	17.65	1376	17.65
15	1997-98	1390	11.76	1427	11.76
16	1996-97	1479	5.88	1519	5.88

The Dependability years for Case-II for Demwe Upper HEP and Demwe Lower HEP are given in Table-4.10.

TABLE-4.10
Dependability year for Demwe Upper HEP and Lower HEP (Case-II)

Rank	Year	Calcs for 90% Dependable year Demwe Upper		Calcs for 90% Dependable year Demwe Lower	
		A.V.Discharge (cumec)	% Time	A.V.Discharge (cumec)	% Time
1	2002-03	666	94.12	699	94.12
2	1994-95	846	88.24	888	88.24
3	1992-93	942	82.35	989	82.35
4	2001-02	960	76.47	1008	76.47
5	1987-88	1071	70.59	1125	70.59
6	1989-90	1141	64.71	1198	64.71
7	1995-96	1159	58.82	1217	58.82
8	1993-94	1160	52.94	1218	52.94
9	1990-91	1245	47.06	1307	47.06
10	1988-89	1360	41.16	1428	41.16
11	1991-92	1365	35.29	1433	35.29
12	1999-00	1368	29.41	1437	29.41
13	2000-01	1441	23.53	1518	23.53
14	1998-99	1445	17.65	1579	17.65
15	1997-98	1504	11.76	1579	11.76
16	1996-97	1622	5.88	1703	5.88

The summary of Dependability years for Case-II for the six hydroelectric projects in the study area are given in Table-4.11.

TABLE-4.11

Different flow dependability at each proposed site (Case II)

Proposed Site	Flow for different dependability (cumec)		
	90 %	75 %	50 %
Kalai HEP Stage-1	317	413	776
Kalai HEP Stage-2	340	443	819
Hutong HEP Stage-1	343	446	839
Hutong HEP Stage-2	352	458	862
Demwe Upper HEP	378	518	981
Demwe Lower HEP	397	544	1030

4.6.3 CASE-III: data series for 20 years (from 1984-1985 to 2003-2004)

The Dependability years for Case-III for Kalai HEP Stage-1 and Stage-2 are given in Table-4.12.

TABLE-4.12
Dependability year at Kalai sites (Case III)

Rank	Year	Calcs for 90% Dependable year Kalai I		Calcs for 90% Dependable year Kalai II	
		A.V.Discharge (cumec)	% Time	A.V.Discharge (cumec)	% Time
1	1986-87	423	95.24	455	95.24
2	2002-03	553	90.48	594	90.48
3	2003-04	557	85.71	598	85.71
4	1992-93	701	80.96	753	80.96
5	1984-85	759	76.19	816	76.19
6	1985-86	812	71.43	872	71.43
7	2001-02	812	66.69	872	66.69
8	1994-95	885	61.90	951	61.90
9	1987-88	934	57.14	1003	57.14
10	1990-91	964	52.38	1036	52.38
11	1989-90	967	47.62	1039	47.62
12	1991-92	1023	42.86	1099	42.86
13	1993-94	1034	38.10	1111	38.10
14	1995-96	1091	33.33	1172	33.33

Rank	Year	Calcs for 90% Dependable year Kalai I		Calcs for 90% Dependable year Kalai II	
		A.V.Discharge (cumec)	% Time	A.V.Discharge (cumec)	% Time
15	1999-00	1151	28.57	1237	28.57
16	1988-89	1185	23.81	1273	23.81
17	1998-99	1189	19.05	1278	19.05
18	2000-01	1239	14.28	1331	14.28
19	1997-98	1285	9.52	1380	9.52
20	1996-97	1368	4.76	1470	4.76

The Dependability years for Case-III for Hutong HEP Stage-1 and Stage-2 are given in Table-4.13.

TABLE-4.13

Dependability year at Hutong sites (Case III)

Rank	Year	Calcs for 90% Dependable year Hutong I		Calcs for 90% Dependable year Hutong II	
		A.V.Discharge (cumec)	% Time	A.V.Discharge (cumec)	% Time
1	1986-87	458	95.24	470	95.24
2	2002-03	598	90.48	615	90.48
3	2003-04	602	85.71	618	85.71
4	1992-93	758	80.96	778	80.96
5	1984-85	821	76.19	843	76.19
6	1985-86	878	71.43	902	71.43
7	2001-02	878	66.69	902	66.69
8	1994-95	958	61.90	983	61.90
9	1987-88	1010	57.14	1037	57.14
10	1990-91	1043	52.38	1071	52.38
11	1989-90	1046	47.62	1074	47.62
12	1991-92	1107	42.86	1136	42.86
13	1993-94	1119	38.10	1149	38.10
14	1995-96	1180	33.33	1212	33.33
15	1999-00	1246	28.57	1279	28.57
16	1988-89	1282	23.81	1316	23.81
17	1998-99	1287	19.05	1321	19.05
18	2000-01	1340	14.28	1376	14.28
19	1997-98	1390	9.52	1427	9.52
20	1996-97	1479	4.76	1519	4.76

The Dependability years for Case-II for Demwe Upper HEP and Demwe Lower HEP are given in Table-4.14.

TABLE-4.14

Dependability year for Demwe Upper HEP and Lower HEP (Case-III)

Rank	Year	Calcs for 90% Dependable year Demwe Upper		Calcs for 90% Dependable year Demwe Lower	
		A.V.Discharge (cumec)	% Time	A.V.Discharge (cumec)	% Time
1	1986-87	524	95.24	558	95.24
2	2002-03	666	90.48	699	90.48
3	2003-04	689	85.71	724	85.71
4	1994-95	846	80.96	888	80.96
5	1984-85	940	76.19	989	76.19
6	1992-93	942	71.43	996	71.43
7	2001-02	960	66.69	1008	66.69
8	1985-86	1000	61.90	1065	61.90
9	1987-88	1071	57.14	1125	57.14
10	1989-90	1141	52.38	1198	52.38
11	1995-96	1159	47.62	1217	47.62
12	1993-94	1160	42.86	1218	42.86
13	1990-91	1245	38.10	1307	38.10
14	1988-89	1360	33.33	1428	33.33
15	1991-92	1365	28.57	1433	28.57
16	1999-00	1368	23.81	1437	23.81
17	2000-01	1441	19.05	1513	19.05
18	1998-99	1445	14.28	1518	14.28
19	1997-98	1504	9.52	1579	9.52
20	1996-97	1622	4.76	1703	4.76

The summary of Dependability years for Case-II for the six hydroelectric projects in the study area are given in Table-4.15.

TABLE-4.15

Different flow dependability at each proposed site (Case III) considering all years (1984-85 to 2003-04)

Proposed Site	Flow for different dependability (cumec)		
	90 %	75 %	50 %
Kalai HEP Stage-1	297	393	659
Kalai HEP Stage-2	319	422	708
Hutong HEP Stage-1	322	425	713
Hutong HEP Stage-2	330	437	732
Demwe Upper HEP	355	487	817
Demwe Lower HEP	373	511	860

4.7 SUMMARY OF ANALYSIS

The summary of annual average flow (considering total years) for all the three cases is shown in Table-4.16.

TABLE-4.16
Annual Average Flow (AAF), Q_{90}, Q_{75}, Q_{50} (based on 1984-85 to 2003-04) for Proposed Sites

Site	CASE I				CASE II				CASE III			
	AAF	$Q_{90\%}$	$Q_{75\%}$	$Q_{50\%}$	AAF	$Q_{90\%}$	$Q_{75\%}$	$Q_{50\%}$	AAF	$Q_{90\%}$	$Q_{75\%}$	$Q_{50\%}$
Kalai HEP Stage-1	967	301	401	693	1024	317	413	776	947	297	393	659
Kalai HEP Stage-2	1039	323	430	744	1100	340	443	819	1017	319	422	708
Hutong HEP Stage-1	1046	325	433	753	1107	343	446	839	1024	322	425	713
Hutong HEP Stage-2	1074	334	445	770	1137	352	458	862	1051	330	437	732
Demwe Upper HEP	1176	371	512	918	1206	378	518	981	1122	355	487	817
Demwe Lower HEP	1234	389	537	964	1266	397	544	1030	1180	373	511	860

Note: All values are in cumec.

It may be observed that in all the three cases of analysis, the total annual flow is increasing with increasing basin area. That means the recorded data has a logic sequence. The values of annual average flow are of same order in cases I & III. Also, values of Q_{90}, Q_{75} and Q_{50} from Flow Duration Curve (FDC) are similar in these two cases (Table-4.16). The higher value of AAF occurs in case II, where only 16 years of data is considered (from 1987-1988 upto 2002-2003). After observing the original data, it is seen that years corresponding to 1986-87 and 2003-04 are very dry years, and these years are excluded in case II, that is why the average values are greater in this case.

4.8 DEPENDABILITY YEAR

From hydropower development point of view, the availability of water for a given percentage of time is important. Generally, 90 % dependable flow of 90% dependable year is considered for reliable power production. The analysis has been carried out to estimate the 90% dependable flow for 90 % dependable year for all the three cases and is shown in Table-4.17.

TABLE-4.17

90 % Dependable Year, AAF, and $Q_{90\ \%}$ for different proposed sites

Site	CASE-I			CASE-II			CASE-III		
	90% Dep Yr	AAF	Q90	90% Dep Yr	AAF	Q90	90% Dep Yr	AAF	Q90
Kalai HEP Stage-1	2002-03	553	297	1992-93	701	187	2003-04	557	258
Kalai HEP Stage-2	2002-03	594	319	1992-93	753	201	2003-04	598	278
Hutong HEP Stage-1	2002-03	598	322	1992-93	758	202	2003-04	602	279
Hutong HEP Stage-2	2002-03	615	330	1992-93	778	208	2003-04	618	287
Demwe Upper HEP	2003-04	689	320	1994-95	846	338	2002-03	666	338
Demwe Lower HEP	2003-04	724	336	1994-95	888	355	2002-03	699	355

It may be noticed that the dependability year is changing depending of the case of analysis and also change with site. For example, in case I, the 90% dependable year corresponds to 2002-03 in Kalai & Hutong sites, but in Demwe, it is corresponding to 2003-04. In case II, the 90% dependable year corresponds to 1992-93 in Kalai & Hutong sites, but in Demwe, it is corresponding to 1994-95. For case III, the 90% dependable year corresponds to 2002-03 for Upper Demwe and Lower Demwe hydroelectric projects and 2003-04 for other four projects being considered as a part of the study. For 75% dependability, the year is 1985-86 for Kalai I & II, Hutong I & II. However for Demwe upper it is 1992-93 and for Demwe

Lower it is 1984-85. Further, it may be noticed that 50% dependable year in all cases is 1996-97. The Tables 4.12 to 4.14 show the corresponding Average Annual Flows.

As case III takes in to account data for larger duration, it is considered as representative for further analysis. The Average Annual flow on the basis of all years flow, dependable year, Average Annual Flow, and corresponding 90 % dependable flow for 90 % dependable year for various sites for this case is shown in Table 4.18.

TABLE-4.18

AAF, 90 % dependable flow ($Q_{90\%}$) for 90 % dependable year, and AAF for 90% and 50 % dependable years

Site	Av. Annual Flow (1984-85 to 2003-04)	90 % dependable year	90 % dependable Flow ($Q_{90\%}$) (2003-04)	Av. Annual Flow for 90 % dependable year (2003-04)	Av. Annual Flow for 50 % dependable year (1996-97)
Kalai HEP Stage-1	947	2003-04	258	557	1368
Kalai HEP Stage-2	1017	2003-04	278	598	1470
Hutong HEP Stage-1	1024	2003-04	279	602	1479
Hutong HEP Stage-2	1051	2003-04	287	618	1519
Demwe Upper HEP	1122	2002-03	338	666	1141
Demwe Lower HEP	1180	2002-03	355	699	1198

4.9 FLOW DURATION CURVES

The Flow Duration Curves for total data in case III (1984-85 upto 2003-04) and for 90% dependable year (2003-04) for all the six proposed sites in Lohit river basin are shown in Figures 4.3 to 4.8 respectively. The summary of flow duration curve data for various hydroelectric projects is given in Tables-4.19 to 4.24.

Figure -4.3: Flow Duration Curve at Kalai HEP Satge-1 with Total Data Case III and 90% Dependable year

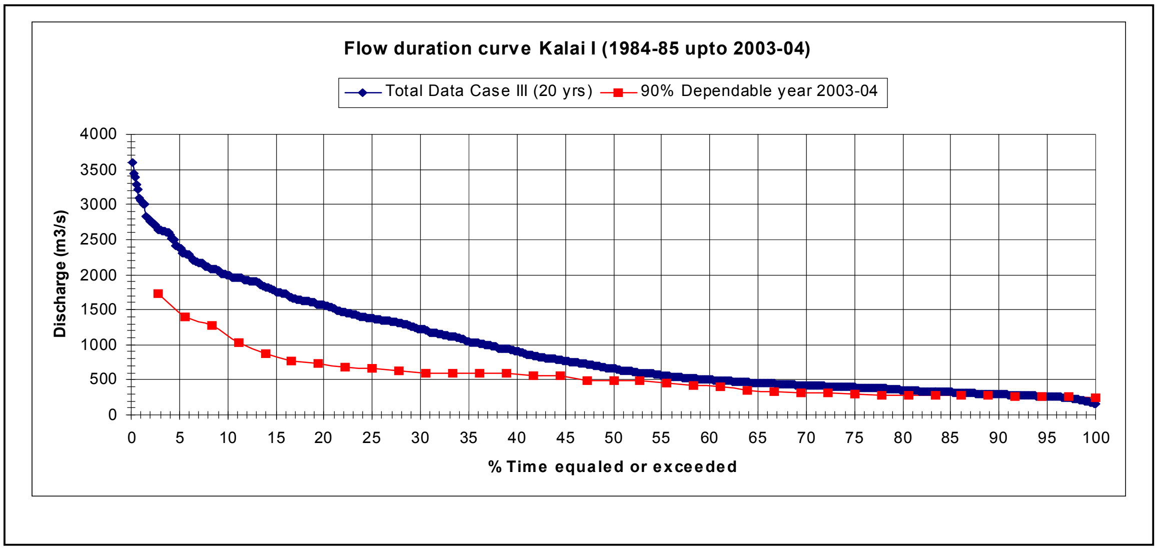


Figure -4.4 Flow Duration Curve at Kalai HEP Stage-2 with Total Data Case III and 90% Dependable year

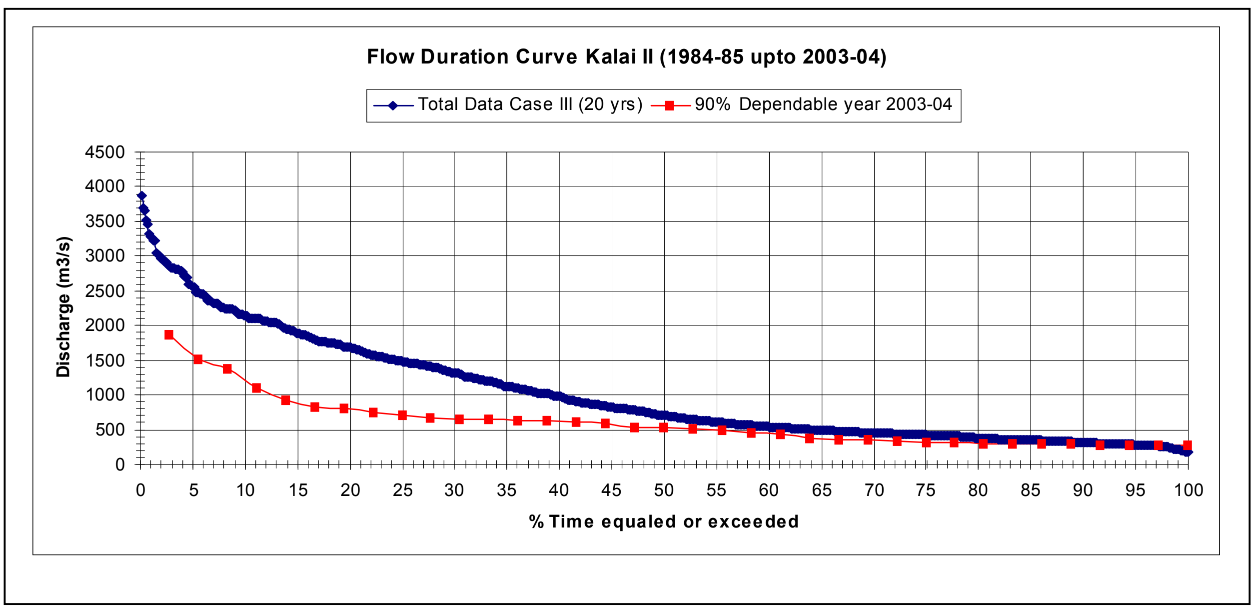


Figure-4.5 Flow Duration Curve at Hutong HEP Satge-1 with Total Data Case III and 90% Dependable year

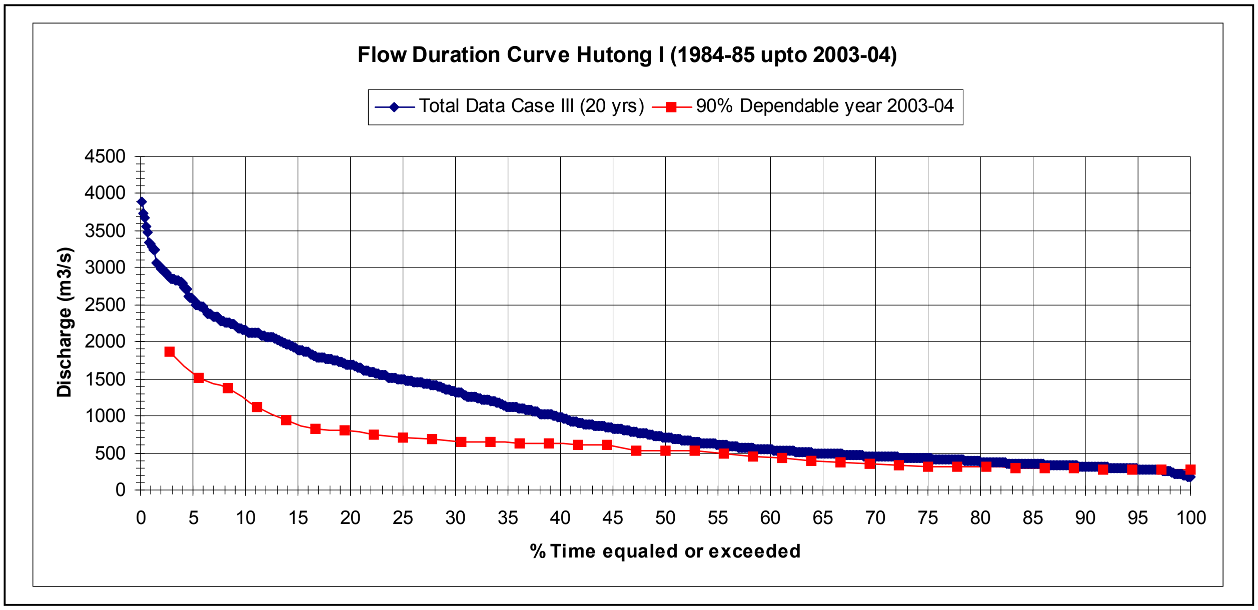


Figure-4.6 Flow Duration Curve at Hutong HEP Stage-2 with Total Data Case III and 90% Dependable year

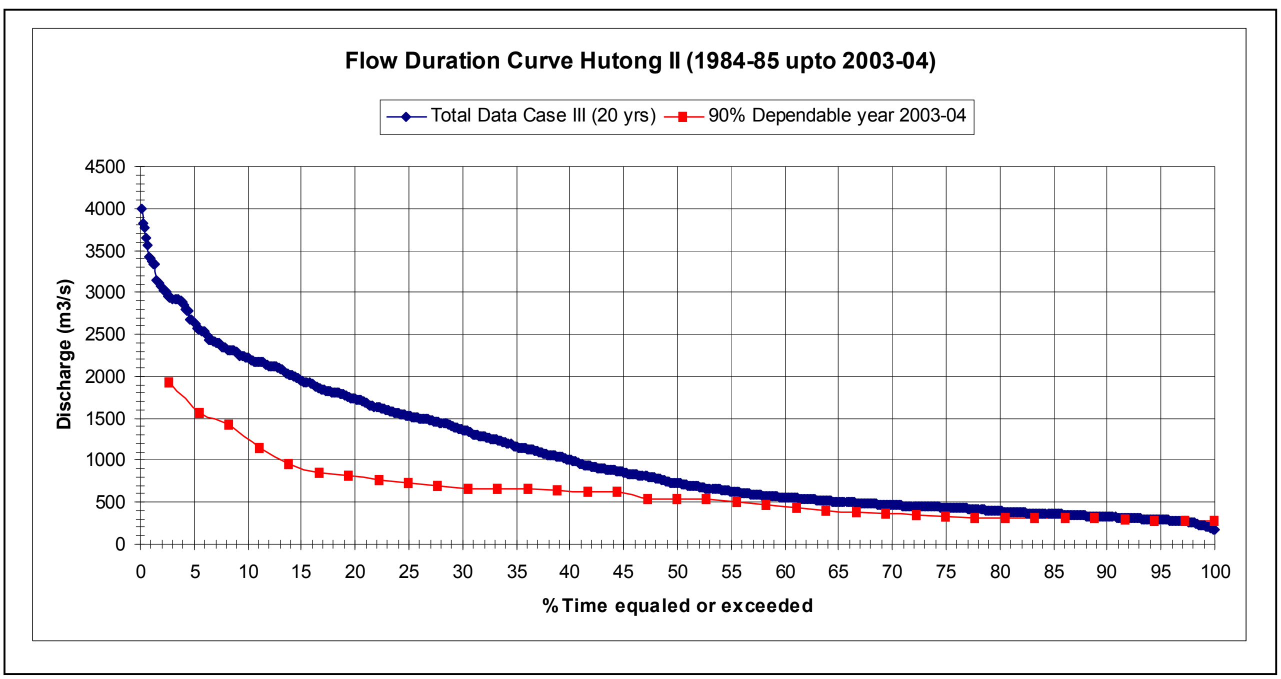


Figure-4.7 Flow Duration Curve at Demwe Upper HEP Total Data Case III and 90% Dependable year

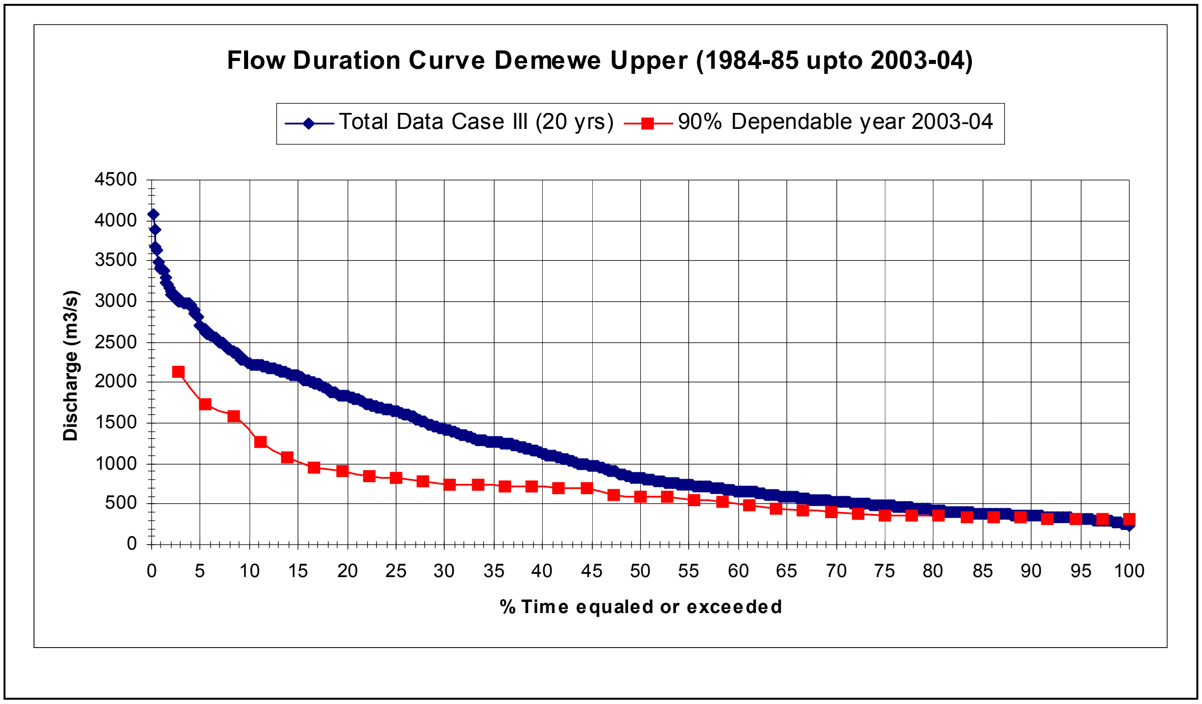


Figure-4.8 Flow Duration Curve at Demwe Lower HEP with Total Data Case III and 90% Dependable year

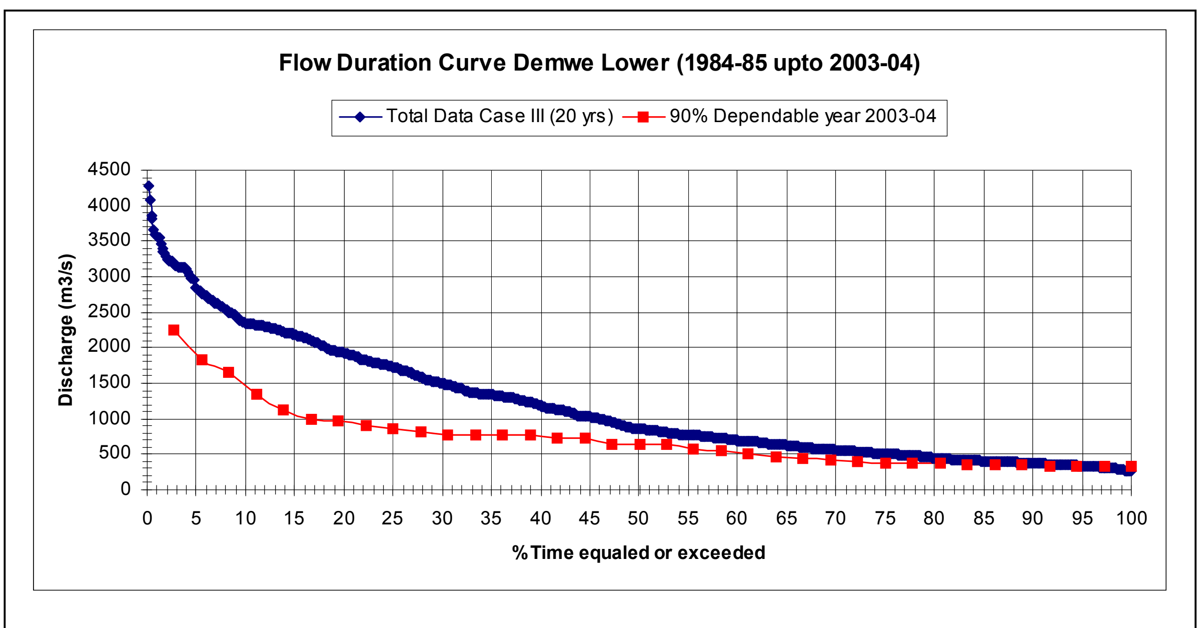


TABLE-4.19
Summary Flow Duration Curve data for Kalai-HEP Stage-1

% Dependability	Case III (cumec)	2003-04 (cumec)
Q50	659	486
Q75	393	295
Q90	297	258
Q95	263	254
Q98	231	254
Q100	156	250

TABLE-4.20
Summary Flow Duration Curve data for Kalai-HEP Stage-2

% Dependability	Case III (cumec)	2003-04 (cumec)
Q50	714	522
Q75	422	317
Q90	320	278
Q95	283	273
Q98	248	272
Q100	176	269

TABLE-4.21
Summary Flow Duration Curve data for Hutong-HEP Stage-1

% Dependability	Case III (cumec)	2003-04 (cumec)
Q50	711	525
Q75	424	319
Q90	322	279
Q95	285	275
Q98	250	274
Q100	169	271

TABLE-4.22
Summary Flow Duration Curve data for Hutong-HEP Stage-2

% Dependability	Case III (cumec)	2003-04 (cumec)
Q50	732	539
Q75	437	327
Q90	330	287
Q95	293	282
Q98	257	282
Q100	173	278

TABLE-4.23
Summary Flow Duration Curve data for Demwe Upper HEP

% Dependability	Case III (cumec)	2003-04 (cumec)
Q50	817	601
Q75	487	365
Q90	355	320
Q95	316	315
Q98	286	314
Q100	239	310

TABLE-4.24
Summary Flow Duration Curve data for Demwe Lower HEP

% Dependability	Case III (cumec)	2003-04 (cumec)
Q50	860	631
Q75	511	383
Q90	373	336
Q95	336	330
Q98	300	330
Q100	254	325

CHAPTER-5

WATER QUALITY

5.1 INTRODUCTION

As per the Terms of Reference, approved for the basin study, water quality monitoring is to be conducted at various locations in the study area. The frequency of monitoring shall be one sampling at different locations per month for six (6) consecutive months. Water quality monitoring was conducted from April 2009 to September 2009.

5.2 SAMPLING SITES

For each proposed project five sampling sites were selected for monitoring, and one sample at each of the 5 locations was collected on monthly basis continuously for 6 months. Thus, a total of thirty (30) sampling locations were covered as a part of the study. The sampling locations covered as a part of the study are listed as below:

- 5000 m upstream of dam site
- 3000 m upstream of dam site
- Dam site
- 3000 m downstream of dam site
- 5000 m downstream of dam site

The sampling locations covered as a part of the study are given in Figure-5.1. The drinking water quality standards are given in Table-5.1.

TABLE-5.1
Drinking water quality standards

Characteristics	*Acceptable	**Cause for Rejection
Turbidity (units on JTU scale)	2.5	10
Colour (Units on platinum cobalt scale)	5.0	25
Taste and Odour	Unobjectionable	Unobjectionable
PH	7.0 to 8.5	<6.5 or >9.2
Total Dissolved Solids (mg/l)	500	1500
Total hardness (mg/l) (as $CaCO_3$)	200	600

Characteristics	*Acceptable	**Cause for Rejection
Chlorides as CD (mg/l)	200	1000
Sulphates (as SO_4)	200	400
Fluorides (as F) (mg/l)	1.0	1.5
Nitrates (as NO_3) (mg/l)	45	45
Calcium (as Ca) (mg/l)	75	200
Magnesium (as Mg) (mg/l)	30	150
Iron (as Fe) (mg/l)	0.1	1.0
Manganese (as Mn) (mg/l)	0.05	0.5
Copper (as Cu) (mg/l)	0.05	1.5
Zinc (as Zn) (mg/l)	5.0	15.0
Phenolic compounds (as phenol) (mg/l)	0.001	0.002
Anionic detergents (as MBAS) (mg/l)	0.2	1.0
Mineral Oil (mg/l)	0.01	0.3
Arsenic (as As) (mg/l)	0.05	0.05
Cadmium (as Cd) (mg/l)	0.01	0.01
Chromium (as hexaalent Cr) (mg/l)	0.05	0.05
Cyanides (as CN) (mg/l)	0.05	0.05
Lead (as Pb) (mg/l)	0.1	0.1
Selenium (as Se) (mg/l)	0.01	0.01
Mercury (total as Hg) (mg/l)	0.001	0.001
Polynuclear aromatic hydrocarbons (PAH)	0.2 μg/l	0.2 μg/l

Notes :

*1. The figures indicated under the column `Acceptable' are the limits up to which water is generally acceptable to the consumers

**2 Figures in excess of those mentioned under `Acceptable render the water not acceptable, but still may be tolerated in the absence of alternative and better source but up to the limits indicated under column "Cause for Rejection" above which are supply will have to be rejected.

5.3 FINDINGS OF THE WATER QUALITY SURVEY

5.3.1 Kalai Hydroelectric project Stage-1

As a part of the study, water quality was monitored at following five locations:

- 5000 m upstream of dam site (W1)
- 3000 m upstream of dam site (W2)
- Dam site (W3)
- 3000 m downstream of dam site (W4)
- 5000 m downstream of dam site (W5)

The results of water quality survey conducted for six months for Kalai-I hydroelectric project are given in Tables-5.2 to 5.7.

TABLE-5.2

Results of water quality monitoring for Kalai hydroelectric project Stage-1: April 2009

Parameter	W1	W2	W3	W4	W5
pH	7.6	7.5	7.5	7.5	7.8
Electrical Conductivity, micromhos/cm	77	78	81	79	74
Total Dissolved Solids, mg/l	56	57	59	58	54
Hardness, mg/l	43	38	41	39	41
Chlorides, mg/l	7	11	8	9	12
Sulphates, mg/l	6	5	7	7	6
Phosphates, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
Nitrates, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
Sodium, mg/l	3.5	2.8	3.0	2.8	4.2
Potassium, mg/l	0.8	1.0	0.8	1.0	0.9
Calcium, mg/l	13.1	11.8	12.5	12.1	12.1
Magnesium, mg/l	2.9	2.1	2.4	2.2	2.4
Iron, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Alkalinity, mg/l	55	48	52	50	52
Copper, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Lead, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Zinc, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Chromium, mg/l	<0.05	<0.05	<0.05	<0.05	<0.05
Mercury, mg/l	<0.001	<0.001	<0.001	<0.001	<0.001
Cadmium, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
BOD, mg/l	1.7	1.5	1.3	1.2	1.3
COD, mg/l	3.2	2.9	2.5	2.4	2.5
DO, mg/l	9.8	9.7	9.7	9.8	9.6
Phenolic compounds, mg/l	BDL	BDL	BDL	BDL	BDL
Oil & Grease, mg/l	BDL	BDL	BDL	BDL	BDL
Total Coliform MPN/100 ml	Nil	Nil	Nil	Nil	Nil

TABLE-5.3

Results of water quality monitoring for Kalai hydroelectric project Stage-1: May 2009

Parameter	W1	W2	W3	W4	W5
pH	7.7	7.5	7.6	7.6	7.8
Electrical Conductivity, micromhos/cm	78	78	80	82	89
Total Dissolved Solids, mg/l	57	57	58	60	65
Hardness, mg/l	45	39	42	40	40
Chlorides, mg/l	7	10	10	9	12
Sulphates, mg/l	6	6	7	8	7
Phosphates, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
Nitrates, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
Sodium, mg/l	3.6	2.9	3.2	3.1	4.1
Potassium, mg/l	1.0	1.0	1.0	1.0	1.0
Calcium, mg/l	13.3	12.0	12.5	12.2	12.1
Magnesium, mg/l	2.9	2.2	2.5	2.3	2.4
Iron, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Alkalinity, mg/l	57	50	53	51	50
Copper, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Lead, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Zinc, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Chromium, mg/l	<0.05	<0.05	<0.05	<0.05	<0.05
Mercury, mg/l	<0.001	<0.001	<0.001	<0.001	<0.001
Cadmium, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
BOD, mg/l	1.8	1.6	1.3	1.3	1.3
COD, mg/l	3.4	3.0	2.5	2.4	2.5
DO, mg/l	9.8	9.8	9.7	9.8	9.5
Phenolic compounds, mg/l	BDL	BDL	BDL	BDL	BDL
Oil & Grease, mg/l	BDL	BDL	BDL	BDL	BDL
Total Coliform MPN/100 ml	Nil	Nil	Nil	Nil	Nil

TABLE-5.4

Results of water quality monitoring for Kalai hydroelectric project Stage-1: June 2009

Parameter	W1	W2	W3	W4	W5
pH	7.8	7.7	7.7	7.6	7.8
Electrical Conductivity, micromhos/cm	79	81	78	71	90
Total Dissolved Solids, mg/l	58	59	57	52	66
Hardness, mg/l	43	40	41	40	43
Chlorides, mg/l	8	11	10	10	14
Sulphates, mg/l	6	7	7	8	7
Phosphates, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
Nitrates, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
Sodium, mg/l	3.7	3.0	3.3	3.3	4.0
Potassium, mg/l	1.0	1.0	0.9	0.9	1.0
Calcium, mg/l	12.8	12.2	12.4	12.3	12.5
Magnesium, mg/l	2.8	2.3	2.5	2.4	2.8
Iron, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Alkalinity, mg/l	55	51	52	51	55
Copper, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Lead, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Zinc, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Chromium, mg/l	<0.05	<0.05	<0.05	<0.05	<0.05
Mercury, mg/l	<0.001	<0.001	<0.001	<0.001	<0.001
Cadmium, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
BOD, mg/l	1.8	1.6	1.4	1.4	1.3
COD, mg/l	3.5	3.0	2.8	2.8	2.5
DO, mg/l	9.8	9.7	9.7	9.8	9.6
Phenolic compounds, mg/l	BDL	BDL	BDL	BDL	BDL
Oil & Grease, mg/l	BDL	BDL	BDL	BDL	BDL
Total Coliform MPN/100 ml	Nil	Nil	Nil	Nil	Nil

TABLE-5.5

Results of water quality monitoring for Kalai hydroelectric project stage-I, July 2009

Parameter	W1	W2	W3	W4	W5
pH	7.6	7.6	7.6	7.5	7.6
Electrical Conductivity, micromhos/cm	73	68	66	75	79
Total Dissolved Solids, mg/l	53	50	48	55	58
Hardness, mg/l	35	34	33	34	35
Chlorides, mg/l	6	8	9	8	7
Sulphates, mg/l	5	5	5	5	5
Phosphates, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
Nitrates, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
Sodium, mg/l	2.8	2.4	2.6	2.8	3.4
Potassium, mg/l	0.8	0.8	0.7	0.8	0.8
Calcium, mg/l	10.2	10.3	9.8	10.2	11.0
Magnesium, mg/l	2.2	2.1	2.0	2.1	2.2
Iron, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Alkalinity, mg/l	44	43	42	43	44
Copper, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Lead, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Zinc, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Chromium, mg/l	<0.05	<0.05	<0.05	<0.05	<0.05
Mercury, mg/l	<0.001	<0.001	<0.001	<0.001	<0.001
Cadmium, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
BOD, mg/l	1.4	1.2	1.2	1.2	1.2
COD, mg/l	2.6	2.2	2.3	2.2	2.2
DO, mg/l	9.9	9.8	9.8	9.9	9.8
Phenolic compounds, mg/l	BDL	BDL	BDL	BDL	BDL
Oil & Grease, mg/l	BDL	BDL	BDL	BDL	BDL
Total Coliform MPN/100 ml	Nil	Nil	Nil	Nil	Nil

TABLE-5.6

Results of water quality monitoring for Kalai hydroelectric project Stage-1: August 2009

Parameter	W1	W2	W3	W4	W5
pH	7.5	7.5	7.6	7.5	7.6
Electrical Conductivity, micromhos/cm	71	68	68	71	77
Total Dissolved Solids, mg/l	52	50	50	52	56
Hardness, mg/l	33	32	32	33	35
Chlorides, mg/l	6	6	7	8	7
Sulphates, mg/l	5	5	5	5	5
Phosphates, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
Nitrates, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
Sodium, mg/l	2.4	2.3	2.6	2.6	3.0
Potassium, mg/l	0.7	0.7	0.7	0.8	0.8
Calcium, mg/l	9.9	9.3	9.5	9.9	10.7
Magnesium, mg/l	2.1	2.0	2.0	2.0	2.0
Iron, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Alkalinity, mg/l	42	41	41	42	44
Copper, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Lead, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Zinc, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Chromium, mg/l	<0.05	<0.05	<0.05	<0.05	<0.05
Mercury, mg/l	<0.001	<0.001	<0.001	<0.001	<0.001
Cadmium, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
BOD, mg/l	1.3	1.3	1.3	1.2	1.2
COD, mg/l	2.5	2.3	2.4	2.2	2.3
DO, mg/l	9.8	9.9	9.9	9.8	9.8
Phenolic compounds, mg/l	BDL	BDL	BDL	BDL	BDL
Oil & Grease, mg/l	BDL	BDL	BDL	BDL	BDL
Total Coliform MPN/100 ml	Nil	Nil	Nil	Nil	Nil

TABLE-5.7

Results of water quality monitoring for Kalai hydroelectric project Stage-1: September 2009

Parameter	W1	W2	W3	W4	W5
pH	7.5	7.6	7.6	7.7	7.5
Electrical Conductivity, micromhos/cm	73	71	64	66	78
Total Dissolved Solids, mg/l	53	52	47	48	57
Hardness, mg/l	35	34	34	36	38
Chlorides, mg/l	8	7	10	8	8
Sulphates, mg/l	6	6	5	8	7
Phosphates, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
Nitrates, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
Sodium, mg/l	2.5	2.4	2.5	2.6	3.2
Potassium, mg/l	0.8	0.8	0.7	0.9	0.8
Calcium, mg/l	10.2	9.8	9.8	10.4	11.0
Magnesium, mg/l	2.3	2.2	2.2	2.5	2.3
Iron, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Alkalinity, mg/l	44	43	43	46	48
Copper, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Lead, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Zinc, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Chromium, mg/l	<0.05	<0.05	<0.05	<0.05	<0.05
Mercury, mg/l	<0.001	<0.001	<0.001	<0.001	<0.001
Cadmium, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
BOD, mg/l	1.4	1.2	1.2	1.2	1.4
COD, mg/l	2.8	2.3	2.3	2.2	2.7
DO, mg/l	9.9	9.7	9.8	9.9	9.8
Phenolic compounds, mg/l	BDL	BDL	BDL	BDL	BDL
Oil & Grease, mg/l	BDL	BDL	BDL	BDL	BDL
Total Coliform MPN/100 ml	Nil	Nil	Nil	Nil	Nil

The pH level in the project area of Kalai hydroelectric project stage-1 ranged from 7.5 to 7.8 at various sampling sites covered as a part of the study. The pH level indicates neutral to marginally alkaline nature of the water, and is within the permissible limit specified for meeting drinking water requirements (Refer Table-5.1).

The TDS level ranged from 47 to 66 mg/l which is well below the permissible limit of 500 mg/l specified for drinking water. The TDS level was found to be lower in monsoon months of July 2009 to September 2009 as compared to summer months of April 2009 to June 2009. This trend was observed for various cations and anions monitored as a part of the study. This could be attributed to higher discharges in monsoon months.

The hardness level ranged from 32 to 45 mg/l indicating soft nature. The hardness level was well below the permissible limit of 200 mg/l specified for drinking water. Hardness is caused by divalent metallic cations. The principal hardness causing cations are calcium, magnesium, strontium and ferrous and iron. The low levels of calcium and magnesium are mainly responsible for the soft nature of water.

Alkalinity of water is a measure of its capacity to neutralize acids. The alkalinity of natural water is due primarily because of the salts of weak acids. The alkalinity was found to be higher than the total hardness in all the water sampling stations monitored as a part of the study, which indicates that entire hardness in the water is on account of carbonate hardness and there is no bicarbonate hardness in the water.

Chlorides occur in all natural waters in widely varying concentrations, chlorides is available in natural water, mainly through solvent power of water, which dissolves chlorides from top soil and deeper formations. The chlorides level ranged from 6 to 14 mg/l, which are well below the permissible limit of 200 mg/l, specified for meeting drinking water requirements.

Sulphates ion is one of the major anions occurring in natural water. It is an important parameter because of its cathartic affect, when it is present in higher concentration. The sulphates level at various sampling stations ranged from 5 to 8 mg/l in various samples monitored for a period of six months as a part of the study. The sulphate was found to be well below the permissible limit of 200 mg/l specified for drinking water purposes.

The concentration of nitrates and phosphates at various sampling locations was observed to below detectable limit of 0.01 mg/l.

The concentration of various cations, e.g. sodium, potassium, calcium and magnesium was observed to be quite low which is also reflected by the low TDS level. Iron was found to be well below the permissible limit of 1 mg/l specified for drinking water purposes.

The concentration of various heavy metals was found to be well below the permissible limits. Concentration of phenolic compounds and oil & grease as expected in a region with no major sources of water pollution from domestic or industrial sources was observed to be quite low.

The BOD values are well within the permissible limit, which indicates the absence of organic pollution loading. This is mainly due to the low population density and absence of industries in the area. The low COD values also indicate the absence of chemical pollution loading in the area. The marginal quantity of pollution load which enters river Lohit, gets diluted.

The DO level ranged from 9.5 to 9.9 mg/l at various sampling locations monitored on a monthly basis for six months as a part of the study. The DO levels were close to saturation limits in water, indicating the excellent quality of water in the study area.

The Total Coliform level was nil at all the sampling sites, indicating the fact that pollution loading is well within the carrying capacity of river Lohit.

5.3.2 Kalai Hydroelectric project Stage-2

As a part of the study, water quality was monitored at following five locations:

- 5000 m upstream of dam site (W6)
- 3000 m upstream of dam site (W7)
- Dam site (W8)
- 3000 m downstream of dam site (W9)
- 5000 m downstream of dam site (W10)

The results of water quality survey conducted for six months for Kalai hydroelectric project, Stage-2 are given in Tables-5.8 to 5.13.

TABLE-5.8
Results of water quality monitoring for Kalai hydroelectric project, Stage-2: April 2009

Parameter	W6	W7	W8	W9	W10
pH	7.6	7.7	7.7	7.7	7.6
Electrical Conductivity, micromhos/cm	79	77	77	77	74
Total Dissolved Solids, mg/l	58	56	56	56	54
Hardness, mg/l	38	35	36	37	34
Chlorides, mg/l	10	7	8	7	8
Sulphates, mg/l	7	6	5	5	6
Phosphates, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
Nitrates, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
Sodium, mg/l	4.2	4.0	3.8	3.0	4.2
Potassium, mg/l	1.0	1.1	1.0	1.2	1.2
Calcium, mg/l	12.2	10.4	10.7	11.3	9.8
Magnesium, mg/l	2.0	2.2	2.1	2.1	2.2
Iron, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Alkalinity, mg/l	49	45	46	48	44
Copper, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Lead, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Zinc, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Chromium, mg/l	<0.05	<0.05	<0.05	<0.05	<0.05
Mercury, mg/l	<0.001	<0.001	<0.001	<0.001	<0.001
Cadmium, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
BOD, mg/l	1.2	1.2	1.3	1.4	1.3
COD, mg/l	2.1	2.2	2.4	2.5	2.4
DO, mg/l	9.5	9.5	9.6	9.4	9.5
Phenolic compounds, mg/l	BDL	BDL	BDL	BDL	BDL
Oil & Grease, mg/l	BDL	BDL	BDL	BDL	BDL
Total Coliform MPN/100 ml	Nil	Nil	Nil	Nil	Nil

TABLE-5.9
Results of water quality monitoring for Kalai hydroelectric project, Stage-2: May 2009

Parameter	W6	W7	W8	W9	W10
pH	7.6	7.6	7.8	7.6	7.7
Electrical Conductivity, micromhos/cm	81	82	81	79	74
Total Dissolved Solids, mg/l	59	60	59	58	54
Hardness, mg/l	42	39	40	40	37
Chlorides, mg/l	11	7	9	10	9
Sulphates, mg/l	6	7	6	8	8
Phosphates, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
Nitrates, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
Sodium, mg/l	4.0	4.2	3.9	3.4	4.1
Potassium, mg/l	1.1	1.2	1.4	1.4	1.4
Calcium, mg/l	12.8	11.6	12.0	11.9	11.1
Magnesium, mg/l	2.3	2.4	2.4	2.4	2.3
Iron, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Alkalinity, mg/l	54	50	52	52	48
Copper, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Lead, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Zinc, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Chromium, mg/l	<0.05	<0.05	<0.05	<0.05	<0.05
Mercury, mg/l	<0.001	<0.001	<0.001	<0.001	<0.001
Cadmium, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
BOD, mg/l	1.5	1.4	1.5	1.5	1.6
COD, mg/l	2.7	2.6	2.8	2.9	3.1
DO, mg/l	9.7	9.7	9.7	9.5	9.6
Phenolic compounds, mg/l	BDL	BDL	BDL	BDL	BDL
Oil & Grease, mg/l	BDL	BDL	BDL	BDL	BDL
Total Coliform MPN/100 ml	Nil	Nil	Nil	Nil	Nil

TABLE-5.10
Results of water quality monitoring for Kalai hydroelectric project, Stage-2: June 2009

Parameter	W6	W7	W8	W9	W10
pH	7.7	7.8	7.8	7.8	7.8
Electrical Conductivity, micromhos/cm	82	85	85	84	81
Total Dissolved Solids, mg/l	60	62	62	61	59

Parameter	W6	W7	W8	W9	W10
Hardness, mg/l	43	42	42	41	40
Chlorides, mg/l	11	9	10	11	10
Sulphates, mg/l	8	8	8	10	9
Phosphates, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
Nitrates, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
Sodium, mg/l	4.2	4.2	4.1	4.2	4.2
Potassium, mg/l	1.2	1.4	1.5	1.5	1.6
Calcium, mg/l	13.1	12.7	12.5	12.2	11.8
Magnesium, mg/l	2.4	2.5	2.5	2.6	2.5
Iron, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Alkalinity, mg/l	55	54	54	53	52
Copper, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Lead, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Zinc, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Chromium, mg/l	<0.05	<0.05	<0.05	<0.05	<0.05
Mercury, mg/l	<0.001	<0.001	<0.001	<0.001	<0.001
Cadmium, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
BOD, mg/l	1.5	1.5	1.6	1.8	1.5
COD, mg/l	3.0	2.9	3.0	3.5	3.0
DO, mg/l	9.9	9.8	9.7	9.4	9.5
Phenolic compounds, mg/l	BDL	BDL	BDL	BDL	BDL
Oil & Grease, mg/l	BDL	BDL	BDL	BDL	BDL
Total Coliform MPN/100 ml	Nil	Nil	Nil	Nil	Nil

TABLE-5.11
Results of water quality monitoring for Kalai hydroelectric project, Stage-2: July 2009

Parameter	W6	W7	W8	W9	W10
pH	7.5	7.6	7.5	7.6	7.5
Electrical Conductivity, micromhos/cm	74	79	80	75	76
Total Dissolved Solids, mg/l	54	55	57	58	54
Hardness, mg/l	37	36	39	37	37
Chlorides, mg/l	7	8	8	9	7
Sulphates, mg/l	6	6	5.9	6	6
Phosphates, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
Nitrates, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
Sodium, mg/l	3.6	3.5	3.3	3.4	3.6
Potassium, mg/l	1.2	1.1	1.2	1.2	1.3

Parameter	W6	W7	W8	W9	W10
Calcium, mg/l	11.6	11.3	11.5	11.7	10.7
Magnesium, mg/l	2.1	2.0	2.1	2.0	2.0
Iron, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Alkalinity, mg/l	44	46	45	48	48
Copper, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Lead, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Zinc, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Chromium, mg/l	<0.05	<0.05	<0.05	<0.05	<0.05
Mercury, mg/l	<0.001	<0.001	<0.001	<0.001	<0.001
Cadmium, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
BOD, mg/l	1.2	1.1	1.2	1.2	1.1
COD, mg/l	2.2	2.3	2.2	2.2	2.3
DO, mg/l	9.5	9.8	9.9	9.7	9.6
Phenolic compounds, mg/l	BDL	BDL	BDL	BDL	BDL
Oil & Grease, mg/l	BDL	BDL	BDL	BDL	BDL
Total Coliform MPN/100 ml	Nil	Nil	Nil	Nil	Nil

TABLE-5.12
Results of water quality monitoring for Kalai hydroelectric project, Stage-2: August 2009

Parameter	W6	W7	W8	W9	W10
pH	7.6	7.6	7.6	7.6	7.7
Electrical Conductivity, micromhos/cm	75	78	79	77	78
Total Dissolved Solids, mg/l	55	57	58	56	57
Hardness, mg/l	38	37	38	38	37
Chlorides, mg/l	8	8	8	8	9
Sulphates, mg/l	6	7	7	8	6
Phosphates, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
Nitrates, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
Sodium, mg/l	3.8	3.9	3.8	3.9	4.0
Potassium, mg/l	1.2	1.2	1.3	1.2	1.2
Calcium, mg/l	11.9	11.2	11.9	11.8	11.2
Magnesium, mg/l	2.0	2.1	2.1	2.1	2.1
Iron, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Alkalinity, mg/l	49	48	49	49	48
Copper, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Lead, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Zinc, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1

Parameter	W6	W7	W8	W9	W10
Chromium, mg/l	<0.05	<0.05	<0.05	<0.05	<0.05
Mercury, mg/l	<0.001	<0.001	<0.001	<0.001	<0.001
Cadmium, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
BOD, mg/l	1.3	1.3	1.3	1.4	1.2
COD, mg/l	2.5	2.6	2.5	2.7	2.3
DO, mg/l	9.9	9.9	9.8	9.6	9.6
Phenolic compounds, mg/l	BDL	BDL	BDL	BDL	BDL
Oil & Grease, mg/l	BDL	BDL	BDL	BDL	BDL
Total Coliform MPN/100 ml	Nil	Nil	Nil	Nil	Nil

TABLE-5.13
Results of water quality monitoring for Kalai hydroelectric project, Stage-2: September 2009

Parameter	W6	W7	W8	W9	W10
pH	7.5	7.7	7.7	7.6	7.5
Electrical Conductivity, micromhos/cm	74	77	78	75	75
Total Dissolved Solids, mg/l	54	56	57	55	54
Hardness, mg/l	37	36	37	37	35
Chlorides, mg/l	7	7	8	7	7
Sulphates, mg/l	6	6	6	6	6
Phosphates, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
Nitrates, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
Sodium, mg/l	3.6	3.4	3.3	3.5	3.6
Potassium, mg/l	1.2	1.2	1.2	1.1	1.2
Calcium, mg/l	11.6	11.0	11.5	11.5	10.7
Magnesium, mg/l	2.0	2.0	2.0	2.0	2.0
Iron, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Alkalinity, mg/l	48	46	48	48	45
Copper, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Lead, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Zinc, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Chromium, mg/l	<0.05	<0.05	<0.05	<0.05	<0.05
Mercury, mg/l	<0.001	<0.001	<0.001	<0.001	<0.001
Cadmium, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
BOD, mg/l	1.2	1.2	1.2	1.2	1.2
COD, mg/l	2.2	2.3	2.2	2.2	2.2
DO, mg/l	9.9	9.8	9.8	9.7	9.8
Phenolic compounds, mg/l	BDL	BDL	BDL	BDL	BDL

Parameter	W6	W7	W8	W9	W10
Oil & Grease, mg/l	BDL	BDL	BDL	BDL	BDL
Total Coliform MPN/100 ml	Nil	Nil	Nil	Nil	Nil

The pH level in various water samples monitored in the project area of Kalai hydroelectric project stage-2 ranged from 7.5 to 7.8. The pH level indicates neutral to marginally alkaline nature of the water. The pH level in water samples was observed to be well within the permissible limit specified for meeting drinking water requirements.

The TDS level ranged from 54 to 62 mg/l which is well below the permissible limit of 500 mg/l specified for drinking water. The TDS level was found to be lower in monsoon months of July 2009 to September 2009 as compared to summer months of April 2009 to June 2009. This trend was observed for various cations and anions as well monitored as a part of the study.The hardness level ranged from 34 to 43 mg/l indicating soft nature of water. The hardness level was well below the permissible limit of 200 mg/l specified for drinking water. Hardness is caused by divalent metallic cations. The low levels of calcium and magnesium are mainly responsible for the soft nature of water.

The alkalinity was found to be higher than the total hardness in all the water sampling stations monitored as a part of the study, which indicates that entire hardness in the water is on account of carbonate hardness and there is no bicarbonate hardness in the water.

The chlorides level ranged from 7 to 11 mg/l, which is well below the permissible limit specified for drinking water (200 mg/l). The sulphates level at various sampling stations ranged from 5 to 10 mg/l in various samples during the monitoring period covered as a part of the study. The sulphate was found to be well below the permissible limit of 200 mg/l specified for drinking water purposes. The concentration of nitrates and phosphates at various sampling locations was observed to below detectable limit of 0.01 mg/l.

The concentration of various cations, e.g. sodium, potassium, calcium and magnesium was observed to be quite low which is also reflected by the low TDS level. Iron was found to be well below the permissible limit of 1 mg/l specified for drinking water purposes.

The concentration of various heavy metals was found to be well below the permissible limits. Concentration of phenolic compounds and oil & grease as expected in a hilly terrain with no major sources of water pollution from domestic or industrial sources was observed to be quite low.

The BOD values are well within the permissible limits, which indicates the absence of organic pollution loading. This is mainly due to the low population density and absence of industries in the area. The low COD values also indicate the absence of chemical pollution loading in the area. The marginal quantity of pollution load which enters river Lohit, gets diluted. The Total Coliform in Kalai hydroelectric project Stage – 2 was found nil at all the sampling sites, indicating the fact that pollution loading is well within the carrying capacity of river Lohit.

The DO level ranged from 9.4 to 9.9 mg/l at various sampling locations monitored on a monthly basis for six months as a part of the study. The DO levels were close to saturation limits in water, indicating the excellent quality of water in the study area.

5.3.3 Hutong Hydroelectric project Stage-1

As a part of the study, water quality was monitored at following five locations:

- 5000 m upstream of dam site (W11)
- 3000 m upstream of dam site (W12)
- Dam site (W13)
- 3000 m downstream of dam site (W14)
- 5000 m downstream of dam site (W15)

The results of water quality survey conducted for six months for Hutong-I hydroelectric project are given in Tables-5.14 to 5.19.

TABLE-5.14
Results of water quality monitoring for Hutong hydroelectric project, Stage-1: April 2009

Parameter	W11	W12	W13	W14	W15
pH	7.7	7.8	7.8	7.9	7.7
Electrical Conductivity, micromhos/cm	74	70	74	78	71
Total Dissolved Solids, mg/l	54	51	54	57	52
Hardness, mg/l	43	42	44	47	42
Chlorides, mg/l	7	7	8	10	6
Sulphates, mg/l	6	5	6	9	6
Phosphates, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
Nitrates, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
Sodium, mg/l	4.4	4.1	4.4	4.7	4.0
Potassium, mg/l	1.5	1.5	1.5	1.8	1.9
Calcium, mg/l	13.0	12.8	13.2	13.9	12.9
Magnesium, mg/l	2.5	2.3	2.6	2.9	2.3
Iron, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Alkalinity, mg/l	55	54	56	60	54
Copper, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Lead, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Zinc, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Chromium, mg/l	<0.05	<0.05	<0.05	<0.05	<0.05
Mercury, mg/l	<0.001	<0.001	<0.001	<0.001	<0.001
Cadmium, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
BOD, mg/l	1.5	1.4	1.6	1.5	1.4
COD, mg/l	2.8	2.8	3.2	2.9	2.7
DO, mg/l	9.5	9.5	9.4	9.5	9.4
Phenolic compounds, mg/l	BDL	BDL	BDL	BDL	BDL
Oil & Grease, mg/l	BDL	BDL	BDL	BDL	BDL
Total Coliform MPN/100 ml	Nil	Nil	Nil	Nil	Nil

TABLE-5.15
Results of water quality monitoring for Hutong hydroelectric project, Stage-1: May 2009

Parameter	**W11**	**W12**	**W13**	**W14**	**W15**
pH	7.7	7.7	7.9	7.9	7.8
Electrical Conductivity, micromhos/cm	77	75	74	81	82
Total Dissolved Solids, mg/l	56	55	54	59	61
Hardness, mg/l	43	44	46	47	43
Chlorides, mg/l	9	10	10	9	7
Sulphates, mg/l	8	6	6	8	7
Phosphates, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
Nitrates, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
Sodium, mg/l	4.5	4.4	4.4	4.8	4.3
Potassium, mg/l	1.8	1.8	1.7	2.0	2.1
Calcium, mg/l	13.0	13.0	13.9	13.8	13.1
Magnesium, mg/l	2.5	2.6	2.8	2.9	2.5
Iron, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Alkalinity, mg/l	55	56	59	60	55
Copper, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Lead, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Zinc, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Chromium, mg/l	<0.05	<0.05	<0.05	<0.05	<0.05
Mercury, mg/l	<0.001	<0.001	<0.001	<0.001	<0.001
Cadmium, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
BOD, mg/l	1.5	1.6	1.6	1.8	1.6
COD, mg/l	2.9	3.2	3.1	3.6	3.1
DO, mg/l	9.4	9.5	9.4	9.4	9.5
Phenolic compounds, mg/l	BDL	BDL	BDL	BDL	BDL
Oil & Grease, mg/l	BDL	BDL	BDL	BDL	BDL
Total Coliform MPN/100 ml	Nil	Nil	Nil	Nil	Nil

TABLE-5.16
Results of water quality monitoring for Hutong hydroelectric project, Stage-1: June 2009

Parameter	W11	W12	W13	W14	W15
pH	7.8	7.7	7.8	7.9	7.7
Electrical Conductivity, micromhos/cm	79	79	82	84	82
Total Dissolved Solids, mg/l	58	58	60	61	60
Hardness, mg/l	45	46	49	50	46
Chlorides, mg/l	9	9	9	9	9
Sulphates, mg/l	8	10	8	10	8
Phosphates, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
Nitrates, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
Sodium, mg/l	4.8	4.6	4.6	4.9	4.5
Potassium, mg/l	1.9	1.8	1.8	2.2	2.0
Calcium, mg/l	13.2	13.5	14.5	14.2	13.9
Magnesium, mg/l	2.8	2.9	3.0	3.6	2.6
Iron, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Alkalinity, mg/l	58	59	63	64	59
Copper, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Lead, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Zinc, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Chromium, mg/l	<0.05	<0.05	<0.05	<0.05	<0.05
Mercury, mg/l	<0.001	<0.001	<0.001	<0.001	<0.001
Cadmium, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
BOD, mg/l	1.8	1.7	1.7	1.8	1.7
COD, mg/l	3.5	3.3	3.3	3.5	3.3
DO, mg/l	9.4	9.5	9.4	9.4	9.5
Phenolic compounds, mg/l	BDL	BDL	BDL	BDL	BDL
Oil & Grease, mg/l	BDL	BDL	BDL	BDL	BDL
Total Coliform MPN/100 ml	Nil	Nil	Nil	Nil	Nil

TABLE-5.17
Results of water quality monitoring for Hutong hydroelectric project, Stage-1: July 2009

Parameter	W11	W12	W13	W14	W15
pH	7.6	7.6	7.7	7.7	7.5
Electrical Conductivity, micromhos/cm	70	73	75	79	74
Total Dissolved Solids, mg/l	51	53	55	58	54
Hardness, mg/l	40	42	47	45	45
Chlorides, mg/l	7	7	6	7	6
Sulphates, mg/l	6	6	7	9	6
Phosphates, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
Nitrates, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
Sodium, mg/l	4.3	4.2	4.4	4.4	4.2
Potassium, mg/l	1.6	1.5	1.5	1.7	1.7
Calcium, mg/l	11.7	12.0	13.6	12.7	13.1
Magnesium, mg/l	2.6	2.9	3.1	3.2	2.9
Iron, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Alkalinity, mg/l	51	54	60	58	58
Copper, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Lead, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Zinc, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Chromium, mg/l	<0.05	<0.05	<0.05	<0.05	<0.05
Mercury, mg/l	<0.001	<0.001	<0.001	<0.001	<0.001
Cadmium, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
BOD, mg/l	1.4	1.4	1.4	1.4	1.4
COD, mg/l	2.6	2.8	2.6	2.7	2.7
DO, mg/l	9.5	9.5	9.6	9.5	9.8
Phenolic compounds, mg/l	BDL	BDL	BDL	BDL	BDL
Oil & Grease, mg/l	BDL	BDL	BDL	BDL	BDL
Total Coliform MPN/100 ml	Nil	Nil	Nil	Nil	Nil

TABLE-5.18
Results of water quality monitoring for Hutong hydroelectric project, Stage-1: August 2009

Parameter	W11	W12	W13	W14	W15
pH	7.6	7.7	7.5	7.6	7.6
Electrical Conductivity, micromhos/cm	62	70	74	75	72
Total Dissolved Solids, mg/l	45	51	55	55	53
Hardness, mg/l	38	41	44	43	43
Chlorides, mg/l	8	6	6	6	6
Sulphates, mg/l	6	6	6	8	5
Phosphates, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
Nitrates, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
Sodium, mg/l	4.1	4.1	4.2	4.1	3.8
Potassium, mg/l	1.7	1.55	1.6	1.6	1.6
Calcium, mg/l	11.2	11.7	12.9	12.5	12.8
Magnesium, mg/l	2.5s	2.8	2.9	2.8	2.6
Iron, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Alkalinity, mg/l	49	52	56	55	55
Copper, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Lead, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Zinc, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Chromium, mg/l	<0.05	<0.05	<0.05	<0.05	<0.05
Mercury, mg/l	<0.001	<0.001	<0.001	<0.001	<0.001
Cadmium, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
BOD, mg/l	1.3	1.3	1.4	1.5	1.4
COD, mg/l	2.5	2.5	2.6	2.9	2.7
DO, mg/l	9.6	9.6	9.6	9.5	9.6
Phenolic compounds, mg/l	BDL	BDL	BDL	BDL	BDL
Oil & Grease, mg/l	BDL	BDL	BDL	BDL	BDL
Total Coliform MPN/100 ml	Nil	Nil	Nil	Nil	Nil

TABLE-5.19
Results of water quality monitoring for Hutong hydroelectric project, Stage-1: September 2009

Parameter	W11	W12	W13	W14	W15
pH	7.6	7.5	7.6	7.5	7.6
Electrical Conductivity, micromhos/cm	64	71	74	74	71
Total Dissolved Solids, mg/l	41	42	43	44	44
Hardness, mg/l	38	41	44	43	43
Chlorides, mg/l	8	8	9	7	6
Sulphates, mg/l	5	7	6	8	6
Phosphates, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
Nitrates, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
Sodium, mg/l	4.2	4.4	4.1	4.3	3.8
Potassium, mg/l	1.6	1.5	1.6	1.5	1.5
Calcium, mg/l	11.9	11.9	12.6	12.6	12.6
Magnesium, mg/l	2.6	2.9	2.9	2.9	2.9
Iron, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Alkalinity, mg/l	55	58	55	57	59
Copper, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Lead, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Zinc, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Chromium, mg/l	<0.05	<0.05	<0.05	<0.05	<0.05
Mercury, mg/l	<0.001	<0.001	<0.001	<0.001	<0.001
Cadmium, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
BOD, mg/l	1.7	1.7	1.5	1.6	1.5
COD, mg/l	3.1	3.2	2.9	3.0	2.9
DO, mg/l	9.7	9.6	9.5	9.5	9.5
Phenolic compounds, mg/l	BDL	BDL	BDL	BDL	BDL
Oil & Grease, mg/l	BDL	BDL	BDL	BDL	BDL
Total Coliform MPN/100 ml	Nil	Nil	Nil	Nil	Nil

The pH level in the project area of Hutong hydroelectric project stage-1 was observed to be in neutral to marginally alkaline range (7.5 to 7.9) at various sampling sites covered as a part of the study.

The TDS level ranged from 41 to 61 mg/l which is well below the permissible limit of 500 mg/l specified for drinking water. The TDS level was found to be lower in monsoon months as compared to summer months. This trend was observed for various cations and anions monitored as a part of the study.

The hardness level ranged from 38 to 50 mg/l indicating soft nature. The hardness level was well below the permissible limit of 200 mg/l specified for drinking water. Hardness is caused by divalent metallic cations. The low levels of calcium and magnesium are mainly responsible for the soft nature of water.

The alkalinity was found to be higher than the total hardness in all the water sampling stations monitored as a part of the study, which indicates that entire hardness in the water is on account of carbonate hardness and there is no bicarbonate hardness in the water.

The chlorides level ranged from 6 to 10 mg/l, which is well below the permissible limit specified for drinking water (200 mg/l). The sulphates level at various sampling stations ranged from 5 to 10 mg/l in various samples monitored for a period of six months as a part of the study. The sulphate was found to be well below the permissible limit of 200 mg/l specified for drinking water purposes. The concentration of nitrates and phosphates at various sampling locations was observed to below detectable limit of 0.01 mg/l.

The concentration of various cations, e.g. sodium, potassium, calcium and magnesium was observed to be quite low which is also reflected by the low TDS level. Iron was found to be well below the permissible limit of 1 mg/l specified for drinking water purposes.

The concentration of various heavy metals was found to be well below the permissible limits. Concentration of phenolic compounds and oil & grease as expected in a hilly terrain with no major sources of water pollution from domestic or industrial sources was observed to be quite low.

The BOD and total coliform values are well within the permissible limit, which indicates the absence of organic pollution loading. This is mainly due to the low population density and absence of industries in the area. The low COD values also indicate the absence of chemical pollution loading in the area. The marginal quantity of pollution load which enters river Lohit, gets diluted.

The DO level ranged from 9.4 to 9.8 mg/l at various sampling locations monitored on a monthly basis for six months as a part of the study. The DO levels were close to saturation limits in water, indicating the excellent quality of water in the study area.

5.3.4 Hutong Hydroelectric project Stage-2

As a part of the study, water quality was monitored at following five locations:

- 5000 m upstream of dam site (W16)
- 3000 m upstream of dam site (W17)
- Dam site (W18)
- 3000 m downstream of dam site (W19)
- 5000 m downstream of dam site (W20)

The results of water quality survey conducted for six months for Hutong-II hydroelectric project are given in Tables-5.20 to 5.25.

TABLE-5.20
Results of water quality monitoring for Hutong hydroelectric project, Stage-2: April 2009

Parameter	W16	W17	W18	W19	W20
pH	7.5	7.7	7.8	7.8	7.8
Electrical Conductivity, micromhos/cm	82	84	89	81	79
Total Dissolved Solids, mg/l	60	61	65	59	56
Hardness, mg/l	46	48	49	48	50
Chlorides, mg/l	10	9	11	7	9
Sulphates, mg/l	8	8	7	8	8
Phosphates, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01

Parameter	W16	W17	W18	W19	W20
Nitrates, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
Sodium, mg/l	4.7	4.6	4.4	4.8	4.3
Potassium, mg/l	1.9	1.8	2.1	1.9	1.7
Calcium, mg/l	14.7	15.2	14.9	15.2	14.7
Magnesium, mg/l	2.4	2.4	2.7	2.5	2.9
Iron, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Alkalinity, mg/l	59	61	62	61	64
Copper, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Lead, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Zinc, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Chromium, mg/l	<0.05	<0.05	<0.05	<0.05	<0.05
Mercury, mg/l	<0.001	<0.001	<0.001	<0.001	<0.001
Cadmium, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
BOD, mg/l	1.9	1.8	1.8	1.9	1.9
COD, mg/l	3.7	3.6	3.5	3.7	3.7
DO, mg/l	9.6	9.6	9.6	9.6	9.5
Phenolic compounds, mg/l	BDL	BDL	BDL	BDL	BDL
Oil & Grease, mg/l	BDL	BDL	BDL	BDL	BDL
Total Coliform MPN/100 ml	Nil	Nil	Nil	Nil	Nil

TABLE-5.21
Results of water quality monitoring for Hutong hydroelectric project, Stage-2: May 2009

Parameter	W16	W17	W18	W19	W20
pH	7.7	7.8	7.8	7.9	7.8
Electrical Conductivity, micromhos/cm	86	89	86	82	81
Total Dissolved Solids, mg/l	63	65	63	60	59
Hardness, mg/l	49	50	48	48	50
Chlorides, mg/l	14	12	9	8	10
Sulphates, mg/l	11	10	8	7	9
Phosphates, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
Nitrates, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
Sodium, mg/l	5.2	4.8	4.5	4.8	4.7
Potassium, mg/l	2.0	2.1	2.5	2.2	2.0
Calcium, mg/l	15.1	15.4	14.9	15.1	14.9
Magnesium, mg/l	2.6	2.6	2.6	2.5	2.8
Iron, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Alkalinity, mg/l	62	64	61	61	64
Copper, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Lead, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1

Parameter	W16	W17	W18	W19	W20
Zinc, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Chromium, mg/l	<0.05	<0.05	<0.05	<0.05	<0.05
Mercury, mg/l	<0.001	<0.001	<0.001	<0.001	<0.001
Cadmium, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
BOD, mg/l	1.8	1.8	1.7	1.8	1.9
COD, mg/l	3.5	3.5	3.2	3.4	3.6
DO, mg/l	9.8	9.7	9.6	9.5	9.5
Phenolic compounds, mg/l	BDL	BDL	BDL	BDL	BDL
Oil & Grease, mg/l	BDL	BDL	BDL	BDL	BDL
Total Coliform MPN/100 ml	Nil	Nil	Nil	Nil	Nil

TABLE-5.22

Results of water quality monitoring for Hutong hydroelectric project, Stage-2: – June 2009

Parameter	W16	W17	W18	W19	W20
pH	7.8	7.9	8.0	7.7	7.7
Electrical Conductivity, micromhos/cm	89	89	88	82	77
Total Dissolved Solids, mg/l	65	65	64	60	56
Hardness, mg/l	55	56	53	52	52
Chlorides, mg/l	15	13	11	12	10
Sulphates, mg/l	11	8	9	9	8
Phosphates, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
Nitrates, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
Sodium, mg/l	5.8	5.4	5.2	5.0	5.2
Potassium, mg/l	2.5	2.4	2.5	2.6	2.6
Calcium, mg/l	16.2	15.8	15.9	16.1	15.6
Magnesium, mg/l	3.4	3.8	3.2	2.9	3.1
Iron, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Alkalinity, mg/l	69	71	67	66	66
Copper, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Lead, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Zinc, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Chromium, mg/l	<0.05	<0.05	<0.05	<0.05	<0.05
Mercury, mg/l	<0.001	<0.001	<0.001	<0.001	<0.001
Cadmium, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
BOD, mg/l	1.9	2.0	1.9	1.9	1.9
COD, mg/l	3.8	3.8	3.8	3.7	3.8
DO, mg/l	9.6	9.6	9.6	9.5	9.6
Phenolic compounds, mg/l	BDL	BDL	BDL	BDL	BDL
Oil & Grease, mg/l	BDL	BDL	BDL	BDL	BDL

Parameter	W16	W17	W18	W19	W20
Total Coliform MPN/100 ml	Nil	Nil	Nil	Nil	Nil

TABLE-5.23
Results of water quality monitoring for Hutong hydroelectric project, Stage-2: July 2009

Parameter	W16	W17	W18	W19	W20
pH	7.7	7.7	7.8	7.6	7.6
Electrical Conductivity, micromhos/cm	82	84	79	77	71
Total Dissolved Solids, mg/l	60	61	58	56	52
Hardness, mg/l	50	47	46	49	48
Chlorides, mg/l	12	10	9	8	9
Sulphates, mg/l	9	6	6	6	8
Phosphates, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
Nitrates, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
Sodium, mg/l	5.1	5.0	4.8	4.5	4.4
Potassium, mg/l	2.2	2.1	2.2	2.2	2.4
Calcium, mg/l	14.9	13.9	14.1	15.2	14.3
Magnesium, mg/l	3.0	2.9	2.7	2.7	2.9
Iron, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Alkalinity, mg/l	63	59	58	62	60
Copper, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Lead, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Zinc, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Chromium, mg/l	<0.05	<0.05	<0.05	<0.05	<0.05
Mercury, mg/l	<0.001	<0.001	<0.001	<0.001	<0.001
Cadmium, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
BOD, mg/l	1.7	1.7	1.6	1.6	1.8
COD, mg/l	3.2	3.2	3.1	3.2	3.5
DO, mg/l	9.2	9.2	9.3	9.3	9.3

Parameter	W16	W17	W18	W19	W20
Phenolic compounds, mg/l	BDL	BDL	BDL	BDL	BDL
Oil & Grease, mg/l	BDL	BDL	BDL	BDL	BDL
Total Coliform MPN/100 ml	Nil	Nil	Nil	Nil	Nil

TABLE-5.24
Results of water quality monitoring for Hutong hydroelectric project, Stage-2: August 2009

Parameter	W16	W17	W18	W19	W20
pH	7.6	7.6	7.6	7.6	7.6
Electrical Conductivity, micromhos/cm	79	79	78	71	74
Total Dissolved Solids, mg/l	58	58	57	52	54
Hardness, mg/l	50	47	46	49	49
Chlorides, mg/l	11	10	8	8	8
Sulphates, mg/l	7	6	5	6	6
Phosphates, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
Nitrates, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
Sodium, mg/l	4.9	4.9	4.6	4.4	4.2
Potassium, mg/l	2.1	2.0	2.0	2.1	2.2
Calcium, mg/l	15.0	14.2	14.5	14.7	14.7
Magnesium, mg/l	2.8	2.8	2.6	2.7	2.7
Iron, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Alkalinity, mg/l	63	59	58	62	62
Copper, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Lead, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Zinc, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Chromium, mg/l	<0.05	<0.05	<0.05	<0.05	<0.05
Mercury, mg/l	<0.001	<0.001	<0.001	<0.001	<0.001
Cadmium, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
BOD, mg/l	1.5	1.5	1.5	1.5	1.5
COD, mg/l	2.9	3.0	3.0	2.9	2.9

Parameter	W16	W17	W18	W19	W20
DO, mg/l	9.2	9.4	9.4	9.4	9.3
Phenolic compounds, mg/l	BDL	BDL	BDL	BDL	BDL
Oil & Grease, mg/l	BDL	BDL	BDL	BDL	BDL
Total Coliform MPN/100 ml	Nil	Nil	Nil	Nil	Nil

TABLE-5.25
Results of water quality monitoring for Hutong hydroelectric project, Stage-2: September 2009

Parameter	W16	W17	W18	W19	W20
pH	7.6	7.6	7.6	7.6	7.6
Electrical Conductivity, micromhos/cm	77	79	77	70	71
Total Dissolved Solids, mg/l	56	58	56	51	52
Hardness, mg/l	49	47	46	47	48
Chlorides, mg/l	8	8	8	7	7
Sulphates, mg/l	7	6	5	7	6
Phosphates, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
Nitrates, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
Sodium, mg/l	5.0	5.1	5.1	4.9	4.4
Potassium, mg/l	2.2	2.1	2.0	2.0	2.0
Calcium, mg/l	15.1	14.2	14.4	14.0	14.2
Magnesium, mg/l	2.6	2.5	2.6	2.6	2.7
Iron, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Alkalinity, mg/l	62	59	58	59	60
Copper, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Lead, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Zinc, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Chromium, mg/l	<0.05	<0.05	<0.05	<0.05	<0.05
Mercury, mg/l	<0.001	<0.001	<0.001	<0.001	<0.001
Cadmium, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
BOD, mg/l	1.6	1.5	1.5	1.5	1.5

Parameter	W16	W17	W18	W19	W20
COD, mg/l	3.0	3.0	3.0	2.9	2.9
DO, mg/l	9.4	9.3	9.3	9.3	9.2
Phenolic compounds, mg/l	BDL	BDL	BDL	BDL	BDL
Oil & Grease, mg/l	BDL	BDL	BDL	BDL	BDL
Total Coliform MPN/100 ml	Nil	Nil	Nil	Nil	Nil

The pH level in the project area of Hutong hydroelectric project stage-2 ranged from 7.5 to 8.0 at various samples covered as a part of the study indicating neutral to marginal alkaline nature of the water.

The TDS level ranged from 51 to 65 mg/l which is well below the permissible limit of 500 mg/l specified for drinking water. The TDS level was found to be lower at all the stations in monsoon months as compared to the summer months. This trend was observed for various cations and anions monitored as a part of the study. This could be attributed to higher discharge in monsoon months.

The hardness level ranged from 46 to 56 mg/l indicating soft nature. The hardness level was well below the permissible limit of 200 mg/l specified for drinking water. The alkalinity was found to be higher than the total hardness in all the water sampling stations monitored as a part of the study, which indicates that entire hardness in the water is on account of carbonate hardness and there is no bicarbonate hardness in the water.

The chlorides level ranged from 7 to 15 mg/l, which is well below the permissible limit specified for drinking water (200 mg/l). The sulphates level at various sampling stations ranged from 5 to 11 mg/l in various samples monitored for a period of six months as a part of the study.

The sulphates were found to be well below the permissible limit of 200 mg/l specified for drinking water purposes. The concentration of nitrates and phosphates at various sampling locations was observed to below detectable limit of 0.01 mg/l.

The concentration of various cations, e.g. sodium, potassium, calcium and magnesium was observed to be quite low which is also reflected by the low TDS level. Iron was found to be well below the permissible limit of 1 mg/l specified for drinking water purposes.

The concentration of various heavy metals was found to be well below the permissible limits. Concentration of phenolic compounds and oil & grease as expected in a hilly terrain with no major sources of water pollution from domestic or industrial sources was observed to be quite low.

The BOD, COD and Total Coliform values are well within the permissible limits, which indicate the absence of organic pollution loading. This is mainly due to the low population density and absence of industries in the area.

The DO level ranged from 9.2 to 9.8 mg/l at various sampling locations monitored on a monthly basis for six months as a part of the study. The DO levels were close to saturation limits in water, indicating the excellent quality of water in the study area.

5.3.5 Demwe Upper Hydroelectric project

As a part of the study, water quality was monitored at following five locations:

- 5000 m upstream of dam site (W21)
- 3000 m upstream of dam site (W22)
- Dam site (W23)
- 3000 m downstream of dam site (W24)
- 5000 m downstream of dam site (W25)

The results of water quality survey conducted for six months for Demwe Upper hydroelectric project are given in Tables-5.26 to 5.31.

TABLE-5.26
Results of water quality monitoring for Demwe Upper hydroelectric project
April 2009

Parameter	W21	W22	W23	W24	W25
pH	7.6	7.7	7.6	7.8	7.7
Electrical Conductivity,	82	78	86	85	86

Parameter	W21	W22	W23	W24	W25
micromhos/cm					
Total Dissolved Solids, mg/l	60	57	63	62	63
Hardness, mg/l	53	53	51	50	48
Chlorides, mg/l	12	12	9	9	10
Sulphates, mg/l	9	10	10	10	10
Phosphates, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
Nitrates, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
Sodium, mg/l	4.8	5.0	4.2	4.6	4.4
Potassium, mg/l	2.1	2.6	2.4	2.8	2.7
Calcium, mg/l	16.2	16.5	15.7	15.9	15.1
Magnesium, mg/l	3.0	2.8	2.8	2.6	2.4
Iron, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Alkalinity, mg/l	67	67	64	63	60
Copper, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Lead, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Zinc, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Chromium, mg/l	<0.05	<0.05	<0.05	<0.05	<0.05
Mercury, mg/l	<0.001	<0.001	<0.001	<0.001	<0.001
Cadmium, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
BOD, mg/l	2.1	1.9	1.9	1.9	1.9
COD, mg/l	4.0	3.6	3.6	3.8	3.8
DO, mg/l	9.5	9.5	9.5	9.5	9.5
Phenolic compounds, mg/l	BDL	BDL	BDL	BDL	BDL
Oil & Grease, mg/l	BDL	BDL	BDL	BDL	BDL
Total Coliform MPN/100 ml	Nil	Nil	Nil	Nil	Nil

TABLE-5.27
Results of water quality monitoring for Demwe Upper hydroelectric project May 2009

Parameter	W21	W22	W23	W24	W25
pH	7.7	7.8	7.7	7.7	7.7
Electrical Conductivity, micromhos/cm	85	76	86	82	86
Total Dissolved Solids, mg/l	62	55	63	60	62
Hardness, mg/l	54	52	52	52	49
Chlorides, mg/l	12	13	10	10	12
Sulphates, mg/l	10	10	10	10	10
Phosphates, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
Nitrates, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
Sodium, mg/l	5.1	5.2	5.3	4.9	4.6

Parameter	W21	W22	W23	W24	W25
Potassium, mg/l	2.1	2.6	2.4	2.8	2.7
Calcium, mg/l	16.5	16.4	15.5	16.2	15.7
Magnesium, mg/l	3.0	2.7	2.9	2.9	2.6
Iron, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Alkalinity, mg/l	68	66	66	66	62
Copper, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Lead, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Zinc, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Chromium, mg/l	<0.05	<0.05	<0.05	<0.05	<0.05
Mercury, mg/l	<0.001	<0.001	<0.001	<0.001	<0.001
Cadmium, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
BOD, mg/l	2.1	2.0	1.9	2.0	1.9
COD, mg/l	4.0	3.9	3.6	4.0	3.8
DO, mg/l	9.5	9.5	9.5	9.5	9.5
Phenolic compounds, mg/l	BDL	BDL	BDL	BDL	BDL
Oil & Grease, mg/l	BDL	BDL	BDL	BDL	BDL
Total Coliform MPN/100 ml	Nil	Nil	Nil	Nil	Nil

TABLE-5.28

Results of water quality monitoring for Demwe Upper hydroelectric project June 2009

Parameter	W21	W22	W23	W24	W25
pH	7.8	7.8	7.8	7.7	7.8
Electrical Conductivity, micromhos/cm	89	79	82	85	89
Total Dissolved Solids, mg/l	65	58	60	62	64
Hardness, mg/l	55	53	52	53	51
Chlorides, mg/l	14	14	12	11	14
Sulphates, mg/l	12	10	9	11	10
Phosphates, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
Nitrates, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
Sodium, mg/l	5.3	5.2	5.5	4.9	4.9
Potassium, mg/l	2.3	2.6	2.5	2.8	2.8
Calcium, mg/l	16.9	16.5	15.9	16.3	16.1
Magnesium, mg/l	3.0	2.9	2.9	2.9	2.7
Iron, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Alkalinity, mg/l	55	53	52	53	51
Copper, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Lead, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Zinc, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Chromium, mg/l	<0.05	<0.05	<0.05	<0.05	<0.05

Parameter	W21	W22	W23	W24	W25
Mercury, mg/l	<0.001	<0.001	<0.001	<0.001	<0.001
Cadmium, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
BOD, mg/l	2.1	2.0	2.0	2.0	2.1
COD, mg/l	4.1	3.9	3.8	4.0	4.1
DO, mg/l	9.5	9.5	9.5	9.5	9.5
Phenolic compounds, mg/l	BDL	BDL	BDL	BDL	BDL
Oil & Grease, mg/l	BDL	BDL	BDL	BDL	BDL
Total Coliform MPN/100 ml	Nil	Nil	Nil	Nil	Nil

TABLE-5.29

Results of water quality monitoring for Demwe Upper hydroelectric project July 2009

Parameter	W21	W22	W23	W24	W25
pH	7.6	7.6	7.7	7.7	7.7
Electrical Conductivity, micromhos/cm	84	77	78	82	81
Total Dissolved Solids, mg/l	61	56	57	60	59
Hardness, mg/l	54	52	51	51	50
Chlorides, mg/l	12	12	10	10	11
Sulphates, mg/l	10	8	8	8	8
Phosphates, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
Nitrates, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
Sodium, mg/l	4.5	4.9	4.9	4.2	4.4
Potassium, mg/l	2.1	2.4	2.2	2.5	2.5
Calcium, mg/l	16.9	16.5	15.9	16.3	16.1
Magnesium, mg/l	2.9	2.6	2.6	2.5	2.4
Iron, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Alkalinity, mg/l	68	66	64	64	63
Copper, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Lead, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Zinc, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1

Parameter	W21	W22	W23	W24	W25
Chromium, mg/l	<0.05	<0.05	<0.05	<0.05	<0.05
Mercury, mg/l	<0.001	<0.001	<0.001	<0.001	<0.001
Cadmium, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
BOD, mg/l	1.8	1.7	1.8	1.7	1.8
COD, mg/l	3.6	3.3	3.5	3.4	3.7
DO, mg/l	9.6	9.6	9.8	9.6	9.6
Phenolic compounds, mg/l	BDL	BDL	BDL	BDL	BDL
Oil & Grease, mg/l	BDL	BDL	BDL	BDL	BDL
Total Coliform MPN/100 ml	Nil	Nil	Nil	Nil	Nil

TABLE-5.30
Results of water quality monitoring for Demwe Upper hydroelectric project August 2009

Parameter	W21	W22	W23	W24	W25
pH	7.6	7.6	7.6	7.6	7.6
Electrical Conductivity, micromhos/cm	82	77	75	79	79
Total Dissolved Solids, mg/l	60	56	55	58	58
Hardness, mg/l	52	50	48	50	48
Chlorides, mg/l	11	11	10	9	9
Sulphates, mg/l	7	7	7	7	7
Phosphates, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
Nitrates, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
Sodium, mg/l	4.2	4.3	4.6	4.0	4.1
Potassium, mg/l	2.0	1.9	1.9	1.9	1.9
Calcium, mg/l	16.3	16.2	15.4	16.0	15.7
Magnesium, mg/l	2.8	2.4	2.4	2.4	2.2
Iron, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Alkalinity, mg/l	66	63	60	63	60
Copper, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Lead, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1

Parameter	W21	W22	W23	W24	W25
Zinc, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Chromium, mg/l	<0.05	<0.05	<0.05	<0.05	<0.05
Mercury, mg/l	<0.001	<0.001	<0.001	<0.001	<0.001
Cadmium, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
BOD, mg/l	1.7	1.7	1.7	1.7	1.7
COD, mg/l	3.5	3.4	3.3	3.4	3.4
DO, mg/l	9.6	9.6	9.6	9.7	9.8
Phenolic compounds, mg/l	BDL	BDL	BDL	BDL	BDL
Oil & Grease, mg/l	BDL	BDL	BDL	BDL	BDL
Total Coliform MPN/100 ml	Nil	Nil	Nil	Nil	Nil

TABLE-5.31
Results of water quality monitoring for Demwe Upper hydroelectric project September 2009

Parameter	W21	W22	W23	W24	W25
pH	7.6	7.5	7.6	7.6	7.6
Electrical Conductivity, micromhos/cm	79	75	73	73	74
Total Dissolved Solids, mg/l	58	55	53	53	54
Hardness, mg/l	49	51	47	49	48
Chlorides, mg/l	10	9	9	7	8
Sulphates, mg/l	7	5	6	7	7
Phosphates, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
Nitrates, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
Sodium, mg/l	4.0	3.9	4.1	3.8	4.0
Potassium, mg/l	1.8	1.8	1.9	1.6	1.7
Calcium, mg/l	16.0	16.1	15.2	15.8	15.5
Magnesium, mg/l	2.2	2.2	2.1	2.0	2.1
Iron, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Alkalinity, mg/l	62	64	59	62	60
Copper, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1

Parameter	W21	W22	W23	W24	W25
Lead, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Zinc, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Chromium, mg/l	<0.05	<0.05	<0.05	<0.05	<0.05
Mercury, mg/l	<0.001	<0.001	<0.001	<0.001	<0.001
Cadmium, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
BOD, mg/l	1.5	1.5	1.7	1.6	1.7
COD, mg/l	3.0	2.9	3.3	3.1	3.2
DO, mg/l	9.6	9.7	9.8	9.7	9.7
Phenolic compounds, mg/l	BDL	BDL	BDL	BDL	BDL
Oil & Grease, mg/l	BDL	BDL	BDL	BDL	BDL
Total Coliform MPN/100 ml	Nil	Nil	Nil	Nil	Nil

The pH level in the project area of Demwe Upper hydroelectric project ranged from 7.5 to 7.8 at various samples covered as a part of the study, which is well within the permissible limit specified for drinking water (Refer Table-5.1).

The TDS level ranged from 53 to 65 mg/l which is well below the permissible limit of 500 mg/l specified for drinking water. The TDS level was found to be lower at all the stations in monsoon months as compared to summer months. This trend was observed for various cations and anions monitored as a part of the study. This could be attributed to higher discharges in monsoon months.

The hardness level ranged from 47 to 55 mg/l indicating soft nature. The hardness level was well below the permissible limit of 200 mg/l specified for drinking water. The alkalinity was found to be higher than the total hardness in all the water sampling stations monitored as a part of the study, which indicates that entire hardness in the water is on account of carbonate hardness and there is no bicarbonate hardness in the water.

The chlorides level ranged from 7 to 14 mg/l, which is well below the permissible limit specified for drinking water (200mg/l). The sulphates level at various sampling stations ranged from 5 to 12 mg/l in various samples monitored for a period of six months as a part of the study. The sulphate was found to be well below the permissible limit of 200 mg/l specified for drinking water purposes. The concentration of nitrates and phosphates at various sampling locations was observed to below detectable limit of 0.01 mg/l.

The concentration of various cations, e.g. sodium, potassium, calcium and magnesium was observed to be quite low which is also reflected by the low TDS level. Iron was found to be well below the permissible limit of 1 mg/l specified for drinking water purposes.

The concentration of various heavy metals was found to be well below the permissible limits. Concentration of phenolic compounds and oil & grease as expected in a hilly terrain with no major sources of water pollution from domestic or industrial sources was observed to be quite low.

The low BOD, COD, Total coliform values along with high DO levels (9.5 to 9.8 mg/l) indicate the absence of pollution loading. This is mainly due to the low population density and absence of industries in the area.

5.3.6 Demwe Lower Hydroelectric project

As a part of the study, water quality was monitored at following five locations:

- 5000 m upstream of dam site (W26)
- 3000 m upstream of dam site (W27)
- Dam site (W28)
- 3000 m downstream of dam site (W29)
- 5000 m downstream of dam site (W30)

The results of water quality survey conducted for six months for Demwe Lower hydroelectric project are given in Tables-5.32 to 5.37.

TABLE-5.32

Results of water quality monitoring for Demwe Lower hydroelectric project April 2009

Parameter	W26	W27	W28	W29	W30
pH	7.9	7.8	7.9	7.6	7.8
Electrical Conductivity, micromhos/cm	89	92	90	82	81
Total Dissolved Solids, mg/l	65	67	66	60	59
Hardness, mg/l	59	60	59	57	55
Chlorides, mg/l	10	10	10	13	11
Sulphates, mg/l	10	9	9	8	9
Phosphates, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
Nitrates, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
Sodium, mg/l	6.0	5.6	4.8	5.1	5.1
Potassium, mg/l	2.7	2.9	2.6	3.2	3.4
Calcium, mg/l	19.1	18.6	17.2	16.7	17.0
Magnesium, mg/l	2.8	3.4	3.8	3.6	3.1
Iron, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Alkalinity, mg/l	73	74	73	71	68
Copper, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Lead, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Zinc, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Chromium, mg/l	<0.05	<0.05	<0.05	<0.05	<0.05
Mercury, mg/l	<0.001	<0.001	<0.001	<0.001	<0.001
Cadmium, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
BOD, mg/l	2.2	2.0	1.8	1.9	1.8
COD, mg/l	4.2	3.7	3.6	3.7	3.5
DO, mg/l	9.6	9.5	9.7	9.5	9.5
Phenolic compounds, mg/l	BDL	BDL	BDL	BDL	BDL
Oil & Grease, mg/l	BDL	BDL	BDL	BDL	BDL
Total Coliform MPN/100 ml	Nil	Nil	Nil	Nil	Nil

TABLE-5.33
Results of water quality monitoring for Demwe Lower hydroelectric project May 2009

Parameter	W26	W27	W28	W29	W30
pH	7.9	7.9	7.9	7.7	7.8
Electrical Conductivity, micromhos/cm	90	89	93	84	79
Total Dissolved Solids, mg/l	66	65	68	61	58
Hardness, mg/l	62	61	60	56	56
Chlorides, mg/l	11	10	12	12	11

Parameter	W26	W27	W28	W29	W30
Sulphates, mg/l	9	10	10	9	9
Phosphates, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
Nitrates, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
Sodium, mg/l	6.2	5.6	4.7	5.2	5.2
Potassium, mg/l	2.8	2.9	2.8	3.5	3.5
Calcium, mg/l	19.5	19.1	17.5	16.2	17.1
Magnesium, mg/l	3.1	3.2	3.6	3.8	3.2
Iron, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Alkalinity, mg/l	77	76	74	69	69
Copper, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Lead, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Zinc, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Chromium, mg/l	<0.05	<0.05	<0.05	<0.05	<0.05
Mercury, mg/l	<0.001	<0.001	<0.001	<0.001	<0.001
Cadmium, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
BOD, mg/l	2.1	2.0	1.8	1.8	1.8
COD, mg/l	4.1	3.9	3.6	3.4	3.5
DO, mg/l	9.6	9.6	9.6	9.6	9.5
Phenolic compounds, mg/l	BDL	BDL	BDL	BDL	BDL
Oil & Grease, mg/l	BDL	BDL	BDL	BDL	BDL
Total Coliform MPN/100 ml	Nil	Nil	Nil	Nil	Nil

TABLE-5.34
Results of water quality monitoring for Demwe Lower hydroelectric project June 2009

Parameter	W26	W27	W28	W29	W30
pH	7.8	7.8	7.9	7.8	7.9
Electrical Conductivity, micromhos/cm	89	92	92	86	81
Total Dissolved Solids, mg/l	63	61	59	57	58
Hardness, mg/l	62	61	60	56	56
Chlorides, mg/l	10	10	10	11	10
Sulphates, mg/l	8	9	10	8	9
Phosphates, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
Nitrates, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
Sodium, mg/l	6.1	5.8	4.9	5.1	5.5
Potassium, mg/l	3.1	3.0	2.8	3.3	3.9

Parameter	W26	W27	W28	W29	W30
Calcium, mg/l	19.7	19.0	17.7	16.5	16.9
Magnesium, mg/l	3.3	3.2	3.5	3.8	3.6
Iron, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Alkalinity, mg/l	77	76	74	69	69
Copper, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Lead, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Zinc, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Chromium, mg/l	<0.05	<0.05	<0.05	<0.05	<0.05
Mercury, mg/l	<0.001	<0.001	<0.001	<0.001	<0.001
Cadmium, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
BOD, mg/l	2.0	2.0	1.9	2.1	2.0
COD, mg/l	4.0	3.9	3.8	4.1	3.9
DO, mg/l	9.6	9.5	9.5	9.6	9.6
Phenolic compounds, mg/l	BDL	BDL	BDL	BDL	BDL
Oil & Grease, mg/l	BDL	BDL	BDL	BDL	BDL
Total Coliform MPN/100 ml	Nil	Nil	Nil	Nil	Nil

TABLE-5.35
Results of water quality monitoring for Demwe Lower hydroelectric project July 2009

Parameter	W26	W27	W28	W29	W30
pH	7.7	7.7	7.7	7.7	7.7
Electrical Conductivity, micromhos/cm	77	75	75	71	70
Total Dissolved Solids, mg/l	56	55	55	52	51
Hardness, mg/l	51	54	54	54	55
Chlorides, mg/l	8	8	9	7	9
Sulphates, mg/l	6	6	7	6	7
Phosphates, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
Nitrates, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01

Parameter	W26	W27	W28	W29	W30
Sodium, mg/l	5.6	5.1	4.3	4.8	5.0
Potassium, mg/l	2.7	2.6	2.2	2.9	3.2
Calcium, mg/l	15.9	17.0	16.8	16.5	16.9
Magnesium, mg/l	2.6	2.8	2.9	3.1	3.0
Iron, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Alkalinity, mg/l	63	67	67	67	68
Copper, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Lead, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Zinc, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Chromium, mg/l	<0.05	<0.05	<0.05	<0.05	<0.05
Mercury, mg/l	<0.001	<0.001	<0.001	<0.001	<0.001
Cadmium, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
BOD, mg/l	1.7	1.7	1.5	1.8	1.5
COD, mg/l	3.3	3.2	3.0	3.5	2.9
DO, mg/l	9.7	9.7	9.6	9.6	9.8
Phenolic compounds, mg/l	BDL	BDL	BDL	BDL	BDL
Oil & Grease, mg/l	BDL	BDL	BDL	BDL	BDL
Total Coliform MPN/100 ml	Nil	Nil	Nil	Nil	Nil

TABLE-5.36

Results of water quality monitoring for Demwe Lower hydroelectric project August 2009

Parameter	W26	W27	W28	W29	W30
pH	7.6	7.6	7.7	7.6	7.5
Electrical Conductivity, micromhos/cm	77	73	70	71	74
Total Dissolved Solids, mg/l	56	53	52	51	54
Hardness, mg/l	51	51	51	53	52
Chlorides, mg/l	8	7	9	7	7
Sulphates, mg/l	6	6	6	6	6
Phosphates, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01

Parameter	W26	W27	W28	W29	W30
Nitrates, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
Sodium, mg/l	5.1	5.0	4.2	4.5	4.7
Potassium, mg/l	2.8	2.5	2.1	2.5	2.8
Calcium, mg/l	16.2	16.5	16.2	16.1	16.3
Magnesium, mg/l	2.6	2.5	2.6	3.0	2.8
Iron, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Alkalinity, mg/l	63	63	63	66	64
Copper, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Lead, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Zinc, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Chromium, mg/l	<0.05	<0.05	<0.05	<0.05	<0.05
Mercury, mg/l	<0.001	<0.001	<0.001	<0.001	<0.001
Cadmium, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
BOD, mg/l	1.5	1.5	1.4	1.6	1.4
COD, mg/l	3.0	2.9	2.8	3.1	2.6
DO, mg/l	9.8	9.7	9.7	9.7	9.6
Phenolic compounds, mg/l	BDL	BDL	BDL	BDL	BDL
Oil & Grease, mg/l	BDL	BDL	BDL	BDL	BDL
Total Coliform MPN/100 ml	Nil	Nil	Nil	Nil	Nil

TABLE-5.37
Results of water quality monitoring for Demwe Lower hydroelectric project September 2009

Parameter	W26	W27	W28	W29	W30
pH	7.5	7.6	7.5	7.5	7.5
Electrical Conductivity, micromhos/cm	71	66	68	69	71
Total Dissolved Solids, mg/l	52	48	50	50	52
Hardness, mg/l	52	50	52	50	51
Chlorides, mg/l	6	7	8	6	6
Sulphates, mg/l	6	6	5	5	6

Parameter	W26	W27	W28	W29	W30
Phosphates, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
Nitrates, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
Sodium, mg/l	4.6	4.5	4.0	4.3	4.3
Potassium, mg/l	2.6	2.3	2.0	2.2	2.5
Calcium, mg/l	16.1	16.2	16.1	15.7	16.0
Magnesium, mg/l	2.5	2.5	2.5	2.7	2.6
Iron, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Alkalinity, mg/l	64	62	64	62	63
Copper, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Lead, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Zinc, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Chromium, mg/l	<0.05	<0.05	<0.05	<0.05	<0.05
Mercury, mg/l	<0.001	<0.001	<0.001	<0.001	<0.001
Cadmium, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
BOD, mg/l	1.4	1.5	1.4	1.5	1.4
COD, mg/l	2.7	2.8	2.6	3.0	2.7
DO, mg/l	9.8	9.8	9.7	9.7	9.7
Phenolic compounds, mg/l	BDL	BDL	BDL	BDL	BDL
Oil & Grease, mg/l	BDL	BDL	BDL	BDL	BDL
Total Coliform MPN/100 ml	Nil	Nil	Nil	Nil	Nil

The pH level in the project area of Demwe Lower hydroelectric project ranged from 7.5 to 7.9 at various samples covered as a part of the study. The pH level is well within the permissible limit specified for drinking water requirements (Refer Table-5.1).

The TDS level ranged from 48 to 68 mg/l which is well below the permissible limit of 500 mg/l specified for drinking water. The TDS level was found to be lower at all the stations in the monsoon months of July 2009 to September 2009 as compared to summer months of April 2009 to June 2009. This trend was observed for various cations and anions monitored as a part of the study. This could be attributed to higher discharges in monsoon months.

The hardness level ranged from 50 to 62 mg/l indicating soft nature of water. The hardness level was well below the permissible limit of 200 mg/l specified for drinking water. The alkalinity was found to be higher than the total hardness in all the water sampling stations monitored as a part of the study, which indicates that entire hardness in the water is on account of carbonate hardness and there is no bicarbonate hardness in the water.

The chlorides level ranged from 6 to 13 mg/l, which is well below the permissible limit specified for drinking water (200 mg/l). The sulphates level at various sampling stations ranged from 5 to 10 mg/l in various samples monitored for a period of six months as a part of the study. The sulphate was found to be well below the permissible limit of 200 mg/l specified for drinking water purposes. The concentration of nitrates and phosphates at various sampling locations was observed to below detectable limit of 0.01 mg/l.

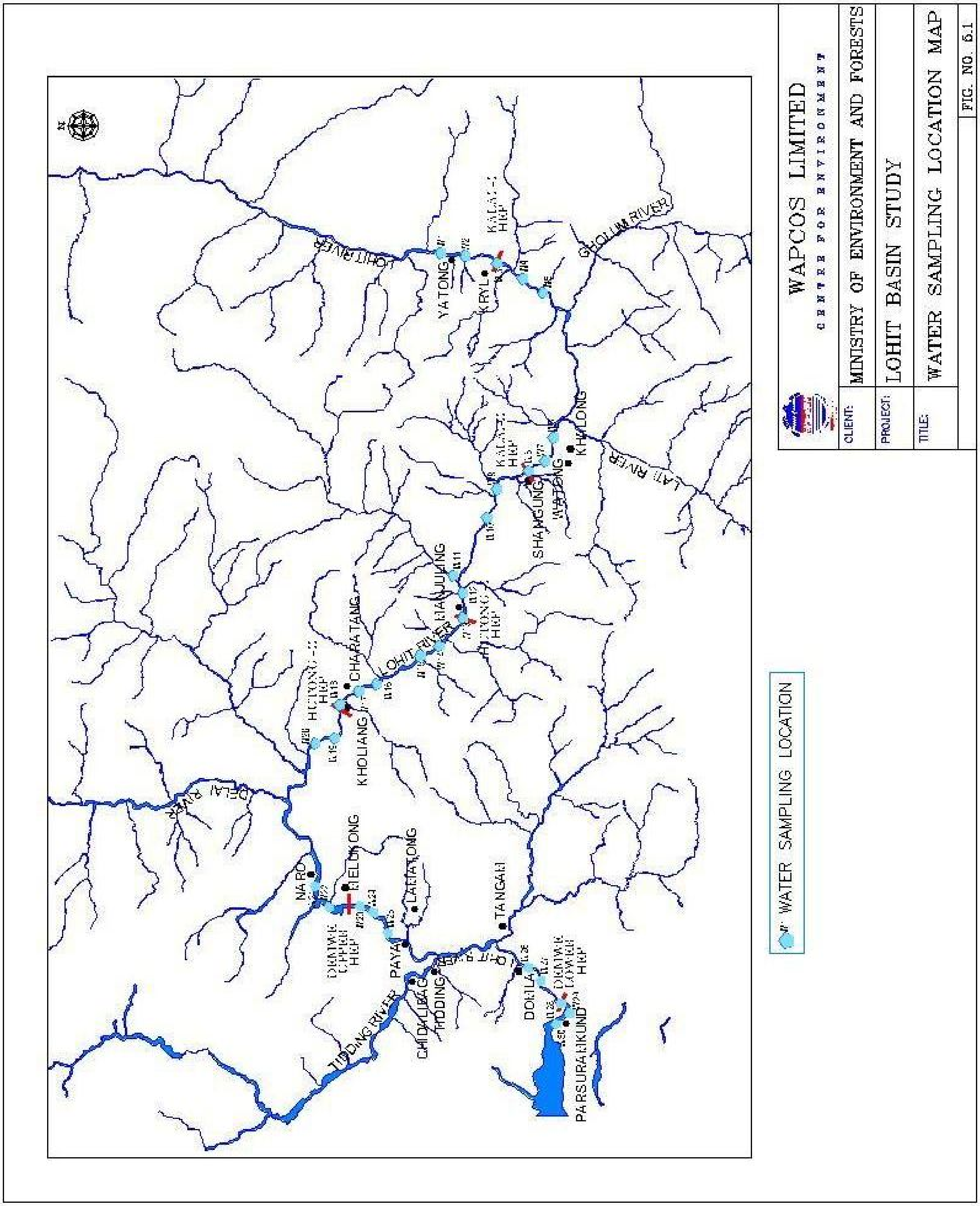
The concentration of various cations, e.g. sodium, potassium, calcium and magnesium was observed to be quite low which is also reflected by the low TDS level. Iron was found to be well below the permissible limit of 1 mg/l specified for drinking water purposes.

The concentration of various heavy metals was found to be well below the permissible limits. Concentration of phenolic compounds and oil & grease as expected in a hilly terrain with no major sources of water pollution from domestic or industrial sources was observed to be quite low.

The low BOD, COD and Total coliform values and near saturation level values of DO indicate the absence of pollution loading in the area. This is mainly due to the low population density and absence of industries in the area. The low COD values also indicate the absence of chemical pollution loading in the area. The marginal quantity of pollution load which enters river Lohit, gets diluted.

5.4 CONCLUSIONS

It can be concluded that water quality is quite good in the area. This is expected in an area with no major sources of water pollution. The main reasons for low pollution loading are low population density, absence of industries, low cropping intensity with minimal or no use of agro-chemicals. The pollution loading observed is well below the carrying capacity available in the river on account of high discharges.


WAPCOS LIMITED
CENTRE FOR ENVIRONMENT
CLIENT: MINISTRY OF ENVIRONMENT AND FORESTS
PROJECT: LOHIT BASIN STUDY
TITLE: WATER SAMPLING LOCATION MAP
FIG. NO. 6.1
WATER SAMPLING LOCATION
LOHIT RIVER
GHOLUM RIVER
LATI RIVER
DELAI RIVER
TIDDING RIVER
YATONG
KRYLA
KALAI-I HEP
KALAI-II HEP
SHANGUNG
WATONG
KHALONG
HAWAJUHING
HUTONG HEP
HUTONG-II HEP
CHARATANG
KHOLIANG
NARO
MELUKONG
DEMWE UPPER HEP
LATATONG
PAYA
TANGAM
CHIDIKLIANG
TIDDING
DORLA
DEMWE LOWER HEP
PARSURAMKUND

CHAPTER-6
AQUATIC ECOLOGY

6.1 GENERAL

Implementation of any developmental project requires sustainable management of the land and water resources. In order to ensure sustainable management of resources, an inventory of the existing resource base and its production and consumption pattern must be studied. As a part of the basin study detailed aquatic ecological sampling study was conducted. The sampling was conducted once every month for a period of six months from April 2009 to September 2009.

The objectives of the study were to:

- Assess biotic resources with special reference to zooplankton, phytoplankton, benthos, macrophytes, invertebrates and fishes.
- Estimate population densities and diversities of phytoplankton, zooplankton, benthos, macrophytes, invertebrates and fish.
- Estimate primary productivity of river at the study sites.
- Assess loss of habitat and conservation needs for fish species in the project area.
- Characterize river ecosystem for trophic status based on the existing status of riverine ecology.
- Document and identify migratory route of migratory fishes, spawning and breeding grounds of different fish species.

6.2 SAMPLING SITES

The study area lies within the state of Arunachal Pradesh and in each proposed project, following five sites were sampled, as listed below:

Kalai hydroelectric Project, Stage-1

- 5000 m upstream of dam site (S1)
- 3000 m upstream of dam site (S2)
- Dam site (S3)
- 3000 m downstream of dam site (S4)
- 5000 m downstream of dam site (S5)

Kalai hydroelectric Project, Stage-2

- 5000 m upstream of dam site (S6)
- 3000 m upstream of dam site (S7)
- Dam site (S8)
- 3000 m downstream of dam site (S9)
- 5000 m downstream of dam site (S10)

Hutong hydroelectric Project, Stage-1

- 5000 m upstream of dam site (S11)
- 3000 m upstream of dam site (S12)
- Dam site (S13)
- 3000 m downstream of dam site (S14)
- 5000 m downstream of dam site (S15)

Hutong hydroelectric Project, Stage-2

- 5000 m upstream of dam site (S16)
- 3000 m upstream of dam site (S17)
- Dam site (S18)
- 3000 m downstream of dam site (S19)
- 5000 m downstream of dam site (S20)

Demwe Upper hydroelectric Project

- 5000 m upstream of dam site (S21)
- 3000 m upstream of dam site (S22)
- Dam site (S23)
- 3000 m downstream of dam site (S24)
- 5000 m downstream of dam site (S25)

Demwe Lower hydroelectric Project

- 5000 m upstream of dam site (S26)
- 3000 m upstream of dam site (S27)
- Dam site (S28)
- 3000 m downstream of dam site (S29)
- 5000 m downstream of dam site (S30)

The location of various sampling locations is shown in Figure-6.1.

6.3 FINDINGS OF THE AQUATIC ECOLOGICAL SURVEY

6.3.1 PHYTOPLANKTONS

Phytoplanktons are the autotrophic component of the plankton community and play an important role in the primary production process in the stream ecosystems. They serve as a base of the aquatic food web, providing essential ecological function for all aquatic life. In terms of numbers, the important groups of phytoplankton comprise of diatoms, dinoflagellates, cyanobacteria, and other groups of unicellular algae. The construction of hydroelectric stations in the mountain rivers/streams will have profound impact on the planktonic communities as the planktonic organisms pass through a regulated stream with cascades of reservoirs. The species composition of two conditions viz. lake conditions and river conditions will be different. Hence, prior to dam construction it is necessary to know the composition, density and diversity of phytoplankton. Density and diversity of phytoplankton in the river water was studied for a period of six months viz., April, May, June, July, August and September 2009 by collecting samples from various sampling locations.

Phytoplankton species, their population density at various sampling sites for different projects is given in **Annexure-VII**. The summary of phytoplankton density observed at various sampling stations during the sampling period is given in Table-6.1.

TABLE-6.1

Phytoplankton density at various sampling stations (No. of individuals/l)

Project	**Month**					
	April 2009	**May 2009**	**June 2009**	**July 2009**	**August 2009**	**September 2009**
Kalai HEP Stage 1	2-16	3-10	2-6	5-8	2-10	2-6
Kalai HEP Stage 2	5-28	2-3	2-15	5-17	3-9	4-9
Hutong HEP Stage 1	2-15	1-7	1-13	4-14	2-7	3-6
Hutong HEP Stage 2	2-17	2-6	1-15	5-18	2-5	4-11
Demwe Upper HEP	5-18	2-19	2-17	2-15	3-16	1-11
Demwe Lower HEP	2-11	1-16	1-4	5-12	4-12	3-5

- Phytoplankton density ranged from 2-16 at various sampling stations monitored for Kalai HEP stage 1.
- Phytoplankton density ranged from 2-28 at various sampling sites monitored for Kalai HEP Stage 2.
- Phytoplankton density ranged from 1-15 at various sampling sites monitored for Hutong HEP Stage 1.
- Phytoplankton density ranged from 1-18 at various sampling sites monitored for Hutong HEP Stage 2.
- Phytoplankton density ranged from 1-19 at various sampling sites monitored for Demwe Upper hydroelectric project.
- Phytoplankton density ranged from 1-16 at various stations monitored for Demwe Lower hydroelectric project.

The density of phytoplanktons was recorded higher in Kalai stage-2 as compared to other projects **(Annexure-VII).** Analysis of variance showed that total density of phytoplankton differed significantly between different projects but did not differ between different sites in each project. The phytoplankton species in the Lohit basin belonged to three classes i.e. Bacillariophyceae, Chlorophyceae and Cyanophyceae. Some of the dominant phytoplanktons found in the Lohit river basin were *Actinastrum*, *Chlorella*, *Microcystis*, *Cymbella* and *Neidium*.

The diversity of phytoplanktons at various sampling locations during the study period is given in Tables-6.2 to 6.7.

TABLE-6.2
Diversity of phytoplanktons at various sampling locations in April 2009

Diversity indices	**Kalai HEP,Stage-1**					**Kalai HEP,Stage-2**				
	S1	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
Taxa	2	3	6	3	2	2	6	3	3	3
No. of individuals	16	7	12	5	2	8	28	21	5	21
Shannon's diversity	0.69	0.80	1.47	0.95	0.69	0.38	1.54	0.67	0.95	0.83
Simpson's index	0.50	0.45	0.69	0.56	0.50	0.22	0.76	0.38	0.56	0.53
Equitability	1.00	0.72	0.82	0.87	1.00	0.54	0.86	0.61	0.87	0.76
	Hutong HEP,Stage-1					**Hutong HEP,Stage-2**				
	S11	**S12**	**S13**	**S14**	**S15**	**S16**	**S17**	**S18**	**S19**	**S20**

Taxa	1	5	4	3	2	2	3	5	1	3
No. of individuals	4	15	15	13	2	5	16	17	2	3
Shannon's diversity	0.00	1.17	0.72	0.54	0.69	0.50	0.46	1.12	0.00	1.10
Simpson's index	0.00	0.59	0.35	0.27	0.50	0.32	0.23	0.55	0.00	0.67
Equitability	0.00	0.73	0.52	0.49	1.00	0.72	0.42	0.70	0.00	1.00
	Demwe Upper HEP					**Demwe Lower HEP**				
	S21	**S22**	**S23**	**S24**	**S25**	**S26**	**S27**	**S28**	**S29**	**S30**
Taxa	2	2	7	4	8	3	2	4	2	6
No. of individuals	5	5	12	14	18	3	2	4	2	11
Shannon's diversity	0.67	0.67	1.79	1.06	1.98	1.10	0.69	1.39	0.69	1.64
Simpson's index	0.48	0.48	0.81	0.58	0.85	0.67	0.50	0.75	0.50	0.78
Equitability	0.97	0.97	0.92	0.76	0.95	1.00	1.00	1.00	1.00	0.92

TABLE-6.3
Diversity of phytoplanktons at various sampling locations in May 2009

Diversity indices	**Kalai HEP,Stage-1**					**Kalai HEP,Stage-2**				
	S1	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
Taxa	2	4	2	3	3	2	3	2	2	2
No. of individuals	6	9	3	10	3	3	3	2	2	2
Shannon's diversity	0.45	1.00	0.64	0.64	1.10	0.64	1.10	0.69	0.69	0.69
Simpson's index	0.28	0.52	0.44	0.34	0.67	0.44	0.67	0.50	0.50	0.50
Equitability	0.65	0.72	0.92	0.58	1.00	0.92	1.00	1.00	1.00	1.00
	Hutong HEP,Stage-1					**Hutong HEP,Stage-2**				
	S11	**S12**	**S13**	**S14**	**S15**	**S16**	**S17**	**S18**	**S19**	**S20**
Taxa	2	1	3	1	2	1	3	3	2	2
No. of individuals	7	2	3	1	2	2	5	4	6	2
Shannon's diversity	0.68	0.00	1.10	0.00	0.69	0.00	0.95	1.04	0.45	0.69
Simpson's index	0.49	0.00	0.67	0.00	0.50	0.00	0.56	0.63	0.28	0.50
Equitability	0.99	0.00	1.00	0.00	1.00	0.00	0.87	0.95	0.65	1.00
	Demwe Upper HEP					**Demwe Lower HEP**				
	S21	**S22**	**S23**	**S24**	**S25**	**S26**	**S27**	**S28**	**S29**	**S30**
Taxa	9	2	5	11	3	1	8	1	4	9
No. of individuals	14	2	8	19	4	1	16	1	4	15
Shannon's diversity	2	0.69	1.39	2.30	1.04	0.00	1.86	0.00	1.39	1.8
Simpson's index	0.88	0.50	0.69	0.89	0.63	0.00	0.81	0.00	0.75	0.87
Equitability	0.92	1.00	0.86	0.95	0.95	0.00	0.89	0.00	1.00	0.81

TABLE-6.4
Diversity of phytoplanktons at various sampling locations in June 2009

Diversity indices	Kalai HEP,Stage-1					Kalai HEP,Stage-2				
	S1	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
Taxa	2	2	5	1	2	2	4	3	1	3
No. of individuals	4	6	6	2	2	8	13	13	2	15
Shannon's diversity	0.69	0.45	1.26	0	0.69	0.37	1.19	0.53	0	0.62
Simpson's index	0.5	0.27	0.80	0	0.50	0.21	0.97	0.27	0	0.33
Equitability	1	0.65	0.78	0	1.00	0.5	0.86	0.48	0	0.57
Diversity indices	**Hutong HEP,Stage-1**					**Hutong HEP,Stage-2**				
	S11	**S12**	**S13**	**S14**	**S15**	**S16**	**S17**	**S18**	**S19**	**S20**
Taxa	1	3	2	3	2	1	2	4	0	2
No. of individuals	1	12	13	13	2	1	12	15	0	2
Shannon's diversity	0.00	0.72	0.27	0.53	0.69	0	0.28	0.85	0.00	0.69
Simpson's index	0.00	0.40	0.14	0.43	0.50	0	0.15	0.43	0.00	0.50
Equitability	0.00	0.65	0.39	0.61	1.00	0	0.85	0.61	0.00	1.00
Diversity indices	**Demwe Upper HEP**					**Demwe Lower HEP**				
	S21	**S22**	**S23**	**S24**	**S25**	**S26**	**S27**	**S28**	**S29**	**S30**
Taxa	1	2	2	3	7	1	2	2	2	3
No. of individuals	2	4	3	4	17	1	2	4	2	4
Shannon's diversity	0	0.69	1.63	1.03	1.67	0	0.69	0.56	0.69	1.03
Simpson's index	0	0.5	0.44	0.62	0.76	0	0.50	0.37	0.50	0.62
Equitability	0	1	0.91	0.94	0.86	0	1.00	0.81	1.00	0.94

TABLE-6.5
Diversity of phytoplanktons at various sampling locations in July 2009

Diversity indices	Kalai HEP,Stage-1					Kalai HEP,Stage-2				
	S1	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
Taxa	1	2	6	2	1	1	4	2	3	2
No. of individuals/l	8	7	6	5	5	7	17	17	5	9
Shannon's diversity	0.00	0.68	1.79	0.67	0.00	0.00	1.05	0.22	0.95	0.35
Simpson's index	0.00	0.49	0.83	0.48	0.00	0.00	0.60	0.11	0.56	0.20
Equitability	0.00	0.99	1.00	0.97	0.00	0.00	0.76	0.32	0.87	0.50
Diversity indices	**Hutong HEP,Stage-1**					**Hutong HEP,Stage-2**				
	S11	**S12**	**S13**	**S14**	**S15**	**S16**	**S17**	**S18**	**S19**	**S20**

Taxa	1	3	3	1	1	3	5	1	3	2
No. of individuals	4	11	14	11	6	9	18	11	7	5
Shannon's diversity	0.00	0.60	0.51	0.00	0.00	1.06	0.84	0.00	0.96	0.67
Simpson's index	0.00	0.31	0.26	0.00	0.00	0.64	0.38	0.00	0.57	0.48
Equitability	0.00	0.55	0.46	0.00	0.00	0.97	0.52	0.00	0.87	0.97
Diversity indices	**Demwe Upper HEP**					**Demwe Lower HEP**				
	S21	**S22**	**S23**	**S24**	**S25**	**S26**	**S27**	**S28**	**S29**	**S30**
No. of Taxa	4	1	9	2	7	2	2	3	3	3
No. of individuals	8	2	13	5	15	6	5	11	10	12
Shannon's diversity	1.21	0.00	2.14	0.50	1.86	0.64	0.67	0.99	1.03	1.01
Simpson's index	0.66	0.00	0.88	0.32	0.65	0.44	0.48	0.60	0.62	0.61
Equitability	0.88	0.00	0.97	0.72	0.89	0.92	0.97	0.91	0.94	0.92

TABLE-6.6
Diversity of phytoplanktons at various sampling locations in August 2009

Diversity indices	**Kalai HEP,Stage-1**					**Kalai HEP,Stage-2**				
	S1	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
Taxa	1	3	1	2	2	1	2	1	2	2
No. of individuals	2	10	2	5	4	3	5	6	9	5
Shannon's diversity	0.00	1.09	0.00	0.67	0.69	0.00	0.67	0.00	0.35	0.67
Simpson's index	0.00	0.66	0.00	0.48	0.50	0.00	0.48	0.00	0.20	0.48
Equitability	0.00	0.99	0.00	0.97	1.00	0.00	0.97	0.00	0.50	0.97
Diversity indices	**Hutong HEP,Stage-1**					**Hutong HEP,Stage-2**				
	S11	**S12**	**S13**	**S14**	**S15**	**S16**	**S17**	**S18**	**S19**	**S20**
Taxa	1	1	2	1	1	1	2	1	1	1
No. of individuals	4	2	7	3	2	2	4	2	5	2
Shannon's diversity	0.00	0.00	0.60	0.00	0.00	0.00	0.56	0.00	0.00	0.00
Simpson's index	0.00	0.00	0.41	0.00	0.00	0.00	0.38	0.00	0.00	0.00
Equitability	0.00	0.00	0.86	0.00	0.00	0.00	0.81	0.00	0.00	0.00
Diversity indices	**Demwe Upper HEP**					**Demwe Lower HEP**				
	S21	**S22**	**S23**	**S24**	**S25**	**S26**	**S27**	**S28**	**S29**	**S30**
Taxa	6	2	3	6	3	1	5	1	3	5
No. of individuals	16	6	3	14	4	5	9	6	4	12
Shannon's diversity	1.75	0.45	1.10	1.63	1.04	0.00	1.47	0.00	1.04	1.42
Simpson's index	0.82	0.28	0.67	0.78	0.63	0.00	0.74	0.00	0.63	0.72
Equitability	0.98	0.65	1.00	0.91	0.95	0.00	0.91	0.00	0.95	0.88

TABLE-6.7

Diversity of phytoplanktons at various sampling locations in September 2009

Diversity indices	Kalai HEP,Stage-1					Kalai HEP,Stage-2				
	S1	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
Taxa	2	2	1	1	2	2	2	2	3	3
No. of individuals	4	6	2	2	5	6	4	4	9	7
Shannon's diversity	0.56	0.45	0.00	0.00	0.67	0.64	0.69	0.56	0.94	0.96
Simpson's index	0.38	0.28	0.00	0.00	0.48	0.44	0.50	0.38	0.57	0.57
Equitability	0.81	0.65	0.00	0.00	0.97	0.92	1.00	0.81	0.85	0.87
Diversity indices	**Hutong HEP,Stage-1**					**Hutong HEP,Stage-2**				
	S11	**S12**	**S13**	**S14**	**S15**	**S16**	**S17**	**S18**	**S19**	**S20**
Taxa	1	1	2	2	2	1	3	2	2	1
No. of individuals	5	6	4	6	3	6	11	7	8	4
Shannon's diversity	0.00	0.00	0.56	0.45	0.64	0.00	0.99	0.41	0.66	0.00
Simpson's index	0.00	0.00	0.38	0.28	0.44	0.00	0.60	0.24	0.47	0.00
Equitability	0.00	0.00	0.81	0.65	0.92	0.00	0.91	0.59	0.95	0.00
Diversity indices	**Demwe Upper HEP**					**Demwe Lower HEP**				
	S21	**S22**	**S23**	**S24**	**S25**	**S26**	**S27**	**S28**	**S29**	**S30**
Taxa	2	3	3	1	2	1	2	2	2	2
No. of individuals	11	8	6	1	3	4	4	3	5	3
Shannon's diversity	0.69	0.90	1.01	0.00	0.64	0.00	0.56	0.64	0.50	0.64
Simpson's index	0.50	0.53	0.61	0.00	0.44	0.00	0.38	0.44	0.32	0.44
Equitability	0.99	0.82	0.92	0.00	0.92	0.00	0.81	0.92	0.72	0.92

- Number of individuals was observed to be higher at sampling locations in the vicinity of Kalai stage-2 hydroelectric project, as compared to the other projects.

6.3.2 ZOOPLANKTONS

Zooplanktons are the heterotrophic component of the plankton community, and is a broad categorization spanning a range of organism sizes that includes both small protozoans and large metazoans. Through their consumption and processing of phytoplankton (and other food sources), zooplankton play an important role in aquatic food webs, both as a resource for consumers on higher trophic levels (including fish), and as a conduit for packaging the organic material in the biological pump. Since they are typically of small size, zooplanktons can respond relatively rapidly to increases in phytoplankton abundance, for instance, during the spring bloom. The construction of hydroelectric stations in the mountain rivers/streams will have profound impact on the planktonic communities as the planktonic organisms pass through a regulated stream with cascades of reservoirs. The species composition of two conditions viz. lake conditions and river conditions will be different. Hence, prior to dam construction it is necessary to know the composition, density and diversity of zooplankton. Density and diversity of zooplanktons in the river water was studied for a period of six months viz., April, May, June, July, August and September 2009 by collecting the samples from five sites of each project i.e. 5000 m upstream of dam site, 3000 m upstream of dam site, Dam site, 3000 m downstream of dam site, 5000 m downstream of dam site.

Zooplankton species, their population density and diversity in the different project sites are summarized in **Annexure VIII**. The density and diversity of zooplankton species was highest at all the sites in April and it showed decreasing trend in the months of May, June, July, August and September. This decreasing trend could be due to changes in physico-chemical properties of water across temporal scale. Analysis of variance showed that the total density of zooplankton differed significantly between different projects ($p<0.05$) but did not differ significantly between different sites in each project. Zooplankton community in Lohit river basin was dominated by members of Rotifera and Cladocera. The dominant genera were *Difflugia*, *Colurella*, *Testudinella*, *Philodina*, *Keratella*, and *Polyarthra*, although their dominance varied across sites and seasons in the Lohit river basin.

The summary of zooplankton density observed at various sampling locations during the study period is given in Table-6.8.

TABLE-6.8
Zooplankton Density at various sampling stations (No. of individuals/lit)

Project	**Month**					
	April 2009	**May 2009**	**June 2009**	**July 2009**	**August 2009**	**September 2009**
Kalai HEP Stage 1	15-26	9-20	5-14	7-10	7-9	2-4
Kalai HEP Stage 2	3-22	3-22	3-11	3-12	2-11	1-8
Hutong HEP Stage 1	2-12	5-10	2-10	5-7	5-8	1-8
Hutong HEP Stage 2	1-25	9-16	6-15	1-13	5-12	4-9
Demwe Upper HEP	2-21	2-21	7-11	1-15	2-16	2-7

Demwe Lower HEP	2-25	4-22	4-16	4-21	4-12	4-8

- Zooplankton density (No of individual/lit) ranged from 2-26 at various stations monitored for Kalai hydroelectric project stage 1.
- Zooplankton density (No of individual/lit) ranged from 1-22 at various stations monitored for Kalai hydroelectric project stage 2.
- Zooplankton density (No of individual/lit) ranged from 1-12 at various stations monitored for Hutong hydroelectric project stage 1.
- Zooplankton density (No of individual/lit) ranged from 1-25 at various stations monitored for Hutong hydroelectric project stage 2.
- Zooplankton density (No of individual/lit) ranged from 1-21 at various stations monitored for Demwe Upper hydroelectric project.
- Zooplankton density (No of individual/lit) ranged from 2-25 at various stations monitored for Demwe Lower hydroelectric project.

The zooplankton density was observed to be higher in the month of April and May 2009 as compared to results for other months.

The diversity of zooplanktons at various sampling locations during the study period is given in Tables-6.9 to 6.14.

TABLE-6.9
Diversity of zooplanktons in the month of April 2009

Diversity indices	**Kalai HEP, Stage-1**					**Kalai HEP, stage-2**				
	S1	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
Taxa	6	5	6	8	7	3	2	1	7	7
No. of individuals	22	24	26	26	15	7	3	3	22	21
Shannon's diversity	1.45	1.51	1.73	1.78	1.68	0.96	0.64	0.00	1.68	1.59
Simpson's index	0.72	0.76	0.81	0.79	0.76	0.57	0.44	0.00	0.78	0.73
Equitability	0.81	0.94	0.96	0.85	0.86	0.87	0.92	0.00	0.87	0.82
Diversity indices	**Hutong HEP, stage-1**					**Hutong HEP stage-2**				
	S11	**S12**	**S13**	**S14**	**S15**	**S16**	**S17**	**S18**	**S19**	**S20**
Taxa	1	3	1	1	3	10	1	6	2	4
No. of individuals	3	12	5	2	11	19	1	25	2	10
Shannon's diversity	0.00	0.96	0.00	0.00	0.93	2.10	0.00	1.37	0.69	1.17
Simpson's index	0.00	0.57	0.00	0.00	0.58	0.85	0.00	0.68	0.50	0.64
Equitability	0.00	0.87	0.00	0.00	0.85	0.91	0.00	0.76	1.00	0.84
Diversity indices	**Demwe Upper HEP**					**Demwe Lower HEP**				
	S21	**S22**	**S23**	**S24**	**S25**	**S26**	**S27**	**S28**	**S29**	**S30**

Taxa	3	2	5	2	5	6	4	1	4	5
No. of individuals	4	7	10	2	21	25	14	2	6	10
Shannon's diversity	1.04	0.60	1.42	0.69	1.56	1.37	1.24	0.00	1.33	1.36
Simpson's index	0.63	0.41	0.72	0.50	0.78	0.68	0.68	0.00	0.72	0.68
Equitability	0.95	0.86	0.88	1.00	0.97	0.76	0.89	0.00	0.96	0.84

TABLE-6.10
Diversity of zooplanktons in the month of May 2009

Diversity indices	**Kalai HEP, Stage-1**					**Kalai HEP, stage-2**				
	S1	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
Taxa	4	4	4	5	5	3	2	1	6	6
No. of individuals	9	17	20	12	13	7	3	3	22	12
Shannon's diversity	1.22	1.28	1.35	1.31	1.38	0.96	0.64	0.00	1.55	1.58
Simpson's index	0.67	0.70	0.74	0.67	0.70	0.57	0.44	0.00	0.75	0.75
Equitability	0.88	0.93	0.98	0.82	0.86	0.87	0.92	0.00	0.86	0.88
Diversity indices	**Hutong HEP, stage-1**					**Hutong -2, stage-1**				
	S11	**S12**	**S13**	**S14**	**S15**	**S16**	**S17**	**S18**	**S19**	**S20**
Taxa	2	2	1	2	2	7	3	4	2	3
No. of individuals	9	10	5	5	6	16	9	13	11	9
Shannon's diversity	0.69	0.61	0.00	0.67	0.45	1.69	0.94	1.16	0.69	0.94
Simpson's index	0.49	0.42	0.00	0.48	0.28	0.77	0.57	0.63	0.50	0.57
Equitability	0.99	0.88	0.00	0.97	0.65	0.87	0.85	0.83	0.99	0.85
Diversity indices	**Demwe Upper HEP**					**Demwe Lower HEP**				
	S21	**S22**	**S23**	**S24**	**S25**	**S26**	**S27**	**S28**	**S29**	**S30**
Taxa	3	1	4	2	5	4	3	4	3	3
No. of individuals/l	4	2	9	2	21	22	8	10	4	8
Shannon's diversity	1.04	0.00	1.22	0.69	1.56	1.28	0.97	0.94	1.04	0.90
Simpson's index	0.63	0.00	0.67	0.50	0.78	0.70	0.59	0.48	0.63	0.53
Equitability	0.95	0.00	0.88	1.00	0.97	0.92	0.89	0.68	0.95	0.82

TABLE-6.11
Diversity of zooplanktons in the month of June 2009

Diversity indices	**Kalai HEP, Stage-1**					**Kalai HEP, stage-2**				
	S1	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
Taxa	2	2	2	2	2	2	2	3	4	4
No. of individuals/l	14	7	9	9	5	3	8	9	11	10
Shannon's diversity	0.26	0.60	0.64	0.64	0.67	0.64	0.66	1.00	1.37	1.22
Simpson's index	0.13	0.41	0.44	0.44	0.48	0.44	0.47	0.59	0.74	0.66
Equitability	0.37	0.86	0.92	0.92	0.97	0.92	0.95	0.91	0.99	0.88
Diversity indices	**Hutong HEP, stage-1**					**Hutong -2, stage-1**				
	S11	**S12**	**S13**	**S14**	**S15**	**S16**	**S17**	**S18**	**S19**	**S20**
Taxa	3	4	3	1	2	2	3	3	3	3

No. of individuals/l	9	8	10	2	6	8	9	15	6	10
Shannon's diversity	0.85	1.21	0.80	0.00	0.45	0.66	0.85	0.99	1.01	0.94
Simpson's index	0.49	0.66	0.46	0.00	0.28	0.47	0.49	0.60	0.61	0.58
Equitability	0.77	0.88	0.73	0.00	0.65	0.95	0.77	0.90	0.92	0.86
Diversity indices	**Demwe Upper HEP**					**Demwe Lower HEP**				
	S21	**S22**	**S23**	**S24**	**S25**	**S26**	**S27**	**S28**	**S29**	**S30**
Taxa	2	3	4	4	3	3	2	3	2	3
No. of individuals	7	7	11	10	11	16	9	15	4	10
Shannon's diversity	0.60	0.80	1.30	1.22	1.04	0.97	0.69	0.99	0.69	0.90
Simpson's index	0.41	0.45	0.71	0.66	0.63	0.59	0.49	0.60	0.50	0.54
Equitability	0.86	0.72	0.93	0.88	0.94	0.89	0.99	0.90	1.00	0.82

TABLE-6.12

Diversity of zooplanktons in the month of July 2009

Diversity indices	**Kalai HEP, Stage-1**					**Kalai HEP, stage-2**				
	S1	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
Taxa	4	4	4	4	5	3	2	1	6	6
No. of individuals	7	8	9	10	10	7	3	3	12	12
Shannon's diversity	1.35	1.21	1.31	1.28	1.51	0.96	0.64	0.00	1.63	1.58
Simpson's index	0.73	0.66	0.72	0.70	0.76	0.57	0.44	0.00	0.78	0.75
Equitability	0.98	0.88	0.95	0.92	0.94	0.87	0.92	0.00	0.91	0.88
Diversity indices	**Hutong HEP, stage-1**					**Hutong HEP, stage-2**				
	S11	**S12**	**S13**	**S14**	**S15**	**S16**	**S17**	**S18**	**S19**	**S20**
Taxa	2	1	1	2	2	4	2	4	1	2
No. of individuals	6	7	5	5	6	10	4	13	1	2
Shannon's diversity	0.64	0.00	0.00	0.67	0.45	1.17	0.56	1.20	0.00	0.69
Simpson's index	0.44	0.00	0.00	0.48	0.28	0.64	0.38	0.64	0.00	0.50
Equitability	0.92	0.00	0.00	0.97	0.65	0.84	0.81	0.86	0.00	1.00
Diversity indices	**Demwe Upper HEP**					**Demwe Lower HEP**				
	S21	**S22**	**S23**	**S24**	**S25**	**S26**	**S27**	**S28**	**S29**	**S30**
Taxa	2	1	4	1	4	4	3	4	3	3
No. of individuals	3	2	9	1	15	21	8	10	4	8
Shannon's diversity	0.64	0.00	1.22	0.00	1.34	1.29	0.97	0.94	1.04	0.90
Simpson's index	0.44	0.00	0.67	0.00	0.73	0.71	0.59	0.48	0.63	0.53
Equitability	0.92	0.00	0.88	0.00	0.97	0.93	0.89	0.68	0.95	0.82

TABLE-6.13

Diversity of zooplanktons in the month of August 2009

Diversity indices	**Kalai HEP, Stage-1**					**Kalai HEP, stage-2**				
	S1	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
Taxa	4	4	4	5	4	3	1	1	5	5
No. of individuals	7	9	7	9	8	7	2	3	11	11
Shannon's diversity	1.15	1.37	1.28	1.47	1.32	0.96	0.00	0.00	1.55	1.41

Simpson's index	0.61	0.74	0.69	0.74	0.72	0.57	0.00	0.00	0.78	0.71
Equitability	0.83	0.99	0.92	0.91	0.95	0.87	0.00	0.00	0.96	0.88
Diversity indices	**Hutong HEP, stage-1**					**Hutong HEP, stage-2**				
	S11	**S12**	**S13**	**S14**	**S15**	**S16**	**S17**	**S18**	**S19**	**S20**
Taxa	2	3	1	3	1	5	2	2	1	2
No. of individuals	8	6	5	7	5	12	6	10	5	8
Shannon's diversity	0.66	1.01	0.00	0.96	0.00	1.47	0.45	0.61	0.00	0.66
Simpson's index	0.47	0.61	0.00	0.57	0.00	0.75	0.28	0.42	0.00	0.47
Equitability	0.95	0.92	0.00	0.87	0.00	0.92	0.65	0.88	0.00	0.95
Diversity indices	**Demwe Upper HEP**					**Demwe Lower HEP**				
	S21	**S22**	**S23**	**S24**	**S25**	**S26**	**S27**	**S28**	**S29**	**S30**
Taxa	2	2	3	2	5	4	3	4	3	3
No. of individuals	3	6	8	2	16	12	8	10	4	8
Shannon's diversity	0.64	0.64	0.97	0.69	1.54	1.31	0.97	0.94	1.04	0.90
Simpson's index	0.44	0.44	0.59	0.50	0.77	0.71	0.59	0.48	0.63	0.53
Equitability	0.92	0.92	0.89	1.00	0.96	0.94	0.89	0.68	0.95	0.82

TABLE-6.14

Diversity of zooplanktons in the month of September 2009

Diversity indices	**Kalai HEP, Stage-1**					**Kalai HEP, stage-2**				
	S1	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
Taxa	2	1	2	2	1	1	1	2	2	3
No. of individuals	3	2	3	4	3	1	3	7	5	8
Shannon's diversity	0.64	0.00	0.64	0.56	0.00	0.00	0.00	0.60	0.67	0.90
Simpson's index	0.44	0.00	0.44	0.38	0.00	0.00	0.00	0.41	0.48	0.53
Equitability	0.92	0.00	0.92	0.81	0.00	0.00	0.00	0.86	0.97	0.82
Diversity indices	**Hutong HEP, stage-1**					**Hutong HEP stage-2**				
	S11	**S12**	**S13**	**S14**	**S15**	**S16**	**S17**	**S18**	**S19**	**S20**
Taxa	1	2	2	2	1	2	2	2	2	2
No. of individuals	1	5	8	3	2	8	7	9	4	6
Shannon's diversity	0.00	0.50	0.38	0.64	0.00	0.66	0.41	0.53	0.56	0.45
Simpson's index	0.00	0.32	0.22	0.44	0.00	0.47	0.24	0.35	0.38	0.28
Equitability	0.00	0.72	0.54	0.92	0.00	0.95	0.59	0.76	0.81	0.65
Diversity indices	**Demwe Upper HEP**					**Demwe Lower HEP**				
	S21	**S22**	**S23**	**S24**	**S25**	**S26**	**S27**	**S28**	**S29**	**S30**
Taxa	3	2	2	2	2	1	1	1	3	2
No. of individuals	6	2	5	6	7	8	5	7	7	4
Shannon's diversity	1.01	0.69	0.50	0.45	0.60	0.00	0.00	0.00	0.96	0.56
Simpson's index	0.61	0.50	0.32	0.28	0.41	0.00	0.00	0.00	0.57	0.38
Equitability	0.92	1.00	0.72	0.65	0.86	0.00	0.00	0.00	0.87	0.81

Highest number of taxa (8) were observed at sampling stations located 3 km downstream of Kalai hydroelectric project stage 1. Highest number of individuals (26) were observed at Kalai hydroelectric project stage 1.

6.3.3 PERIPHYTONS

Periphyton is a complex mixture of algae, cyanobacteria, heterotrophic microbes, and detritus that is attached to submerged surfaces in most aquatic ecosystems. It serves as an important food source for invertebrates, tadpoles, and some fish. It can also absorb contaminants; removing them from the water column and limiting their movement through the environment. The periphyton is also an important indicator of water quality; responses of this community to pollutants can be measured at a variety of scales representing physiological to community-level changes. Construction of concrete structures on flowing waters alter the flow and temperature regimes, hydraulics, the availability and stability of substrata, channel morphology, the riparian vegetation, and as a result, the community structure of aquatic communities. The change in flow regimes may have impact on the periphytic community in the stream ecosystem. Hence, prior to construction of such large hydroelectric projects, a preliminary assessment of the composition, density and diversity of periphytic algal community is needed. The periphytic algal components were sampled in the project sites for 6 months viz. April, May, June, July, August and September 2009. During July-September, periphyton density could not be determined, as due to high volume of water and turbidity periphyton population was not found in the river. Samples of periphytic algae were collected by scraping 1 cm^2 area of the substratum on which they were growing. The scraped algae were then put in a small container and brought to the laboratory for identification. Density of the periphytic algae was expressed in terms of cm^2.

The Periphyton density observed at various sampling sites in different project sites are summarized in **Annexure IX**. Periphyton communities were prominent in the months of April, May and June in the shallow, rocky and gravelly bottoms in all the project sites of Lohit river basin. However, their population became inconspicuous in the months of July, August and September due to increase in water level in the river. The common periphyton genera found in the project sites were *Nitzchia*, *Hormidium*, *Spirogyra*, *Chlorella*, *Gloeocapsa* and *Cymbella*. Overall, 9 taxa of periphytic algae were recorded from all the sites in the Lohit river basin. Analysis of variance showed that the total density of periphytic algae did not differ significantly between different projects as well as between different sites in each project.

The summary of periphyton density observed at various sampling sites is given in Table-6.15.

TABLE-6.15

Density (No. of individuals/cm^2) of periphyton at various sampling sites

Project	Month		
	April 2009	May 2009	June 2009
Kalai HEP Stage 1	70-100	40-100	30-90
Kalai HEP Stage 2	30-110	40-80	30-60
Hutong HEP Stage 1	80-110	70-110	40-90
Hutong HEP Stage 2	70-120	50-120	30-80
Demwe Upper HEP	50-150	70-120	30-70
Demwe Lower HEP	30-160	60-140	30-90

- Density of periphytons ranged from 30-100 /cm^2 at various sampling sites monitored for Kalai hydroelectric project stage 1
- Density of periphytons ranged from 30-110 /cm^2 at various sampling sites monitored for Kalai hydroelectric project stage 2
- Density of periphytons ranged from 40-110 /cm^2 at various sampling sites monitored for Hutong hydroelectric project stage 1
- Density of periphytons ranged from 30-120 /cm^2 at various sampling sites monitored for Hutong hydroelectric project stage 2
- Density of periphytons ranged from 30-150 /cm^2 at various sampling sites monitored for Demwe Upper hydroelectric project
- Density of periphytons ranged from 30-160 /cm^2 at various sampling sites monitored for Demwe Lower hydroelectric project

The diversity of periphytons at various sampling locations during the study period is given in Tables-6.16 to 6.18.

TABLE-6.16
Diversity of periphytons in the month of April 2009

Diversity indices	Kalai HEP, Stage-1					Kalai HEP, Stage-2				
	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
No. of Taxa	2	2	2	3	4	3	2	1	4	4
No. of individuals	70	90	90	80	100	70	30	30	110	90
Shannon's diversity	0.60	0.53	0.64	0.74	1.16	0.96	0.64	0.00	1.12	1.15
Simpson's index	0.41	0.35	0.44	0.41	0.64	0.57	0.44	0.00	0.61	0.62
Equitability	0.86	0.76	0.92	0.67	0.84	0.87	0.92	0.00	0.81	0.83
Diversity indices	**Hutong HEP, Stage-1**					**Hutong HEP Stage-2**				
	S11	**S12**	**S13**	**S14**	**S15**	**S16**	**S17**	**S18**	**S19**	**S20**
No. of Taxa	5	4	3	5	4	5	5	3	3	5
No. of individuals	110	110	90	80	100	110	100	110	120	70
Shannon's diversity	1.41	1.03	1.00	1.49	1.22	1.46	1.51	0.32	0.92	1.41
Simpson's index	0.71	0.55	0.59	0.75	0.66	0..97	0.76	0.15	0.57	0.74
Equitability	0.88	0.75	0.91	0.93	0.88	0.91	0.94	0.30	0.84	0.92
Diversity indices	**Demwe Upper HEP**					**Demwe Lower HEP**				
	S21	**S22**	**S23**	**S24**	**S25**	**S26**	**S27**	**S28**	**S29**	**S30**
No. of Taxa	5	3	5	4	4	3	3	4	2	3
No. of individuals	120	130	150	50	150	160	80	100	30	80
Shannon's diversity	1.52	1.07	1.49	1.33	1.34	1.09	0.97	0.94	0.64	0.90
Simpson's index	0.76	0.65	0.76	0.72	0.73	0.66	0.59	0.48	0.44	0.53
Equitability	0.94	0.98	0.93	0.96	0.97	0.99	0.89	0.68	0.92	0.82

TABLE-6.17
Diversity of periphytons in the month of May 2009

Diversity indices	Kalai HEP, Stage-1					Kalai HEP, Stage-2				
	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
Taxa	4	3	3	3	3	3	3	4	4	3
No. of individuals	90	40	60	100	100	60	40	80	70	60
Shannon's diversity	1.15	1.04	1.01	0.95	1.03	1.01	1.04	1.32	1.28	1.01
Simpson's index	0.62	0.63	0.61	0.56	0.62	0.61	0.63	0.72	0.69	0.61
Equitability	0.83	0.95	0.92	0.87	0.94	0.92	0.95	0.95	0.92	0.92
Diversity indices	**Hutong HEP, Stage-1**					**Hutong HEP Stage-2**				
	S11	**S12**	**S13**	**S14**	**S15**	**S16**	**S17**	**S18**	**S19**	**S20**
Taxa	3	3	2	3	3	2	3	3	4	3
No. of individuals	110	80	80	80	70	50	120	110	90	90
Shannon's diversity	0.92	0.90	0.66	0.90	1.00	0.67	0.92	0.86	1.15	0.85
Simpson's index	0.56	0.53	0.47	0.53	0.61	0.48	0.57	0.51	0.62	0.49

Equitability	0.83	0.82	0.95	0.82	0.91	0.97	0.84	0.78	0.83	0.77
Diversity indices	**Demwe Upper HEP**					**Demwe Lower HEP**				
	S21	**S22**	**S23**	**S24**	**S25**	**S26**	**S27**	**S28**	**S29**	**S30**
Taxa	3	4	4	4	4	4	4	4	4	4
No. of individuals	90	70	80	100	120	140	70	100	60	100
Shannon's diversity	0.94	1.35	1.21	1.22	1.24	1.10	1.15	0.94	1.24	1.22
Simpson's index	0.57	0.73	0.66	0.66	0.68	0.62	0.61	0.48	0.67	0.66
Equitability	0.85	0.98	0.88	0.88	0.89	0.79	0.83	0.68	0.90	0.88

TABLE-6.18

Diversity of periphytons in the month of June 2009

Diversity indices	**Kalai HEP, Stage-1**					**Kalai HEP, Stage-2**				
	S1	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
Taxa	2	2	1	2	2	1	2	2	1	2
No. of individuals	70	80	30	90	60	30	30	60	30	50
Shannon's diversity	0.60	0.56	0.00	0.64	0.69	0.00	0.64	0.64	0.00	0.67
Simpson's index	0.41	0.38	0.00	0.44	0.50	0.00	0.44	0.44	0.00	0.48
Equitability	0.86	0.81	0.00	0.92	1.00	0.00	0.92	0.92	0.00	0.97
Diversity indices	**Hutong HEP, Stage-1**					**Hutong HEP Stage-2**				
	S11	**S12**	**S13**	**S14**	**S15**	**S16**	**S17**	**S18**	**S19**	**S20**
Taxa	2	3	1	2	3	3	3	1	3	1
No. of individuals	80	40	50	90	40	80	60	70	70	30
Shannon's diversity	0.66	1.04	0.00	0.64	1.04	1.08	1.01	0.00	0.96	0.00
Simpson's index	0.47	0.63	0.00	0.44	0.63	0.66	0.61	0.00	0.57	0.00
Equitability	0.95	0.95	0.00	0.92	0.95	0.99	0.92	0.00	0.87	0.00
Diversity indices	**Demwe Upper HEP**					**Demwe Lower HEP**				
	S21	**S22**	**S23**	**S24**	**S25**	**S26**	**S27**	**S28**	**S29**	**S30**
Taxa	2	1	1	1	2	3	1	3	3	2
No. of individuals	50	50	40	30	70	40	30	50	90	50
Shannon's diversity	0.67	0.00	0.00	0.00	0.60	1.04	0.00	1.06	0.93	0.67
Simpson's index	0.48	0.00	0.00	0.00	0.41	0.63	0.00	0.64	0.56	0.48
Equitability	0.97	0.00	0.00	0.00	0.86	0.95	0.00	0.96	0.85	0.97

6.3.4 BENTHIC INVERTEBRATES

Benthic invertebrates are organisms that live on the bottom of a water body (or in the sediment) and have no backbone. Their size spans 6-7 orders of magnitude and they range from microscopic (*e.g.* microinvertebrates, <10 microns) to a few tens of centimetres or more in length (*e.g.* macroinvertebrates, >50 cm). Benthic invertebrates live either on the surface of bed forms (*e.g.* rock, coral or sediment - epibenthos) or within sedimentary deposits (infauna), and comprise several types of feeding groups *e.g*. deposit-feeders, filter-feeders, grazers and predators. The abundance, diversity, biomass and species composition of benthic invertebrates can be used as indicators of changing environmental conditions. Construction of dams may impact the benthic invertebrates by alteration of the physical characteristics of the river which includes sub-stratum, current velocity, food availability, water temperature, dissolved oxygen level and water chemistry. Prior to commissioning of power projects on a river, an enumeration of the benthic invertebrates in the proposed sites is necessary. Therefore, in the present study, an enumeration of benthic invertebrates was done in order to know their composition, density and diversity in different reaches of the river.

The population density of various invertebrate species is summarized in **Annexure-X.** Lohit river basin showed a high diversity of benthic invertebrates with overall 30 of invertebrates belonging to 8 orders recorded from all the project sites. Members of Ephemeroptera, Trichoptera, Plecoptera and Diptera dominated the invertebrate group in the project sites. Other orders included Coleoptera, Hemiptera, Megaloptera and Odonata. The families of macroinvertebrates included *Baetidae, Chironomidae, Cordulegastridae, Corixidae, Corydalidae, Dytiscidae, Ecdyonuridae, Elmidae, Ephemerellidae, Glossosomatidae, Gomphidae, Gyrinidae, Heptageniidae, Hydropsychidae, Leptoceridae, Leptophlebiidae, Mesovelidae, Molannidae, Nemouridae, Peltoperlidae, Perlidae, Perlodideae, Philopotamidae, Polycentropidae, Psychomyiidae, Rhagionidae, Simulidae, Tabanidae, Taeniopterygidae* and *Tipulidae* and their abundance varied across different months as well as at different sites. Analysis of variance showed that the total density of invertebrates differ significantly between the projects ($p<0.05$) but did not significantly differ between different sites in each project. The diversity and abundance of macroinvertebrates was higher in the months of April and May, while it decreased in the rainy months of July, August and September. The density and abundance of macroinvertebrates in the later months decreased due to increased water flow regime which washed off the macroinvertebrates and their habitats.

The summary of density of benthic invertebrates at various sampling sites is given in Table-6.19.

TABLE-6.19
Density of Benthic invertebrates at various sampling sites (No. of individuals/cm^2)

Project	Month					
	April 2009	May 2009	June 2009	July 2009	August 2009	September 2009
Kalai HEP Stage 1	15-28	12-30	5-12	7-12	2-8	2-5
Kalai HEP Stage 2	13-20	12-26	6-16	8-12	2-6	2-5
Hutong HEP Stage 1	7-13	7-11	4-17	3-9	4-6	4-11
Hutong HEP Stage 2	8-22	4-8	3-11	7-12	3-7	3-11
Demwe Upper HEP	6-17	5-8	3-5	8-11	5-10	1-7
Demwe Lower HEP	8-24	3-9	1-7	5-13	2-7	1-9

- The density of benthic invertebrates ranged from 2-30 at various sampling sites of Kalai hydroelectric project stage 1.
- The density of benthic invertebrates ranged from 2-26 at various sampling sites of Kalai hydroelectric project stage 2.
- The density of benthic invertebrates ranged from 3-17 at various sampling sites of Hutong hydroelectric project stage 1.
- The density of benthic invertebrates ranged from 3-22 at various sampling sites of Hutong hydroelectric project stage 2.
- The density of benthic invertebrates ranged from 1-17 at various sampling sites of Demwe Upper hydroelectric project.
- The density of benthic invertebrates ranged from 1-24 at various sampling sites of Demwe Lower hydroelectric project.

In general, the density of benthic invertebrates was higher in the months of April and May as compared to the other months.

The diversity of benthic invertebrates at various sampling locations during the study period is given in Tables-6.20 to 6.25.

TABLE-6.20
Diversity of benthic invertebrates in the month of April 2009

Diversity indices	Kalai HEP, Satge-1					Kalai HEP, Stage-2				
	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
Number of Taxa	6	5	6	8	7	8	7	7	8	7
No. of individuals	28	24	26	27	15	20	16	17	19	13
Shannon's diversity	1.36	1.51	1.73	1.75	1.68	1.88	1.84	1.82	1.89	1.73
Simpson's index	0.69	0.76	0.81	0.78	0.76	0.82	0.83	0.82	0.82	0.78
Equitability	0.76	0.94	0.96	0.84	0.86	0.90	0.95	0.94	0.91	0.89
Diversity indices	Hutong HEP, Stage-1					Hutong HEP, Stage-2				
	S11	S12	S13	S14	S15	S16	S17	S18	S19	S20
Number of Taxa	5	5	3	4	4	10	4	6	5	5
No. of individuals	9	13	7	8	12	22	10	15	8	11
Shannon's diversity	1.52	1.30	0.80	1.32	1.14	1.97	1.19	1.62	1.49	1.37
Simpson's index	0.77	0.65	0.45	0.72	0.64	0.81	0.66	0.77	0.75	0.69
Equitability	0.95	0.81	0.72	0.95	0.83	0.86	0.86	0.90	0.93	0.85
Diversity indices	Upper Demwe					Lower Demwe				
	S21	S22	S23	S24	S25	S26	S27	S28	S29	S30
Number of Taxa	4	3	6	5	5	7	4	6	5	5
No. of individuals	6	9	11	7	17	24	14	12	8	10
Shannon's diversity	1.33	1.00	1.59	1.55	1.54	1.87	1.24	1.35	1.56	1.36
Simpson's index	0.72	0.59	0.76	0.78	0.78	0.84	0.68	0.63	0.78	0.68
Equitability	0.96	0.91	0.89	0.96	0.96	0.96	0.89	0.75	0.97	0.84

TABLE-6.21
Diversity of benthic invertebrates in the month of May 2009

Diversity indices	Kalai HEP, Satge-1					Kalai HEP, Stage-2				
	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
Number of Taxa	6	3	3	4	3	6	4	3	6	3
No. of individuals	30	14	20	12	24	22	15	14	26	12
Shannon's diversity	1.56	0.83	0.83	1.08	0.65	1.61	1.24	1.06	1.56	0.72
Simpson's index	0.58	0.87	0.87	0.58	0.35	0.77	0.68	0.64	0.76	0.40
Equitability	0.87	0.76	0.76	0.78	0.59	0.90	0.89	0.97	0.87	0.66
Diversity indices	Hutong HEP, Stage-1					Hutong HEP, Stage-2				
	S11	S12	S13	S14	S15	S16	S17	S18	S19	S20

Number of Taxa	3	3	4	3	5	3	2	5	5	5
No. of individuals	11	8	9	10	7	5	4	8	7	8
Shannon's diversity	0.93	1.04	1.31	0.90	1.55	1.05	0.56	1.39	1.55	1.49
Simpson's index	0.58	0.63	0.72	0.54	0.78	0.64	0.38	0.69	0.78	0.75
Equitability	0.85	0.95	0.95	0.82	0.96	0.96	0.81	0.86	0.96	0.93
Diversity indices	**Upper Demwe**					**Lower Demwe**				
	S21	**S22**	**S23**	**S24**	**S25**	**S26**	**S27**	**S28**	**S29**	**S30**
Number of Taxa	4	3	5	3	3	4	4	4	2	3
No. of individuals	8	5	8	6	7	7	9	8	3	5
Shannon's diversity	1.12	1.05	1.49	0.87	1.08	1.28	1.15	1.26	0.64	0.95
Simpson's index	0.66	0.64	0.75	0.50	0.65	0.69	0.62	0.69	0.44	0.56
Equitability	0.88	0.96	0.93	0.79	0.98	0.92	0.83	0.91	0.92	0.86

TABLE-6.22
Diversity of benthic invertebrates in the month of June 2009

Diversity indices	**Kalai HEP, Satge-1**					**Kalai HEP, Stage-2**				
	S1	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
Number of Taxa	5	4	5	4	5	4	2	4	4	4
No. of individuals	12	8	10	5	9	12	7	16	8	6
Shannon's diversity	1.23	1.21	1.56	1.33	1.52	0.98	1.00	1.16	1.07	1.24
Simpson's index	0.61	0.66	0.78	0.72	0.77	0.51	0.41	0.62	0.56	0.67
Equitability	0.77	0.88	0.97	0.96	0.95	0.71	0.86	0.83	0.77	0.90
Diversity indices	**Hutong HEP, Stage-1**					**Hutong HEP, Stage-2**				
	S11	**S12**	**S13**	**S14**	**S15**	**S16**	**S17**	**S18**	**S19**	**S20**
Number of Taxa	3	4	5	4	3	5	2	4	2	5
No. of individuals	4	9	17	5	7	7	3	11	5	8
Shannon's diversity	1.04	1.21	1.52	1.33	1.00	1.55	0.64	1.24	0.67	1.49
Simpson's index	0.63	0.67	0.76	0.72	0.61	0.78	0.44	0.68	0.48	0.75
Equitability	0.95	0.88	0.94	0.96	0.91	0.96	0.92	0.89	0.97	0.93
Diversity indices	**Upper Demwe**					**Lower Demwe**				
	S21	**S22**	**S23**	**S24**	**S25**	**S26**	**S27**	**S28**	**S29**	**S30**
Number of	3	3	4	3	2	3	4	1	1	2

Taxa										
No. of individuals	5	4	5	3	4	7	6	5	1	2
Shannon's diversity	0.95	1.04	1.33	1.10	0.56	0.96	1.24	0.00	0.00	0.69
Simpson's index	0.56	0.63	0.72	0.67	0.38	0.57	0.67	0.00	0.00	0.50
Equitability	0.68	0.95	0.98	1.00	0.81	0.87	0.90	0.00	0.00	1.00

TABLE-6.23
Diversity of benthic invertebrates in the month of July 2009

Diversity indices	**Kalai HEP, Satge-1**					**Kalai HEP, Stage-2**				
	S1	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
Number of Taxa	4	5	5	5	5	4	4	6	6	8
No. of individuals	8	9	12	11	7	12	11	8	10	10
Shannon's diversity	1.07	1.52	1.47	1.29	1.48	1.31	1.37	1.73	1.61	1.03
Simpson's index	0.56	0.77	0.75	0.64	0.73	0.71	0.74	0.81	0.76	0.86
Equitability	0.77	0.95	0.92	0.80	0.92	0.94	0.99	0.97	0.90	0.97
Diversity indices	**Hutong HEP, Stage-1**					**Hutong HEP, Stage-2**				
	S11	**S12**	**S13**	**S14**	**S15**	**S16**	**S17**	**S18**	**S19**	**S20**
Number of Taxa	4	5	3	3	4	6	4	6	6	4
No. of individuals	6	8	5	3	9	7	12	12	8	10
Shannon's diversity	1.24	1.49	0.95	1.10	1.15	1.75	1.31	1.54	1.67	1.17
Simpson's index	0.67	0.75	0.56	0.67	0.62	0.82	0.71	0.74	0.78	0.64
Equitability	0.90	0.93	0.86	1.00	0.83	0.98	0.94	0.86	0.93	0.84
Diversity indices	**Upper Demwe**					**Lower Demwe**				
	S21	**S22**	**S23**	**S24**	**S25**	**S26**	**S27**	**S28**	**S29**	**S30**
Number of Taxa	4	3	3	5	2	6	5	3	4	3
No. of individuals	11	9	11	9	8	13	10	9	7	5
Shannon's diversity	1.16	1.00	0.99	1.52	0.56	1.63	1.23	0.68	1.28	1.05
Simpson's index	0.64	0.53	0.60	0.77	0.38	0.78	0.60	0.37	0.69	0.64
Equitability	0.84	0.91	0.91	0.95	0.81	0.91	0.76	0.62	0.92	0.96

TABLE-6.24
Diversity of benthic invertebrates in the month of August 2009

Diversity indices	Kalai HEP, Satge-1					Kalai HEP, Stage-2				
	S1	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
Number of Taxa	2	2	3	4	1	2	2	3	4	3
No. of individuals	6	3	6	8	2	6	2	5	5	6
Shannon's diversity	0.64	0.64	1.10	1.26	0.00	0.64	0.69	0.95	1.33	1.01
Simpson's index	0.44	0.44	0.61	0.69	0.00	0.46	0.50	0.56	0.72	0.61
Equitability	0.92	0.92	0.92	0.91	0.00	0.92	1.00	0.86	0.96	0.92
Diversity indices	**Hutong HEP, Stage-1**					**Hutong HEP, Stage-2**				
	S11	**S12**	**S13**	**S14**	**S15**	**S16**	**S17**	**S18**	**S19**	**S20**
Number of Taxa	2	4	4	1	1	5	2	2	2	3
No. of individuals	4	4	6	6	4	7	3	5	7	3
Shannon's diversity	0.56	1.39	1.33	0.00	0.00	1.48	0.64	0.67	0.68	1.10
Simpson's index	0.38	0.75	0.72	0.00	0.00	0.73	0.44	0.48	0.49	0.67
Equitability	0.81	1.00	0.96	0.00	0.00	0.92	0.92	0.97	0.99	1.00
Diversity indices	**Upper Demwe**					**Lower Demwe**				
	S21	**S22**	**S23**	**S24**	**S25**	**S26**	**S27**	**S28**	**S29**	**S30**
Number of Taxa	4	4	5	5	3	2	2	2	3	3
No. of individuals	7	10	6	5	5	4	2	4	7	4
Shannon's diversity	1.28	1.28	1.56	1.61	0.95	0.69	0.69	0.69	0.96	1.04
Simpson's index	0.69	0.70	0.78	0.80	0.56	0.50	0.50	0.50	0.57	0.63
Equitability	0.92	0.92	0.97	1.00	0.86	1.00	1.00	1.00	0.87	0.95

TABLE-6.25
Diversity of benthic invertebrates in the month of September 2009

Diversity indices	Kalai HEP, Satge-1					Kalai HEP, Stage-2				
	S1	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
Number of Taxa	1	2	3	3	1	2	4	2	4	2
No. of individuals	3	3	5	3	2	2	4	5	5	4
Shannon's diversity	0.00	0.64	1.05	1.10	0.00	0.69	1.39	0.67	1.33	0.69
Simpson's index	0.00	0.44	0.64	0.67	0.00	0.50	0.25	0.48	0.72	0.50
Equitability	0.00	0.92	0.96	1.00	0.00	1.00	1.00	0.97	0.96	1.00
Diversity indices	**Hutong HEP, Stage-1**					**Hutong HEP, Stage-2**				
	S11	**S12**	**S13**	**S14**	**S15**	**S16**	**S17**	**S18**	**S19**	**S20**
Number of Taxa	5	4	3	3	4	3	1	2	3	2
No. of individuals	5	6	11	4	8	8	4	11	7	3
Shannon's diversity	1.61	1.33	1.00	1.04	1.21	1.08	0.00	0.47	1.00	0.64
Simpson's index	0.80	0.72	0.60	0.65	0.66	0.66	0.00	0.30	0.61	0.44
Equitability	1.00	0.96	0.91	0.95	0.88	0.99	0.00	0.68	0.91	0.92
Diversity indices	**Upper Demwe**					**Lower Demwe**				
	S21	**S22**	**S23**	**S24**	**S25**	**S26**	**S27**	**S28**	**S29**	**S30**
Number of Taxa	1	2	5	5	4	4	2	5	1	3
No. of individuals	1	4	6	7	7	9	6	8	1	9
Shannon's diversity	0.00	0.69	1.56	1.55	1.28	1.15	0.64	1.49	0.00	1.00
Simpson's index	0.00	0.50	0.78	0.78	0.69	0.62	0.44	0.75	0.00	0.59
Equitability	0.00	1.00	0.97	0.96	0.92	0.83	0.92	0.93	0.00	0.91

6.3.5 PRIMARY PRODCUTIVITY

Phytoplanktons are autotrophic, prokaryotic or eukaryotic algae that live near the water surface where there is sufficient light to support photosynthesis. Among the more important groups are the diatoms, cyanobacteria, dinoflagellates and coccolithophores. Phytoplankton accounts for half of all photosynthetic activity on Earth and contribute significantly to primary production process in aquatic ecosystems. Phytoplankton primary productivity is defined as the rate of organic matter production by the growth of planktonic plants.

The details of primary productivity for the months of April, May, June, July, August and September 2009 at different project sites are summarized in **Annexure XI**. Gross primary production (GPP) and net primary production (NPP) show an increase in the months of April May and June, and then decreases in the months of July, August and September at all the sites. The summary of primary productivity observed at various sampling sites is given in Table-6.26.

TABLE-6.26
Primary productivity at various sampling sites

Project		Month					
		April 2009	**May 2009**	**June 2009**	**July 2009**	**August 2009**	**September 2009**
Kalai HEP Stage 1	Gross Primary	18.7-37.5	31.2-93.7	46.9-93.8	17.5-18.1	17.8-19.7	17.5-19.7
	Net Primary	12.5-37.5	15.6-46.8	15.6-46.9	11.5-13.5	11.2-14.8	11.5-14.8
Kalai HEP Stage 2	Gross Primary	28.1-37.5	46.8-78.1	46.9-93.7	17.5-18.1	16.8-18.5	17.5-18.8
	Net Primary	25.0-37.5	31.2-62.5	15.6-48.9	12.0-25.0	11.2-12.8	11.5-12.5
Hutong HEP Stage 1	Gross Primary	18.7-28.1	46.8-62.5	31.2-62.5	18.1-18.7	16.5-16.8	16.7-18.1
	Net Primary	12.5-25.0	15.6-31.2	15.5-54.7	12.0-12.5	10.2-12.4	11.5-12.5
Hutong HEP Stage 2	Gross Primary	28.1-37.5	31.2-78.1	46.9-78.1	17.5-18.1	17.1-18.1	16.5-18.7
	Net Primary	12.5-37.5	15.6-46.8	15.6-54.7	11.5-13.5	10.8-13.2	11.2-12.8
Demwe Upper HEP	Gross Primary	18.8-56.3	31.2-62.5	46.9-62.5	16.3-18.8	16.2-17.2	16.3-18.8
	Net Primary	12.5-50.0	15.6-31.2	15.6-31.3	12.0-14.0	11.2-12.6	11.0-13.6
Demwe Lower HEP	Gross Primary	18.7-37.5	46.8-78.1	46.9-93.7	17.5-18.7	16.5-17.1	17.1-18.5
	Net Primary	12.5-25.0	15.6-31.3	15.6-62.5	12.5-25.0	11.2-12.6	10.8-12.5

6.3.6 TROPHIC STATUS IN LOHIT BASIN

Trophic status is a useful means of classifying water bodies and describing aquatic processes in terms of the productivity of the system. The trophic status of a water body can be determined by estimating the quantities of nitrogen and phosphorous concentration. The estimation of these two nutrients in an aquatic body is necessary as they tend to be the limiting resources and an increase in these nutrients increases the algal productivity. Algal biomass and productivity is yet another indicator of the trophic status of a water body in which lower values correspond to oligotrophic state. Vollenweider (1974) used GPP as a criteria for classifying water bodies on trophic nature as, oligotrophic (0.065 - 0.3 g $Cm^{-2}d^{-1}$), mesotrophic (0.25 – 1.0 g $Cm^{-2}d^{-1}$) and eutrophic (1.0 – 8.0 g $Cm^{-2}d^{-1}$).

In the present study, the water bodies in different project sites had low concentrations of nitrate and total phosphorous (<0.015 mg l^{-1}). Overall, phytoplankton population is also low and the community is mainly dominated by Bacillariophyceae (diatoms), although some sites had dominance of Chlorophyceae and Cyanophyceae. Periphytic algal communities can be seen in some shallow areas of the project sites, but their diversity and density is low and their distribution is restricted to some pockets only. Overall, zooplankton population is dominated by Rotiferans and Cladocerans which mostly feed on fish waste, dead bacteria, algae and small particles of food suspended in water generated from falling leaf litter from the riparian forest areas. The benthic invertebrate communities are dominated by Ephemeroptera and Plecoptera which are abundant in undisturbed habitats mainly feeding on detritus. They can be classified as grazers, scrapers and filter feeders. Some invertebrates are carnivorous feeding on larvae of other species. The GPP values for all the project sites lies within the range of 0.065 - 0.3 g $Cm^{-2}d^{-1}$ as suggested by Vollenweider (1974). Hence, based on all the above the trophic status of the project areas may be classified as oligotrophic.

6.4 DIVERSITY OF FISH FAUNA IN ARUNACHAL PRADESH

Works done on fish diversity in the state is fragmentary and limited by the following studies viz., McClelland (1839), Chaudhary (1913), Hora (1921), Jayaram and Majumder (1964), Srivastava (1966), Choudhury and Sen (1977), Ghosh (1979), Dutta and Barman (1984, 1995), and Nath and Dey (2000). These studies mainly dealt with systematics including new records from India viz., *Amblyceps apangi* and *Amblyceps arunachalensis* (Nath and Dey 1989). Recently, Bagra *et al*. (2009) prepared a checklist of 213 species of fishes for Arunachal Pradesh of which 138 species were first hand collections from 35 rivers in the state. About 5 species are endemic to this region viz., *Amblyceps apangi*, *Amblyceps arunachalensis*, *Labeo devdevi*, *Osteacheilus neilli* and *Calisa labiosus*. The distribution of fishes in Arunachal Pradesh can be mainly attributed to altitude and topography. The higher elevations have cold water forms such as *Schizothorax* spp., *Glyptothorax* spp. etc. The foot hills and mid-elevations comprises of Mahseers such as *Acrossocheilus hexagonolepis*, *Tor tor*, *Tor putitora* which are economically important. Other species include *Labeo dero*, *Labeo pangusia*, *Clarius* sp., *Wallago attu*, *Aborichthys aor*, *Pabda* sp., *Notopterus notopterus*, *Belone cancila* etc. The state also has a number of ornamental fishes such as: Barbs and minnows (*G. chapra*, *A. mola*, *P. ticto*, *A. morar*, *S. bacaila*), Cat fishes (*Ailia coila*, *B. tengana*, *H. hara*, *G. horal*, *M. vittatus*, *M. montanus*), Eels (*M. aculeatus*, *M. armatus*, *P. indica*), Glass fish (*C. baculis*, *C. nama*, *C. ranga*), Gourami (*C. fasciata*, *C. labiosus*), Loaches (*A. elongatus*, *A. kempi*, *N. devdevi*, *B. dario*, *B. rostrata*), Needle fish (*X. cancila*), Perches (*B. badis, N. nandus*), Snakeheads (*C. marulius*, *C. striatus*, *C. orientalis*), Puffer fish (*T. cutcutia*), Knife fish (*N. notopterus*).

Ichthyofaunal diversity of Lohit river comprises of 62 species of 16 families with Cyprinidae forming the largest family represented by 25 species. Each of the families Channidae, Heteropneustidae, Notopteridae, Nandidae, Claridae, Anabantidae, Belonidae, Psilorhynchidae and Anguillidae is represented by a single species. Table-6.27 depicts the composition and conservation status of fish in Lohit river based on available literature.

TABLE-6.27

Fish composition and their status in Lohit river

Family	Species	Status
Cyprinidae	*Aspidoparia jaya*	VU
Cyprinidae	*A. morar*	LRnt
Cyprinidae	*Barilius barna*	LRnt
Cyprinidae	*Barilius bendelisis*	LRnt
Cyprinidae	*B. tileo*	LRnt
Cyprinidae	*Chagunius chagunio*	
Cyprinidae	*Crossocheilus latius latius*	LRnt
Cyprinidae	*Garra gotyla gotyla*	VU
Cyprinidae	*G. gotyla lissorhynchus*	VU
Cyprinidae	*G. macllelandi*	

Family	Species	Status
Cyprinidae	*Labeo dero*	VU
Cyprinidae	*Labeo dyocheilus*	VU
Cyprinidae	*L. pangusia*	LRnt
Cyprinidae	*L.gonius*	LRnt
Cyprinidae	*Acrossocheilus hexagonolepis*	
Cyprinidae	*Puntius ticto*	LRnt
Cyprinidae	*Raiamas bola*	
Cyprinidae	*Schizopyge stolizckae*	LRnt
Cyprinidae	*Schizothoraichthys esocinus*	LRnt
Cyprinidae	*S. Progastus*	LRnt
Cyprinidae	*Schizothorax richardsonii*	VU
Cyprinidae	*Tor putitora*	EN
Cyprinidae	*T. tor*	EN
Cyprinidae	*T.mosal*	EN
Cyprinidae	*Rasbora elanga*	
Sisoridae	*Hara hara*	
Sisoridae	*Hara jerdoni*	
Sisoridae	*Bagarius bagarius*	VU
Sisoridae	*Euchiloglanis hodgarti*	EN
Sisoridae	*Euchiloglanis kamengensis*	VU
Sisoridae	*Exostoma labiatum*	
Sisoridae	*Glyptothorax coheni*	
Sisoridae	*Glyptothorax conirostris*	
Sisoridae	*Glyptothorax pectinopterus*	LRnt
Sisoridae	*Pseudocheneis sulcatus*	VU
Sisoridae	*Sisor rhabdophorus*	EN
Cobitidae	*Somileptes gongota*	LRnt
Cobitidae	*Botia dario*	
Cobitidae	*Botia rostrata*	
Cobitidae	*Noemacheilus botia*	LRnt
Cobitidae	*Noemacheilus rupecola repecola*	LRnt
Cobitidae	*Noemacheilus sikimaiensis*	EN
Amblycipitidae	*Amblyceps apangi*	
Amblycipitidae	*Amblyceps arunachalensis*	
Amblycipitidae	*Amblyceps mangois*	LRnt
Anabantidae	*Anabus testudineus*	
Anguillidae	*Anguilla bengalensis*	EN
Bagridae	*Olyra longicaudata*	
Bagridae	*Aorichthys singhala (often found)*	DD
Siluridae	*Rita rita*	LRnt
Siluridae	*Silurus afgana*	

Family	Species	Status
Siluridae	*Wallago attu (often found)*	
Claridae	*Clarias batrachus (often found)*	VU
Balitoridae	*Aborichthys elongatus*	
Balitoridae	*Aborichthys kempi*	
Balitoridae	*Balitora bruceii*	LRnt
Channidae	*Channa* sp. *(rarely found)*	
Heteropneustidae	*Heteropneoustis fossilis (often found)*	VU
Nandidae	*Badis badis*	DD
Notopteridae	*Notopterus notopterus*	LRnt
Psilorhynchidae	*Psilorhynchus balitora*	
Belonidae	*Xenontodon cancilai*	LRnt

Source: CEIA Report, Lower Demwe Hydroelectric Project
Note: (VU) vulnerable, LRnt-Low Risk- near threatened; EN-Endangered.

Out of 62 species of fishes reported in Lohit river based on available literature, 41 have been assessed for their conservation status (CAMP-BCPP, 1997). A total of 7 species are 'endangered' (EN) while 11 are 'vulnerable' (VU). The 'VU' species which are fished abundantly in Lohit river are *Schizothorax richardsonii*, *Labeo dero*, *Garra gotyla gotyla* and *G. lissorhynchus* whereas, *Tor putitora, T. tor*, *T. mosal* are 'EN' species, which accounts as the main capture fishery. Two species like *Aorichthys seenghala* and *Badis badis* have been categorized under the threatened category of 'Data Deficient' (DD); the remaining species are declared as 'Low Risk- near threatened' (LRnt).

6.4.1 ASSESSMENT OF FISH DIVERSITY IN LOHIT BASIN

The assessment of fish diversity in Lohit basin was done in the months of April, May, June, July, August and September 2009. Random sampling in selected areas of the projects in the river basin was carried out using a cast net at morning (6:00 — 8:00) hours. The sampling was done at various sampling sites outlined in section 6.2. The sampled fishes were identified using the taxonomic keys (Nath & Dey 2000, Bagra *et al*. 2009, and Viswanath NBFGR).

The fish fauna at the sampling sites belonged to 2 families i.e. Cyprinidae and Siluridae. The fishes encountered in Kalai I and Kalai II project areas were

Schizothorax richardsonii and *Acrossocheilus hexagonolepis*. In Hutong I and Hutong II hydroelectric project areas, *Schizothorax richardsonii*, *Tor putitora* and *Acrossocheilus hexagonolepis* were encountered. The fish species found in area of Upper Demwe hydroelectric were *Schizothorax richardsonii*, *Tor putitora* and *Acrossocheilus hexagonolepis*. In Lower Demwe HEP the fish composition comprised of *Schizothorax richardsonii*, *Tor putitora*, *Labeo pangusia*, *Tor tor*, *Chagunius chagunio*, *Garra gotyla*, *Acrossocheilus hexagonolepis* and *Rita rita*. The details are given in Tables-6.28 to 6.33.

TABLE-6.28
Fish composition at various sampling sites of Kalai HEP, Stage-1

Family	Species	S1	S2	S3	S4	S5
Cyprinidae	*Schizothorax richardsonii*	×	×	×	×	×
Cyprinidae	*Acrossocheilus hexagonolepis*	×	×	×	×	×

TABLE-6.29
Fish composition at various sampling sites of Kalai HEP, Stage-2

Family	Species	S6	S7	S8	S9	S10
Cyprinidae	*Schizothorax richardsonii*	×	×	×	×	×
Cyprinidae	*Acrossocheilus hexagonolepis*	×	×	×	×	×

TABLE-6.30
Fish composition at various sampling sites of Hutong HEP, Stage-1

Family	Species	S11	S12	S13	S14	S15
Cyprinidae	*Schizothorax richardsonii*	×	×	×	×	
Cyprinidae	*Tor putitora*	×	×	×	×	×
Cyprinidae	*Acrossocheilus hexagonolepis*	×	×	×	×	×

TABLE-6.31
Fish composition at various sampling sites of Hutong HEP, Stage-2

Family	Species	S16	S17	S18	S19	S20
Cyprinidae	*Schizothorax richardsonii*	×	×		×	×
Cyprinidae	*Tor putitora*	×	×	×	×	×

Cyprinidae	*Acrossocheilus hexagonolepis*	×	×	×	×	×

TABLE-6.32

Fish composition at various sampling sites of Demwe Upper HEP

Family	Species	S21	S22	S23	S24	S25
Cyprinidae	*Schizothorax richardsonii*	×	×	×	×	×
Cyprinidae	*Tor putitora*	×	×	×	×	×
Cyprinidae	*Acrossocheilus hexagonolepis*	×	×	×	×	×

TABLE-6.33

Fish composition at various sampling sites of Demwe Lower HEP

Family	Species	S26	S27	S28	S29	S30
Cyprinidae	*Schizothorax richardsonii*	×	×	×	×	×
Cyprinidae	*Tor putitora*	×	×	×	×	×
Cyprinidae	*Labeo pangusia*	×	×	×	×	×
Cyprinidae	*Tor tor*	×	×	×	×	×
Cyprinidae	*Chagunius chagunio*	×	×	×	×	×
Cyprinidae	*Garra gotyla*	×	×	×	×	×
Cyprinidae	*Acrossocheilus hexagonolepis*	×	×	×	×	×
Siluridae	*Rita rita*	×	×	×	×	×

Fish species such as *Tor tor* and *Tor putitora* are migratory in nature. The construction of dam under various proposed project would affect the upward and downward migration of fish and may disturb the fish habitat. In course of impoundment, the resident species (both migratory and non-migratory) would get trapped as a result of damming. The natural recruitments may be affected due to closure of migratory routes from the flood plains to the hill streams. Due to different construction activities of dam most of the substratum in the river bed will be altered, and some of these sites can be potential breed/spawning sites to some of the non-migrating resident fishes. The spawning ground of most of the fishes is characterized by a gravelly substrate with a slower water flow rate. The removal of boulder, gravel, sand and earth may have adverse impact on the spawning of these species. The migration characteristics of various fish species observed in the study area is given in Table-6.34.

TABLE-6.34
Migration distance, spawning season and spawning substrate of some of the fish species

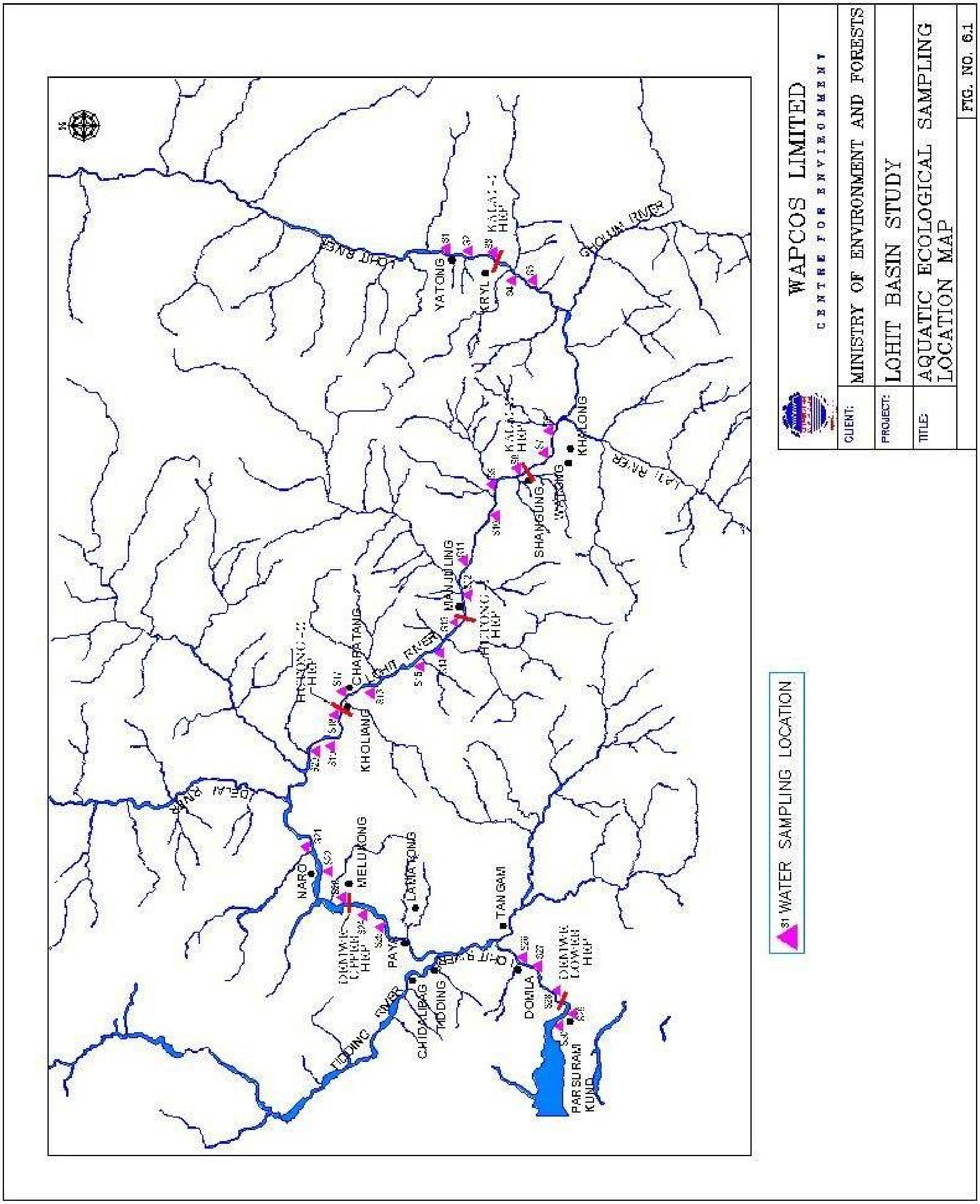
Family	Species	Migration distance	Spawning season	Spawning substrate
Cyprinidae	*Schizothorax richardsonii*	Short to Mid	Aug-Sep	Gravelly substrate
Cyprinidae	*Acrossocheilus hexagonolepis*	Short to Mid	May-July	Gravelly substrate
Cyprinidae	*Labeo pangusia*	Short to Mid	May -July	Gravelly substrate
Cyprinidae	*Chagunius chagunio*	Short to Mid	May-June	Gravelly substrate
Cyprinidae	*Tor putitora*	Long	Sep -Oct	Gravelly substrate
Cyprinidae	*Tor tor*	Long	Sep -Oct	Gravelly substrate
Cyprinidae	*Garra gotyla*	Short to Mid	May - Jul	Gravelly substrate

The migratory route of the fishes as such would be affected to some extent, but then the entire river course is regularly drained by numerous inlets in forms of small rivers, seasonal nallahs, channels, rivulets and like water sources where these fishes can get refuge during course of their migration to carry out their annual spawning/breeding activity. In a nutshell, total fish community will not be wiped out or totally disturbed because of dams, However there will be some ecological changes in the river course. For which conservation and mitigation measures has been proposed under Chapter 10 i.e. Environment Management Plan (EMP).

Breeding grounds for fishes

Tor spp. are long distance migrants, while other species such as *Schizothorax*, *Acrossocheilus*, *Labeo*, *Chagunius*, and *Garra* spp. migrate mid to short distances. The spawning period for long distance migrants is from September to October, while for other species the migration period is mainly from June to August. All the fishes in the present study need a gravelly substrate for spawning.

It is noted that, a study was carried out by fisheries expert for the evaluation of fish habitats and breeding grounds in the project area of Demwe Lower Hydro Electric Project as part of environmental impact assessment study of the project. The study concluded that, owing to the straight reach (without any meanders), moderate to steep gradient of the river course, high flow velocity of water, absence of stagnant/ calm water pools, human interference etc the project area of Demwe Lower HEP does not represent the ideal conditions for fish breeding grounds.


WAPCOS LIMITED
CENTRE FOR ENVIRONMENT
CLIENT: MINISTRY OF ENVIRONMENT AND FORESTS
PROJECT: LOHIT BASIN STUDY
TITLE: AQUATIC ECOLOGICAL SAMPLING LOCATION MAP
FIG. NO. 6.1
WATER SAMPLING LOCATION
LOHIT RIVER
GHOLUM RIVER
DELAI RIVER
TIDDING RIVER
YATONG
KRYL
KHALONG
SHANGUNG
MANJULING
CHAPATANG
KHOLIANG
NARO
MELURONG
PAYA
TANGAM
CHIDALIBAG
TIDDING
DOMLA
PARSURAM KUND

CHAPTER-7
TERRESTRIAL ECOLOGY

7.1 INTRODUCTION

The state of Arunachal Pradesh lies within coordinates 26° 30' N and 29° 30' N latitudes and 91° 30' E and 97° 30' E longitudes. The state has a very wide altitudinal variation ranging from flood plains of Brahmaputra to more than 7600 m high mountain peaks. The elevational variation, associated variability in climatic and edaphic factors, phytogeographical position, and undulating topography of the state have led to formation of varied ecological diversity, with a rich gene pool of wild and domesticated plant species. The mountainous topography of the state presents an ideal condition for the development of hydro-electric projects. Based on the size and volume of water drained, there are five major river basins in the state, namely, Kameng River Basin, Subansiri River Basin, Siang River Basin, Dibang River Basin and Lohit River Basin. The above mentioned major rivers of the state either constitute or finally drain into the Brahmaputra River. Each of these rivers has very high potential of hydro-power generation. Besides, there are many tributaries and distributaries of these rivers which also offer suitable locations for the development of hydro-electric power projects. On the other hand, more than 80% of the total geographical area of Arunachal Pradesh is covered with forest (FSI 2003). Therefore, development of hydropower projects would obviously affect the forest area of the state. Considering the importance of power in country's development, it is required to maintain a balance between the development of hydropower projects and forest conservation. As the first step of forest conservation, it is essential that the floristic survey of the proposed project sites be made in order to make an account of the plant diversity in the area and identify the species for conservation.

7.2 HISTORICAL ACCOUNT ON FLORISTIC SURVEYS IN ARUNACHAL PRADESH

A large number of European botanists and explorers visited the area in the early 19th century (Buchanan-Hamilton 1820, Roxburgh 1820-1824, Griffith 1847, Hooker 1854, 1872-1897, Hooker and Thompson 1855, Clarke 1889, Burkill 1924-1925, 1965, Kingdom Ward 1929, 1960). Lieutenant R. Wilcox and Captain Bedford visited the *Mishmi Hills* in Arunachal Pradesh during their survey of Assam and the neighboring countries for geographic discoveries in the North East Frontier (1825-1828). However, it was W. Griffith (1847) who made botanical explorations for the first time and the '*Flora of Mishimee Hills'* was based on his collections made during October-December, 1836. After that Thomas J. Booth made horticultural explorations during 1840-1850 from *Bisnath* (Assam) to the '*Daphla Hills*' in the southeastern corner of Bhutan and described a few Rhododendrons from the area. However, Robinson (1841) gave the first kind of floristic account of the region. Further, Hooker (1854 and 1906) presented a detailed account on the vegetation and flora of the region. In the 20th century, the floristic explorations gained momentum which resulted in publication of some important floristic accounts of the region such as *Botany of Abor Expedition* by I.H. Burkill (1924-25), *Botanical Expedition in the Mishmi Hills* by Kingdom Ward (1929-1931), *A Sketch of the Vegetation of Aka Hills* by N.L. Bor (1938), *Lohit Valley* by Kingdom Ward (1953) and, *The Flora of Aka Hills* by K.P. Biswas (1941) based on the collections of N.L. Bor (1931-1934). Lately, Kanjilal *et al*. (1934-1940) published the regional *Flora of Assam* in 5 volumes, containing the first hand account of the vegetation of North East.

For extensive floristic explorations in the northeast region, the Botanical Survey of India was reorganized and the Eastern Circle was established at Shillong in December, 1955. To enable further explorations in Arunachal Pradesh, a Field Station was established at Itanagar in July 1977. Since then, several floristic accounts on Arunachal Pradesh were published viz., Panigrahi and Naik (1961), Rao and Panigrahi (1961), Panigrahi (1965, 1966), Rao and Joseph (1965), Panigrahi and Joseph (1966), Sastry (1966), Panigrahi and Kar (1967), Joseph (1968, 1975, 1981), Rao and Ahuja (1969), Sahni (1969), Rao (1972), Rao and Deori (1980), Hajra (1970, 1973, 1976), Rao and Murti (1990), Rao (1994). *A contribution to the Flora of Namdapha, Arunachal Pradesh* (Chauhan *et al*. 1996), *Materials for the Flora of Arunachal Pradesh*, Vol. 1 (ed. Hajra *et al*. 1996), Orchidaceae of Arunachal Pradesh (Checklist) (Chowdhery and Pal 1997), and Orchid Flora of Arunachal Pradesh (Chowdhery 1998) are some of the contributions made towards the floristic accounts of Arunachal Pradesh. Haridasan (1997) and Haridasan *et al.* (1998) gave a brief account of the flora of Dibang valley and Lohit districts of Arunachal Pradesh.

7.3 FOREST TYPES IN ARUNACHAL PRADESH

Champion and Seth (1968), Rao and Panigrahi (1961), Sahni (1981), Rao and Hajra (1986) are some prominent workers who studied the forest and vegetation of Arunachal Pradesh. Rao (1972) categorized the vegetation of Arunachal Pradesh into the following types:

- Tropical
- Sub-tropical
- Temperate
- Sub-alpine
- Alpine based

Recently, Kaul and Haridasan (1987) classified the forest and identified 6 major types within 4 climatic categories and compared them with the classical types of Champion and Seth (1968). The forest types of Arunachal Pradesh can be classified into:

1. Tropical Forests
    i. Tropical evergreen forests
    ii. South Bank Tropical Wet Evergreen Dipterocarpus Forests
    iii. North Bank Tropical Evergreen Nahor-Jutuli Forests
    iv. Tropical Semi-Evergreen Forests
    v. Low Hills and Plains Semi-Evergreen Forests
    vi. Riverine Semi-Evergreen Forests
2. Sub-tropical Forests
3. Pine Forests

4. Temperate Forests
    i. Temperate broad leaved forests
    ii. Temperate conifer forests
5. Alpine Forests
6. Degraded Forests
    i. Bamboo forests
    ii. Grasslands

According to Champion and Seth (1968) classification the forest types of Arunachal Pradesh can be categorized as:

1. Assam valley tropical evergreen forests (IB/C1)
2. Upper Assam valley tropical evergreen forests (IB/C2)
3. Assam alluvial plains semi-evergreen forests (2B/C1a)
4. Sub Himalayan light alluvial semi-evergreen forests (2B/C1/S1)
5. East Himalayan moist deciduous forests (3C/C3B)
6. Eastern hollock forests (3/1S2)
7. East Himalayan subtropical forests (8B/C1)
8. Assam subtropical pine forests (9/C2)
9. East Himalayan wet temperate forests (11B/C1)
10. Lauraceae forests (11B/C1a)
11. Bak Oak forests (11B/C1b)
12. High level Oak forests (11B/C1c)
13. Naga hill temperate forests (11B/C2)
14. East Himalayan mixed coniferous forests (12/C3a)
15. Abies delavayi forests (12/C3b)
16. East Himalayan sub-alpine birch/fir forests (14/C2)
17. Alpine pastures (15/C3)
18. Dry alpine scrub (16/C1)
19. Dwarf juniper scrub (16/E1)

7.4 FLORISTIC DIVERSITY OF ARUNACHAL PRADESH

Arunachal Pradesh accounts for 2.5% of the total geographical area of the country and contains more than 23.5% of the flowering plants of India. 76.9% families of India are represented in Arunachal Pradesh. Chowdhery *et al*. (1996) enumerated 4,117 species of angiosperms belonging to 1295 genera and 192 families from the state against 17,500 species in 2984 genera and 247 families in India. Out of these 2,986 species belonging to 970 genera and 165 families are of dicots and 1,131 species under 325 genera belonging to 27 families are of monocots. There are about 41 monotypic families. Among the dicots, the monotypic herbaceous families, Balsaminaceae, Begoniaceae, are represented by 33 species of *Impatiens* and 19 species of *Begonia* respectively. While, the monotypic families representing the tree species like Aceraceae and Symplocaceae are represented by 15 species of *Acer* and 13 species of *Symplocos* respectively. The monotypic families of the monocots are Dioscoreaceae and Smilacaceae. They are represented by 25 species of *Dioscorea* and 19 species of *Smilax* respectively. Pteridophytes also form a significant feature of the vegetation in the state. Out of 1020 species of ferns occurring in India, 452 species are recorded from Arunachal Pradesh (Baishya 1999). The diversity of fern allies like *Selaginella* and *Lycopodium* are best represented in this region.

The family Orchidaceae is a highly evolved groups of plants with 1,229 species belonging to 184 genera in India (Singh and Chauhan 1999) out of which 545 species belonging to 122 genera are reported from Arunachal Pradesh (Chowdhery 1998), of which 20 species are endemic to the state (Hegde 1998). Among all the described species of orchids from Arunachal Pradesh, 17 species are saprophytes, 138 species are terrestrials and 383 species are epiphytes. Some of the dominant genera are *Bulbophyllum*, *Calanthe*, *Cymbidium*, *Dendrobium* and *Eria*.

Bamboos are also a dominant group of plants in the state. 23 genera and 120 species are so far known from India (Biswas 1998) of which 17 genera and 89 species are represented in the northeast India (Haridasan 2000). 26 species belonging to 9 genera of bamboo occur in Arunachal Pradesh. Some of the important genera are: *Bambusa* (4 species), *Dendrocalamus* (6 species), *Schizostachyum* (7 species) and *Chimonocalamus* (2 species).

Among Gymnosperms, out of 48 species belonging to 15 genera and 8 families native in India 24 species in 13 genera are found in Arunachal Pradesh. Some of the cultivated species of gymnosperms include *Agathis robusta*, *Araucaria columnaris*, *Cryptomeria japonica*, *Taxodium disticum* and *Thuja orientalis*. *Amentotaxus assamicus* is endemic to Arunachal Pradesh.

The state abounds in quite a large number of primitive flowering plants and many species of Annonaceae, Piperaceae and Lauraceae do not occur in other parts of

India except Northeast region, Eastern Himalaya, Assam and Burma. Some of the primitive genera are *Magnolia*, *Alnus*, *Betula*, *Holboellia*, *Exbucklandia* etc.

The physiographic features along with its geological history have contributed to high endemism in this relatively young mountain system. The occurrence of endemics, determined by biogeographic provinces, unique ecosystems, and topographical and climatological interfaces, is suggestive of biogeography, center of speciation, and adaptive evolution of the biota of this region. Out of 17,500 described species of flowering plants, over 5000 species belonging to 140 genera and 47 families are endemic to India. It is estimated that *ca* 3,500 endemic species occur in northeast India. Chowdhery (1999) provides a list of 238 endemic taxa from Arunachal Pradesh.

7.5 FOREST TYPES IN LOHIT BASIN

Lohit basin is rich in plant diversity. The major forest types surveyed in the Lohit river basin including the Upstream area are:

- Tropical semi-evergreen forest
- Tropical secondary forest
- Plantation forests
- Montane sub-tropical wet hill forest
- East Himalayan sub-tropical pine forest
- East Himalayan wet lower temperate forest
- East Himalayan wet temperate forest
- East Himalayan coniferous forest.

7.5.1 Tropical semi-evergreen forests

The vertical stratification in these types of forests is clearly distinguishable into emergent, canopy and sub-canopy tree layers, shrub layer and ground flora. The tropical climatic conditions have favored growth of a multitude of plants making these forests resource rich. Patches of primary undisturbed evergreen forests, especially on the left bank of Lohit river are seen, which are dominated by tree species such as *Altingia excelsa, Canarium strictum, Duabanga grandiflora*, *Ficus* spp*., Terminalia myriocarpa*, *Pterospermum acerifolium, Meliosma simplicifolia,* etc. The shrub layer is rich and includes species like *Acacia pennata, Acacia pruinescen, Boehmeria longifolia, Boehmeria macrophylla, Calamas erectus, Calamus leptospadix, Clerodendron coolebrokianum, Debregessia longifolia* and *Desmodium laxiflorum.* The herbaceous layer consists of *Begonia* sp., *Cyanotis vaga*, *Lygodium flexuosum*, *Ophiopogon intermedius*, *Pilea* sp., *Symethea ciliata* etc. Some species found in the study area are important from conservation point of view such as *Lagerstroemia muniticarpa* which is globally an endangered category of species. Plants of economic importance such as timber, medicinal, edible fruits were common e.g., *Canarium strictum* is a very good incense yielding tree and *Pandanus* species is a fiber yielding tree species.

Such forests are seen all along the river valley and are found in the areas of Kalai stage-1, Kalai stage-2, Hutong stage-1, Hutong stage-2, Upper Demwe, Lower Demwe hydroelectric projects. These forests belong to the following categories of Champion and Seth classification (1968):

2B/C1a Assam alluvial Plains semi-evergreen forests

This is a closed high forest community with varying proportions of evergreen and deciduous trees in the top storey. The important species include *Terminalia myriocarpa, Ailanthus integrifolia, Canarium strictum, Castanopsis indica, Dillenia indica, Dysoxylum procerum, Garuga gamblei, Michelia champaca, Phoebe cooperiana, Pterospermum acerifolium* and *Syzygium cumini.* Second storey is represented by trees like *Albizia lucida, Cinnamomum pauciflorum, Dalbergia sissoo, Gynocardia odorata, Magnolia hodgsonii, Meliosma simplicifolia* etc. Understorey is represented by bamboos, canes, and many woody shrubs and climbers. Epiphytes are represented by a few ferns, orchids and lianas that grow on the large tree trunks. Shrubs in these forests are represented by *Boehmeria macrophylla, Calamus leptospadix, Dracaena angustifolia, Oxyspora paniculata, Maotia puya, Phlogacanthus thrysiflorus, Micromelum integerimum, Difflugossa colorata.* The forest floor, wherever disturbed, is covered with herbs and tall grasses like *Ageratum conyzoides, Bidens bipinnata, Eriophorum comosum,* *Commelina benghalensis, Imperata cylindrica, Pogonatherum paniceum, Saccharum longisetosus* and *S. spontaneum.*

2B/1S1 Sub-Himalayan light alluvial semi-evergreen forest

This is a mixed high forest community which occurs in lower elevation of Lohit basin, particularly along the river banks. The top canopy in these forests consists of many deciduous trees, while the second storey is dense mixed and consists of both evergreen and deciduous tree species. The top canopy comprises *Duabanga grandiflora, Garuga gamblei, Phoebe hainesiana, Artocarpus lokoocha, Spondias pinnata* and *Terminalia myriocarpa.* The second storey is represented by *Callicarpa arborea, Glochidion lanceolarium, Gynocardia odorata, Macaranga denticualata Mallotus roxburghii, Ficus elmerii, Endospermum chinensis,* etc. This type of forest is found in the submergence area of Demwe Lower hydroelectric project. The understorey of these forests is represented by bamboos, canes, palms and shrubs. Shrubby species include *Bambusa pallida, Boehmeria macrophylla, Calamus floribundus, Clerodendrum bracteatum, Costus speciosus, Boehmeria hamiltonii, Micromelum integerrimum, Oxyspora paniculata* and *Pinanga gracilis. Caryota urens,* a tall palm, makes a noticeable presence in this forest. Climbers are represented by species of *Pegia nitida, Cayratia pedata, Dioscorea pentaphylla, Entada purseatha, Pothosscandens, Raphidophora lancifolia, Stephania hernandifolia, Thunbergia grandiflora,* etc. Some common epiphytes present here are species of *Dendrobium, Pholidota, Eria, Asplenium, Hoya, Lepisorus* and *Microsorium.* The forest floors which are disturbed at many places show gaps and are covered with herbs and grasses like *Polygonum chinensis, Ageratum conyzoides, Alpinia alughas, Bidens bipinnata, Commelina benghalensis, Cyrtococcum accrescens, Digitaria ciliaris, Oplismenus compositus, Saccharum longisetosus, S. spontaneum* and *Thysanolaena maxima.*

7.5.2 Tropical secondary forests

These forests have lesser species diversity and are formed of secondary successional species. The density of plants is low and structure is less complex. The secondary forests have grown along the West bank of the river where primary forests have been cleared in the past for timber or shifting cultivation. The secondary forests are dominated by trees belonging to species *Macaranga denticulate* and *Callicarpa arborea.* The old grown secondary forest, particularly in certain patches along Lohit River gives the impression of an undisturbed primary forest. The herbaceous flora of these forests is mostly of weedy nature. These types of forests are seen along the West bank of the river in all the project sites.

According to Champion and Seth (1968) classification, the following forest type is also found under the secondary forest category.

2SI Secondary moist bamboo brakes

These scattered bamboo brakes occur in areas which are abandoned and cleared for agriculture. *Bambusa pallida, Dendrocalamus Hamiltoni* are the important species under this forest category.

7.5.3 Plantation forests

The plantations have been raised along the left bank of the Lohit river in Lower Demwe where primary forests have been cleared in the past for timber. The plantation is dominated by trees belonging to species *Bombax cieba*, *Emblica officinalis*, *Albizia chinensis* and *Kydia calycina*. Some tree species that grow here are *Bombax ceiba, Macaranga denticulata, Sterculia villosa, stereospermum colais, Spondias pinnata*, etc. and are found growing along the edges of degraded bamboo forests.

7.5.4 Montane Subtropical wet hill forests

This forest type occurs in Lohit basin around upper reaches of Demwe and Zero point. These forests generally occur on hilly terrain between 900-1200 m elevations and are dominated by evergreen species. These forests are undisturbed on the left bank of the river Lohit (opposite bank of the road). One can approach these forests after crossing the hanging bridges across the river. *Alnus nepalensis, Prunus cerasoides, Quercus lamellosa* and *Engelhardtia spicata* are dominant species in this forest.

According to Champion and Seth (1968) classification, the forest falls under 8B/ C I East Himalayan sub-tropical wet hill forests category. A number of deciduous trees also occur in the canopy. The top canopy is comprised of *Alnus nepalensis, Castanopsis hystrix, Cinnamomum glaucesens, Engelhardtia spicata, Phoebe attenuata, Prunus cersoides, Quercus lamellosa, Magnolia campbelliI,* etc. The second storey is represented by some medium sized evergreen tree species such as *Brassaiopsis speciosa, Macropanax undulatus, Rhus chinensis, Saurauia roxburghii, Persea gambelii, Symplocos glomerata,* etc. The understorey consists of a number of shrubs and climbers and among shrubs found in these forests are *Boehmeria macrophylla, Chasalia curviflora, Debregeasia longifolia, Eurya acuminata, Medinilla erythrophylla, Oxyspora paniculata,* etc. There are numerous climbers and epiphytes and the species of *Mastersia, Cissus, Pegia, Bauhinia, Clematis, Dioscorea, Smilax, Entada,* etc. constitute important climbers and lianas. The ground flora at many places is disturbed and the canopy shows gaps. These gaps are represented by herbs and grasses viz., *Ageratum conyzoides, Aster mollisculus, Anaphalis busua, Bidens bipinnata, Cardamine hirsuta, Crassocephalum crepidioides, Impatiens* sp.*, Persicaria capitata, P. barabata, Setaria glauca, Themeda arundinacea, Thysanolaena maxima, Viola pilosa,* etc.

7.5.5 East Himalayan sub-tropical pine forest

This forest type is not found in Champion and Seth (1968) classification. This forest is dominated by *Pinus merkusii* occurring at an elevational range of 1200 – 1400 m in Chigwinti Walong – Kaho area and before reaching Walong. Although not described by Champion and Seth (1968), it can be categorized as Sub-tropical pine forests.

7.5.6 East Himalayan wet lower temperate forest

This forest type is in continuity with montane subtropical wet hill forest occurring in the elevation range of 1200 -2500 m elevation. The dominant tree species in this forest are *Acer campbellii, Alnus nepalensis, Castanopsis tribuloides, Engelhardtia spicata* and *Quercus lamellose.* According to Champion and Seth (1968) classification, following forest type falls under this category.

11b/C1 East Himalayan Wet temperate forests

These forests are closed evergreen forests of trees of medium height and occur between 1700-2700m in the higher hills. The important trees of the canopy include *Acer campbellii, Alnus nepalensis, Betula alnoides, Exbucklandia populnea, Castanopsis tribuloides, Engelhardtia spicata* and *Quercus lamellosa.* The middle storey is represented by some moderate sized tree species such as *Eurya acuminata, Ilex dipyrena, Litsea* sp., *Lyonia ovalifolia, Prunus cerasoides* and *Mahonia pycnophylla*. These forests are found in upper reaches of Khairang and Chigunti areas. Shrubs are represented by the species of *Berberis, Mahonia, Rubus, Sinarundinaria falcata, Viburnum erubescens,* etc. There are only a few climbers, while epiphytes are represented by ferns and orchids. The ground flora is represented by species of *Anaphalis, Cardamine, Campanula, Circium, Fragaria, Plantago, Persicaria, Stellaria* and *Viola.*

7.5.7 East Himalayan coniferous forest

This forest is found on the drier ridges between 2500 m and 2700m elevations. Beyond Kibito, this forest type is encountered. They form the Upstream area of the basin. According to Champion and Seth (1968), this forest belongs to 12/C3 East Himalayan mixed coniferous forests category.

The forests of this zone are dense evergreen, with predominating Hemlocks and firs. Hemlock *(Tsuga dumosa*) makes appearance in the upper reaches as a dominant tree species, At the higher elevations Hemlock gives way to Silver fir (*Abies densa*). Apart from the conifers, some oak mixed deciduous broad-leaved species such as *Acer, Betula, Magnolia* and *Rhododendron* are also found in the forests. The undergrowth is represented by a number of evergreen shrubs such as *Berberis, Cotoneaster, Rhododendron, Salix, Thamnocalamus and Viburnum.* Most of the shrubs are laden with many epiphytic mosses and lichens.

7.6 VEGETATION PATTERN IN THE LOHIT BASIN

The vegetation particularly along East bank is relatively undisturbed. However, there are patches of forests which have been recently cleared for shifting cultivation even along this bank. The West bank of the river is relatively degraded. Orange orchards, human settlements and jhum fields are often seen along this accessible bank. In some of the areas which had long fallow period usually in little remote areas had trees like *Duabanga grandiflora*, *Macaranga denticulata* and bamboo species which essentially are pioneer species. Such tree species are good for fuel wood purpose. A few fodder trees such as *Ficus* spp. were seen along the roadside. Beside this, Bamboo species and *Musa* sp*.* were also found in these jhum fallows. The forest at the disturbed area shows stunted growth and showed three distinct strata viz., canopy layer of trees with 10m height, shrub layer and the ground layer. However, undisturbed primary forest of the area had distinct stratification. At places emergent trees of isolated trees followed by a thick canopy, subcanopy and undercanopy layers was observed.

7.7 PLANT DIVERSITY IN THE PROJECT SITES

The vegetation and floristic survey in the Lohit basin was done for the project sites listed as below:

- Kalai stage-1 hydroelectric project
- Kalai stage-2 hydroelectric project
- Hutong stage-1 hydroelectric project
- Hutong stage-2 hydroelectric project
- Demwe Upper hydroelectric project
- Demwe Lower hydroelectric project

The monitoring was done for two seasons, i.e., summer season (April 2009) and monsoon season (August 2009).

7.8 FIELD SURVEY

Field visit was undertaken to gather information on the representative floral diversity of each project area and for which 4 to 5 sampling locations were identified at each project site. Considering the difficult terrain, quadrat method was used for vegetation sampling. The phyto-sociological data was collected by laying the quadrats randomly of different sizes at each sampling site of the selected projects. The size of the quadrats laid were 10x10m for trees and shrubs and 1 x 1 m for herb component.

The sampling locations for terrestrial ecological survey are shown in Figure-7.1.

During the survey, number of plants of different species in each quadrat was identified and counted. The height of individual trees was estimated using an Abney level/ Binocular and the DBH of all trees were measured at 1.5 m above the ground level.

Based on the quadrat data, frequency, density and cover (basal area) of each species were calculated. The importance value index (IVI) for different tree species were determined by summing up the Relative Density, Relative Frequency and Relative Cover values. The Relative Density and Relative Frequency values were used to calculate the IVI of shrubs and herbs. IVI represent the contribution that a species makes to the community in respect of: (a) the number of plants within the quadrats (abundance), (b) its influence on the other species through its shading, competition or aggressiveness (dominance), and (c) its contribution to the community through its distribution (frequency). Thus, the index is purely a measure of the contribution of a species to that vegetation in which it is present, regardless of whether the ground is completely covered or very sparsely covered.

The volume of wood for trees was estimated using the data on DBH (measured at 1.5 m above the ground level) and height. The volume was estimated using the formula: $\pi r^2 h$, where r is the radius and h is the estimated height of the bole of the tree. The data on density and volume were presented in per ha basis.

To assess diversity of floral elements and numerical structure of the plant community in the study sites, different diversity indices were used. A diversity index is a mathematical measure of species diversity in a community. They provide more information about community composition than simply species richness (i.e., the number of species present); they also take the relative abundances of different species into account. Two species diversity indices viz., Shannon index of general diversity (H) and Evenness index (e) were computed using PAST software:

Shannon index. It is an index used to measure diversity in categorical data. In a basic sense, it is the information entropy of the distribution in a given area treating species as symbols and their relative population sizes as the probability. The diversity index takes into account the number of individuals as well as number of taxa. It varies from 0 for communities with only a single taxon to high values for communities with many taxa, each with few individuals. The advantage of this index is that it takes into account the number of species and the evenness of the species. The index is increased either by having additional unique species, or by having greater species evenness. Higher values of Shannon index indicate that a particular community has more information.

$$\overline{H} = -\Sigma \frac{ni}{N} ln\left(\frac{ni}{N}\right)$$

Buzas and Gibson's evenness index was calculated using the formula: e^{H}/S, where H is the Shannon's index and S represents the number of species. It indicates the relative abundance or proportion of individuals among the species.

During the vegetation survey, herbaria were prepared for the plants that had flowers and fruits. Conservation status of the recorded plant species were identified referring to the Red Data Book of India and other available literature, flora and herbarium pertaining to the rare/ endangered species of Arunachal Pradesh.

7.9 PLANT DIVERISTY AT VARIOUS SITES

7.9.1 Kalai hydroelectric project, Stage-1

The following sites were monitored as a part of the Terrestrial Ecological Survey:

- T1 - Dam site
- T2 - Submergence area
- T3 - Upstream area
- T4 - 1 km downstream of dam site
- T5 - 3 km downstream of Wallang village

The findings of the vegetation survey at various sampling sites are given in **Annexure-XII**. The summary of the findings of vegetation survey are given in Table-7.1. The diversity indices of various floral species are given in Table-7.2.

TABLE-7.1
Density (ind./ha) of various floral species at various sampling sites covered in Kalai hydroelectric project, Stage-1

S.No.	Sampling Site	Trees	Shrubs	Herbs	
				Summer	Monsoon
1.	Dam site	570	1895	294520	361500
2.	Submergence area	550	2245	270000	354000
3.	Upstream area	290	1320	297500	380500
4.	1 km downstream of dam site	335	4100	238000	374525
5.	3 km downstream of Wallang village	320	2235	277500	393500

Note: Summer Season- April 2009, Monsoon season- August 2009

TABLE-7.2
Species Diversity Indices for Kalai hydroelectric project, Stage-1

Vegetation component	Diversity Indices Shannon's Diversity Index (H)	Evenness Index (e)
Dam site		
Trees	2.35	0.89
Shrubs	2.11	0.88
Herbs	2.18 (April), 2.71 (Aug)	0.75 (April), 0.90(Aug)
Submergence area		
Trees	1.75	0.76
Shrubs	2.00	0.87
Herbs	2.27 (April), 2.25 (Aug)	0.91 (April), 0.91 (Aug)
Upstream area		
Trees	0.17	0.25
Shrubs	1.85	0.83
Herbs	1.49 (April), 1.55 (Aug)	0.72 (April), 0.75 (Aug)
1 km downstream of dam site		
Trees	2.40	0.88
Shrubs	1.94	0.78
Herbs	2.45 (April), 2.65 (Aug)	0.90 (April), 0.92 (Aug)
3 km downstream of Wallang village		
Trees	1.37	0.70
Shrubs	1.66	0.85
Herbs	1.58 (April), 1.55 (Aug)	0.76 (April), 0.75 (Aug)

Note: Summer Season- April 2009, Monsoon season- August 2009

The dam site is located near Quibang village. The submergence is confined to narrow strips along the river Lohit, on account of steep slopes on both the sides. Relatively less steep areas, which has greater human interferences on account of increased accessibility, disturbed secondary forests were observed. A few jhum cultivation plots and orange orchards were also seen along this bank. In the proposed damsite, 14 tree species were recorded. The average tree density at this site was 570 trees/ha. *Albizia* sp. with 180 individuals was the dominant tree species. There were 12 shrubs with a density of 1895 individuals/ha. *Boehmeria* *longifolia* and *Debregessia longifolia* dominated the shrub layer. The species richness as well as density of herb was higher during the monsoon season as compared to summer season. *Ageratum conyzoides* and *Saccharum spontaneum* were dominant species in the herbaceous layer. Species diversity was high and the Shannon's Index for all three components (tree, shrub and herb) was more than 2 in the forests studied. The evenness index value ranged from 0.75-0.90 for most of the components.

In the submergence area, 10 tree species were recorded in this forest. The average tree density at this site was 550 trees/ha. Eleven shrub and twelve herbs including climbers were recorded from this forest. *Artemisia nilagirica* and *Debregessia longifolia* were dominant shrub species, while *Imperata cylindrica* and *Ageratum conyzoides* were the dominant herbs. Shannon's diversity index for tree, shrub and herb was more than 1.75, while the evenness index was also high having values more than 0.76.

The upstream area is represented by Pine forest and only two species were recorded in this forest. The average tree density at this site was low (290 trees/ha). *Pinus merkusii* was the dominant tree species. Nine shrub and eight herbs including climbers were recorded from this forest. The herb density was higher during the monsoon season. *Artemisia* spp., among shrub and *Imperata cylindrica, Ageratum conyzoides* and *Nephrolepis cordifolia* among herb were the dominant species. Shannon's diversity index for the tree components was very less (0.17) while for shrubs and herbs it ranged from 1.49-1.85. Evenness values ranged from 0.25-0.83 for trees, shrub and herbs.

In 1 km downstream of dam site, 15 tree species were recorded. The dominant tree species in the site were *Ficus cunia* (90 individuals /ha) and *Saurauria nepalensis* (45 individuals /ha). The average tree density at this site was 335 trees/ha. *Artemisia nilagirica* and *Boehmeria longifolia* were dominant shrub species. *Imperata cylindrica* and *Ageratum conyzoides* were dominant herbs in both summer and monsoon seasons.

Seven tree species were recorded at the site located 3 km downstream of Wallang village. The dominant tree species in the site was *Pinus merkusii* (135 individuals/ha). The average tree density at this site was 320 trees/ha. *Artemisia nilagirica* was dominant shrub species, while *Imperata cylindrica* and *Ageratum conyzoides* dominated the herbaceous layer in both the summer and monsoon season.

The tree and shrubs did not show any difference in terms of composition and diversity while herbaceous component shows difference in the density of the species with season at all the sites.

7.9.2 Kalai hydroelectric project, Stage-2

The following sampling sites were monitored at various locations in the Kalai hydroelectric project, Stage-2:

- T6 - Dam site
- T7 - Submergence area
- T8 - Upstream area
- T9 - 1 km downstream of Hawai
- T10 - 3-5 km downstream

The findings of the vegetation survey at various sampling sites are given in **Annexure-XIII**. The summary of the findings of vegetation survey are given in Table-7.3. The diversity indices of various floral species are given in Table-7.4.

TABLE-7.3
Density of various floral species at various sampling sites covered in Kalai hydroelectric project, Stage-2

Unit (No./ha)

S.N.	Sampling site	Trees	Shrubs	Herbs	
				Summer	Monsoon
1.	Dam Site	515	1490	196500	351000
2.	Submergence area	610	3040	187000	284500
3.	Upstream area	550	1695	293000	320500
4.	1 km downstream of Hawai	575	2920	199000	259500
5.	3-5 km downstream	640	2325	185500	299000

Note: Summer Season- April 2009, Monsoon season- August 2009

TABLE-7.4
Species Diversity Indices for different vegetation components in Kalai hydroelectric project, Stage-2

Vegetation component	Diversity Indices	
	Shannon's Diversity Index (H)	Evenness Index (e)
Dam site		
Trees	2.44	0.95
Shrubs	2.08	0.86
Herbs	2.83 (April), 3.08 (Aug)	0.86 (April), 0.93 (Aug)
Submergence Area		
Trees	2.42	0.94
Shrubs	2.16	0.80
Herbs	2.84 (April), 2.91 (Aug)	0.90 (April), 0.90(Aug)
Upstream site		
Trees	2.35	0.89
Shrubs	2.16	0.87
Herbs	2.18 (April), 2.71(Aug)	0.75 (April), 0.93(Aug)
1km downstream of Hawai		
Trees	2.21	0.89
Shrubs	1.94	0.81
Herbs	2.75 (April), 2.84 (Aug)	0.90(April), 0.91 (Aug)
3-5 km downstream		
Trees	2.33	0.94
Shrubs	2.25	0.83
Herbs	2.65(April), 2.91 (Aug)	0.89 (April), 0.90 (Aug)

Note: Summer Season- April 2009, Monsoon season- August 2009

In the proposed dam site, thirteen tree species were recorded. The average tree density at this site was 515 trees/ha. Eleven shrub and twenty seven herbs including climbers were recorded from this forest. *Pandanas odoratissima* and *Grewia* sp. dominated the tree layer while *Boehmeria longifolia* and *Debregessia longifolia* dominated the shrub layer and *Drymaria cordata, Nephrolepis cordifolia* and *Pilea umbrosa* were dominant in the herbaceous layers. Species diversity was high and the Shannon's Index for all three components (tree, shrub and herb) was more than 2.0 in the forests studied. The evenness index was also high having values and ranged from 0.86-0.95 for most of the components.

In the submergence area, thirteen tree species were recorded. The average tree density at this site was 610 trees/ha and the dominant species were *Saurauria nepalensis* and *Ficus cunia*. *Artemisia nilagirica* and *Urena lobata* dominated the shrub layer. *Spilanthes paniculata* and *Nephrolepis cordifolia* were dominant species in the herbaceous layer.

In the sampling site within the upstream area, fourteen tree species were recorded. The average tree density at this site was 550 trees/ha. Twelve shrubs and eighteen herbs including climbers were recorded from this forest. *Boehmeria longifolia* and *Debregessia longifolia* dominated the shrub layer. *Ageratum conyzoides* and *Nephrolepis cordifolia* were dominant species in the herbaceous layer. In general, species diversity was high and the Shannon's Index for all three components (tree, shrub and herb) was more than 2.16 in the forests studied. The evenness index was more than 0.75 for all the components.

In 1 km downstream of Hawai, 12 tree species were recorded and the average tree density at this site was 575 trees/ha. The dominant tree species were *Ficus cunia* and *Grewia* sp. *Artemisia nilagirica* and *Urena lobata* dominated the shrub layer. *Bidens pilosa* and *Ageratum conyzoides* were dominant species in the herbaceous layer.

In 3-5 km downstream, 12 tree species were recorded and the average tree density at this site was 640 trees/ha. The dominant tree species were *Ficus cunia* and *Brassiopsis glomerulata*. *Artemisia nilagirica* and *Boehmeria longifolia* dominated the shrub layer. *Drymaria cordata*, *Nephrolepis cordifolia* and *Ageratum conyzoides,* were dominant species in the herbaceous layer.

The tree and shrubs did not show any difference in terms of composition and diversity while there was a slight change in the density of herbaceous component in all the sites.

7.9.3 Hutong hydroelectric project, Stage-1

The following sampling sites were covered as a part of the terrestrial ecological survey for Hytong hydroelectric project, stage-1:

- T11 - Dam site
- T12- Submergence area
- T13 - Upstream area
- T14 - 1 km downstream of dam site

The findings of the vegetation survey at various sampling sites are given in **Annexure-XIV.** The summary of the findings of vegetation survey are given in Table-7.5. The diversity indices of various floral species are given in Table-7.6.

TABLE-7.5

Density of various floral species at various sampling sites of Hutong hydroelectric project, Stage-1 Unit (No./ha)

S.No.	Sampling site	Trees	Shrubs	Herbs	
				Summer	Monsoon
1.	Dam site	500	1540	199500	382500
2.	Submergence area	610	2020	203000	360500
3.	Upstream area	530	1500	356000	360340
4.	1 km downstream of dam site	740	3460	202000	346000

Note: Summer Season- April 2009, Monsoon season- August 2009

TABLE-7.6

Species Diversity Indices for different vegetation components in Hutong hydroelectric project, Stage-1

Vegetation component	Diversity Indices	
	Shannon's Diversity Index (H)	Evenness Index (e)
Dam site		
Trees	1.88	0.91
Shrubs	1.97	0.86
Herbs	2.97 (April), 2.99 (Aug)	0.92 (April), 0.93 (Aug)
Submergence Area		
Trees	2.33	0.93

Vegetation component	Diversity Indices	
	Shannon's Diversity Index (H)	Evenness Index (e)
Shrubs	2.28	0.84
Herbs	2.77 (April), 2.76 (Aug)	0.92 (April), 0.86 (Aug)
Upstream Area		
Trees	2.44	0.95
Shrubs	2.08	0.87
Herbs	2.83 (April), 3.08 (Aug)	0.85 (April), 0.93 (Aug)
1 km downstream of dam site		
Trees	2.24	0.90
Shrubs	2.40	0.80
Herbs	2.84 (April), 2.96 (Aug)	0.93 (April), 0.93 (Aug)

Note: Summer Season- April 2009, Monsoon season- August 2009

In the dam site eight tree species were recorded. The average tree density at this site was 500 trees/ha. Eleven shrubs and twenty five herbs including climbers were recorded from this forest. *Ficus cunia* and *Alnus nepalensis* dominated the tree layer while *Boehmeria longifolia* and *Debregessia longifolia* dominated the shrubs and *Ageratum conyzoides* and *Drymaria cordata* dominated the herbaceous layer. In general, diversity of herbs was high in the proposed damsite. The Shannon's Index for all three components (tree, shrub and herb) ranged from 1.88-2.99 in the forests studied. Evenness value was higher for the tree component in the proposed damsite and the evenness index ranged from 0.86-0.93 for most of the components.

In the submergence site 12 tree species were recorded and the average tree density at this site was 610 trees/ha. *Brassiopsis glomerulata* and *Grewia* sp. dominated the tree layer while *Urena lobata and Oxospora paniculata* were dominant shrubs. *Nephrolepis cordifolia* and *Ageratum conyzoides* were the dominant herb species during summer season while *Drymaria cordata* dominated the herbaceous layer during monsoon season.

In the Upstream site 13 tree species were recorded. The average tree density at this site was 530 trees/ha. Eleven shrub and twenty seven herbs including climbers were recorded from this forest. *Pandanas odoratissima* and *Ficus cunia*. dominated the tree layer while *Boehmeria longifolia* dominated the shrub layer and *Drymaria cordata* and *Nephrolepis cordifolia* were dominant in the shrub and herbaceous layer. In general, species diversity was high and the Shannon's Index for all three components (tree, shrub and herb) was more than 2.0 in the forests studied. The evenness index ranged from 0.85-0.95 for most of the components.

Twelve tree species were recorded in 1 km downstream of damsite. The average tree density at this site was 740 trees/ha. *Alnus nepalensis* and *Ficus cunia* dominated the tree layer with 150 individuals/ha each. *Artemisia nilagirica* and *Urena lobata* were the dominant shrubs. *Nephrolepis cordifolia* and *Ageratum conyzoides* were the dominant herbs during summer while *Drymaria cordata* dominant the herbaceous layer during rainy season. The tree and shrubs did not show any difference in terms of composition and diversity while difference in the density of herbaceous component was recorded at all the sites in the two study season.

7.9.4 Hutong hydroelectric project, Stage-2

The following sampling sites were covered as a part of the ecological survey for Hutong hydroelectric project, stage-2:

- T15 - Dam site
- T16 - Submergence area
- T17 - Upstream area
- T18 - 1 km downstream of dam site
- T19 - Confluence point of Lohit and Dau rivers

The findings of the vegetation survey at various sampling sites are given in **Annexure-XV**. The summary of the findings of vegetation survey are given in Table-7.7 The diversity indices of various floral species are given in Table-7.8

TABLE-7.7
Density of various floral species at various sampling sites of Hutong hydroelectric project, Stage-2
Unit (No./ha)

S. No.	Sampling site	Trees	Shrubs	Herbs	
				Summer	Monsoon
1.	Dam site	645	4200	214500	365500
2.	Submergence area	615	1965	188500	298000
3.	Upstream area	465	985	209500	364500
4.	1 km downstream of dam site	615	3445	199500	359500
5.	Confluence point of Lohit and Dau rivers	435	3140	223000	366000

TABLE-7.8
Species Diversity Indices for different vegetation components in Hutong hydroelectric project, Stage-2

Vegetation component	Diversity Indices	
	Shannon's Diversity Index (H)	Evenness Index (e)
Dam site		
Trees	2.59	0.86
Shrubs	2.15	0.70
Herbs	2.88 (April), 2.95 (Aug)	0.87 (April), 0.91 (Aug)
Submergence area		
Trees	2.81	0.89
Shrubs	2.59	0.81
Herbs	2.88 (April), 2.97 (Aug)	0.89 (April), 0.90(Aug)
Upstream area		
Trees	1.88	0.90
Shrubs	1.97	0.82
Herbs	2.97 (April), 2.99 (Aug)	0.92 (April), 0.93 (Aug[
1 km downstream of dam site		
Trees	2.33	0.84
Shrubs	2.56	0.87
Herbs	2.86 (April),3.12 (Aug)	0.88 (April), 0.94 (Aug)
Confluence point of Lohit and Dau rivers		
Trees	2.59	0.89

Shrubs	2.46	0.82
Herbs	2.96 (April), 3.20 (Aug)	0.90 (April), 0.95 (Aug)

Note: Summer Season- April 2009, Monsoon season- August 2009

The dam site is located near Kombling village. The submergence starts from the dam site and continues beyond Dhanbari village. Sampling included disturbed and degraded forest on the right bank and primary undisturbed vegetation on the left bank of river Lohit (about 1000 m). Because of steep slopes on both the sides, most submergence area is confined to narrow strips along the river Lohit. The west bank of the river, is relatively less steep and is dominated by disturbed secondary forests. A few jhum cultivation plots and orange orchards were seen along this bank.

Twenty tree species were recorded in the proposed dam site. The average tree density at this site was 645 trees/ha. Twenty two shrub and twenty seven herbs including climbers were recorded from this forest. *Musa* sp. and *Ficus cunia* dominated the tree layer while *Artemisia nilagirica* and *Urena lobata* dominated the shrub layer. *Ageratum conyzoides* and *Bidens pilosa* were dominant in the herbaceous layer during summer while in monsoon season *Ageratum conyzoides* dominated the herb layer. In general, species diversity was high for trees and herbs. The Shannon's Index for all three components (tree, shrub and herb) ranged from 2.15-2.95 in the forests studied. The evenness index values ranged from 0.70-0.91 for most of the components.

In the submergence area, 23 tree species were recorded. The average tree density at this site was high 615 trees/ha due to dominance of *Dendrocalamus* sp. Twenty four shrub and twenty seven herbs including climbers were recorded from this forest. *Oxospora paniculata, Artemisia nilagirica* and *Acacia pruniscens* were dominant shrub species. *Ageratum conyzoides* and *Borreria articularis* dominated the herb layer during summer while *Ageratum conyzoides and Spilanthes paniculata* was the dominant herb during monsoon season. Diversity of tree and herbs was higher. Shannon's diversity index for tree, shrubs and herbs ranged from 2.59-2.97

while the evenness index was more than 0.81.

In the Upstream area, eight tree species were recorded. The average tree density at this site was 465 trees/ha. Eleven shrub and twenty five herbs including climbers were recorded from this area. *Alnus nepalensis* and *Brassiopsis glomerulata* dominated the tree layer while *Debregessia longifolia* and *Oxospora paniculata* in the shrub layer and *Pilea sp., Galinsoga parviflora and Commelina sp* in the herb layer were dominant species. The Shannon's Index for all three components (tree, shrub and herb) ranged from 1.88-2.99 in the forests studied. Evenness value was higher for the tree component and the evenness index ranged from 0.82-0.93 for most of the components.

Sixteen tree species were recorded in 1 km downstream of dam site with average tree density of 615 trees/ha. The dominant species in this site were *Musa* sp. and *Artemisia* spp, were dominant shrub species, while *Nephrolepis cordifolia* and *Ageratum conyzoides* were the dominant herbs.

In the confluence point of Lohit and Dau river, 18 tree species were recorded. The average tree density at this site was 435 trees/ha. The dominant tree species in this site were *Musa* sp. and *Ficus cunia. Artemisia nilagirica, Artemisia spp.* and *Urena lobota* were dominant shrub species, while *Nephrolepis cordifolia* and *Ageratum conyzoides* were the dominant herb.

The tree and shrubs did not show any difference in terms of composition and diversity while there was a difference in the density of herbaceous component at all the site in different study season.

7.9.5 Demwe Upper hydroelectric project

The following, sampling sites were monitored as a part of the vegetation survey for Demwe Upper hydroelectric project:

- T20 - Dam site
- T21 - Submergence area
- T22 - Upstream area
- T23 - 1 km downstream of confluence of Tidding and Lohit rivers
- T24 - Confluence point of rivers Dalai and Lohit

The findings of the vegetation survey at various sampling sites are given in

Annexure-XVI. The summary of the findings of vegetation survey are given in Table-7.9. The diversity indices of various floral species are given in Table-7.10

TABLE-7.9
Density of various floral species at various sampling sites In Demwe Upper hydroelectric project Unit (No./ha)

S.N.	Sampling site	Trees	Shrubs	Herbs	
				Summer	Monsoon
1.	Dam Site	420	1205	186000	324500
2.	Submergence area	695	1565	219000	325500
3.	Upstream area	630	1370	215000	312500
4.	1 km downstream of confluence of Tidding and Lohit river	640	1530	232500	313000
5.	Confluence point of rivers Dalai & Lohit	635	3115	230000	333500

Note: Summer Season- April 2009, Monsoon season- August 2009

TABLE-7.10
Species Diversity Indices for different vegetation components in Demwe Upper Hydroelectric project

Vegetation component	Diversity Indices	
	Shannon's Diversity Index (H)	Evenness Index (e)
Dam Site		
Trees	3.13	0.93
Shrubs	2.72	0.83
Herbs	3.06 (April), 3.14 (Aug)	0.90 (April), 0.92(Aug)
Submergence area		
Trees	3.19	0.92
Shrubs	2.40	0.72
Herbs	2.76 (April), 2.81 (Aug)	0.79(April), 0.81 (Aug)
Upstream area		
Trees	3.34	0.92
Shrubs	2.51	0.74
Herbs	2.95 (April), 2.99 (Aug)	0.88(April), 0.89(Aug)
1 km downstream of Tidding and Lohit river confluence point		
Trees	2.21	0.81
Shrubs	2.52	0.76
Herbs	2.84 (April), 3.02 (Aug)	0.89 (April), 0.89 (Aug)

Vegetation component	**Diversity Indices**	
	Shannon's Diversity Index (H)	**Evenness Index (e)**
Confluence point of Dalai and Lohit		
Trees	2.73	0.88
Shrubs	2.57	0.78
Herbs	3.03 (April), 3.11(Aug)	0.93 (April), 0.91 (Aug)

Note: Summer Season- April 2009, Monsoon season- August 2009

Twenty nine tree species were recorded in the proposed dam site. The average tree density at this site was 420 trees/ha. Twenty six shrub and thirty herbs including climbers were recorded from this forest. *Duabanga grandiflora* was the dominant tree species with 40 individuals/ha. *Artemisia nilagirica, Piper sp.* and *Debregessia longifolia*, dominated the shrub layer. *Elatostemma* sp. and *Commelina sp.* were dominant in the herbaceous layer during summer whereas Commelina sp. and *Drymaria cordata* were the dominant herbs during rainy seasons. Species diversity was high and the Shannon's Index for all three components (tree, shrub and herb) was more than 2.72 in the forests studied. The evenness index ranged from 0.83-0.93 for most of the components.

In the submergence area, thirty two tree species were recorded. The average tree density at this site was 695 trees/ha. Twenty seven shrub and thirty two herbs including climbers were recorded from this forest. *Albizia chinensis* followed by *Dendrocalamus hamiltonii were* the dominant and co-dominant tree species respectively. *Artemisia nilagirica* was the dominant shrub species while *Drymaria cordata* dominated the herbaceous layer. Shannon's diversity index for tree, shrub and herb was more than 2.40, while the evenness index ranged from 0.72-0.92 for the trees, shrubs and herbs.

In the Upstream area, 37 tree species were recorded. The average tree density at this site was 630 trees/ha. *Bamboo* sp., *Pterospermum acerifolium, Canarium strictum* and *Altingia excelsa* are the dominant tree species. A total of twenty nine shrubs as well as 29 herbs including climbers were recorded from this forest. *Piper* sp. among shrub and *Elatostemma* sp. and *Commelina* sp., among herb were the dominant species. Shannon's diversity index for all the three components (tree, shrub and herb) was more than 2.51, while the evenness index ranged from 0.74-0.92 for trees, shrubs and herbs.

Fifteen tree species were recorded in 1 km downstream of Tidding and Lohit river confluence point. The average tree density at this site was 640 trees/ha due to dominance of *Musa* sp. Other dominant tree species are *Ficus cunia* and *Brassiopsis glomerulata*. *Piper* sp and *Boehmeria longifolia*, among shrub and *Elatostemma* sp. *Nephrolepis cordifolia,* and *Drymaria cordata* among herb were the dominant species.

In the confluence point of Dalai and Lohit river 22 tree species were recorded. The average tree density at this site was 635 trees/ha. *Pandanas odoratissima* followed by *Macaranga denticulata*, were the dominant tree species. *Plectranthus striatus* and *Artemisia nilagirica* among shrub and, *Thysanolaena maxima*, and *Ageratum conyzoides* among herbs were the dominant species.

The tree and shrubs did not show any difference in terms of composition and diversity while there was a slight difference in the diversity of herbaceous component at all the sites.

7.9.6 Demwe Lower hydroelectric project

The various sampling sites were covered as a part of the vegetation survey for Demwe Lower hydroelectric project sites are:

- T25 - Dam and Power House site
- T26 - Submergence area
- T27 - Upstream area
- T28 - Downstream (Near Colony) area

The findings of the vegetation survey at various sampling sites are given in **Annexure-XVII**. The summary of the findings of vegetation survey are given in Table-7.11 The diversity indices of various floral species are given in Table-7.12

TABLE-7.11
Density of various floral species at various sampling sites of Demwe Lower hydroelectric project Unit (No./ha)

S. No.	Sampling site	Trees	Shrubs	Herbs	
				Summer	Monsoon

1.	Dam and Power House site	450	4050	139500	289500
2.	Submergence area.	300	1900	128500	247500
3.	Upstream area	390	1720	131000	287500
4.	Downstream (Near Colony)area	395	3455	152000	163000

TABLE-7.12

Species Diversity Indices for different vegetation components in Demwe Lower hydroelectric project

Vegetation component	Shannon's Diversity Index (H)	Evenness Index (e)
Dam site and Power House site		
Trees	2.68	0.92
Shrubs	1.93	0.77
Herbs	2.76(April), 2.07 (Aug)	0.90 (April), 0.67 (Aug)
Submergence area		
Trees	2.82	0.98
Shrubs	2.19	0.99
Herbs	3.08 (April), 3.07 (Aug)	0.91 (April), 0.91 (Aug)
Upstream area		
Trees	2.75	0.95
Shrubs	1.81	0.73
Herbs	3.01 (April), 3.09 (Aug)	0.89(April), 0.90 (Aug)
Downstream (Near Colony) area		
Trees	1.42	0.88
Shrubs	1.38	0.60
Herbs	2.12(April), 2.10 (Aug)	0.82(April), 0.82 (Aug)

Sampling included vegetation on east and west bank of river Lohit. The Power House site is located about 200 m downstream from the dam site. Because of steep slopes, most submergence area is confined to narrow strips along the river Lohit. The submergence area is mostly characterized by rock outcrop devoid of any trees with isolated sites having some tree cover. The proposed colony area is on the left bank of river Lohit and is approximately 100 m away from the existing helipad near Parsuram kund.

In the Dam and Power House site eighteen species of trees represented by 450 individuals/ha were recorded. *Alangium chinensis* was the dominant tree species. Twelve species of shrubs and twenty two herbs including climbers were recorded from the site. *Boehmeria macrophylla* was found as the most dominant shrub species. *Bidens pilosa*, *Elatostemma* sp. and *Imperata cylindrica* were the dominant herb species. Shannon's diversity index was more than 1.93 and evenness index ranged from 0.67-0.92.

The submergence area had sixteen tree species. The tree density was 300 individuals /ha. *Macaranga denticulata* was the dominant tree species. Nine shrub and twenty nine herbs including climbers were recorded from this site. *Boehmeria spp.* was the dominant species in the shrub layer and *Elatostema platyphyllum* and *Pilea* sp. were found to be dominant herbs species during summer. Shannon's diversity index was more than 2 for all the components and the evenness value ranged from 0.91-0.99.

In the upstream area, there were eighteen tree species. The density was 390 trees /ha and dominated by *Ficus semicordata*. The associated species in the tree canopy were *Alangium chinensis*, *Brassiopsis glomerulata*, *Duabanga grandiflora*, *Kydia calycina*, *Chukrasia tabularis*, and *Pandanus nepalensis*. Twelve shrub and thirty herb species including climbers were recorded in this forest. *Boehmeria longifolia* was the dominant shrub and *Pilea* sp and *Elatostemma* sp. and were the dominant species among herb layer. Shannon's diversity Index was more than 1.81 for all three components (tree, shrub and herb) and evenness index was between 0.73 - 0.95. Five tree species were recorded in the Downstream (Near Colony) area with a density of 395 individuals /ha. *Sterculia villosa* was the dominant tree species. Ten shrub and thirteen herbs were recorded from the site. *Eupatorium odoratum* dominated the shrub layer while *Ageratum conyzoides* followed by *Imperata cylindica* were dominant in the herb layer. Species diversity was low for tree and shrub Shannon's Index was less than 2 for tree and shrub while that for herbs

Shannon's Index was above 2. The evenness index ranged from 0.60-0.88 for trees, shrub and herbs.

The tree and shrubs did not show any difference in terms of composition and diversity while there was a slight difference in the diversity of herbaceous component in all the sites.

7.10 ECONOMICALLY IMPORTANT PLANTS

The forests of Arunachal Pradesh are endowed with many useful plant species viz., timber yielding species, medicinal plants, bamboos, rattans, wild ornamental plants, etc. The state can be termed as a repository of medicinal plants (Haridasan et at. 1996). The indigenous people in the state live in close association with the forests and have accumulated a vast treasure of knowledge related to utilization of plants. This knowledge of medicinal plants is becoming a potential source of information for the pharmaceutical industries. The list of economically important plant species observed at various sampling sites in the area of various hydroelectric projects is given in Table-7.13.

TABLE-7.13
List of Economically important plant species observed at various sampling sites

S. N.	Species	Uses
A.	**Kalai Hydroelectric Project, Stage-1**	
1	*Ficus cunia*	Fodder
2	*Macaranga denticulata*	Fuel
3	*Nephrolepis cordifolia*	Medicinal
4	*Alnus nepalensis*	Fuel
5	*Rubus* spp.	Edible
6	*Thysanolaena maxima*	Broom industry, fodder
7	*Saurauria nepalensis*	Fodder
B.	**Kalai Hydroelectric Project, Stage-2**	
1	*Ficus cunia*	Fodder
2	*Macaranga denticulata*	Fuel
3	*Nephrolepis cordifolia*	Medicinal
4	*Pandanus odoratissima*	Fibre
5	*Rubus* spp.	Edible
6	*Thysanolaena maxima*	Broom industry, fodder
7	*Saurauria nepalensis*	Fodder

S. N.	Species	Uses
C.	**Hutong Hydroelectric Project, Stage-1**	
1	*Ficus cunia*	Fodder fuel
2	*Macaranga denticulata*	
3	*Nephrolepis cordifolia*	Medicinal
4	*Rubus* spp.	Edible
5	*Thysanolaena maxima*	Broom industry, fodder
D.	**Hutong Hydroelectric Project Stage-2**	
1	*Clerodendron colebrookianum*	Leafy vegetable
2	*Ficus cunia*	Fodder
3	*Macaranga denticulata*	Fuel
4	*Nephrolepis cordifolia*	Medicinal
5	*Rubus* spp.	Edible
6	*Terminalia myriocarpa*	Timber
7	*Thysanolaena maxima*	Broom industry, fodder
8	*Saurauria nepalensis*	Fodder
9	*Spondias axillaries*	Fruits edible
E.	**Demwe Upper Hydroelectric Project**	
1	*Clerodendron colebrookianum*	Leafy vegetable
2	*Ficus cunia*	Fodder
3	*Ficus roxburqhii*	Fodder, fruits edible
4	*Macaranga sp.*	Fuel
5	*Nephrolepis cordifolia*	Medicinal
6	*Pandanus odoratissima*	Fibre
7	*Rubus* spp.	Edible
8	*Terminalia myriocarpa*	Timber
9	*Thysanolaena maxima*	Broom industry, fodder
10	*Saurauria nepalensis*	Fodder
11	*Sapium baccatum*	Timber
12	*Spondias axillaries*	Fruits edible
F.	**Demwe Lower Hydroelectric Project**	
1.	*Syzygium cumini*	Medicinal, leaves edible
2.	*Ficus roxburghii*	Fodder, fruits edible
3.	*Macaranga spp.*	Fuel
4.	*Nephrolepis cordifolia*	Medicinal
5.	*Kydia calycina*	Fuel, timber
6.	*Rubus sp.*	Edible
7.	*Terminalia myriocarpa*	Timber, fuel
8.	*Dalbergia sissoo*	Timber
9.	*Spondias pinnata*	Fruits edible, medicinal
10.	*Emblica officinalis*	Fruits edible, medicinal

In Kalai Hydroelectric Project, Stage-1, seven economically important plant species were recorded. They were namely, *Ficus cunia*, *Macaranga denticuiata*, *Nephrolepis cordifolia*, *Alnus nepalensis*, *Rubus* spp., *Thysanolaena maxima* and *Saurauria nepalensis*.

At Kalai Hydroelectric Project, Stage-2, various plants of economic importance such as timber, medicinal, edible fruits were commonly observed. *Pandanus odoratissima* is a fiber yielding tree species & *Nephrolepis cordifolia has medicinal values*. These are seen commonly here and there at the project sites.

Five economically important plants were recorded from Hutong Hydroelectric Project, Stage-1 viz., *Ficus cunia*, *Macaranga denticuiata*, *Nephrolepis cordifolia*, *Rubus* spp. and *Thysanolaena maxima.*

About 9 economically important plant species were recorded from the study area in Hutong Hydroelectric Project, Stage-2. These include *Clerodendron colebrookianum*, *Ficus cunia*, *Macaranga denticulata*, *Nephrolepis cordifolia*, *Rubus* spp., *Terminalia myriocarpa*, *Thysanolaena maxima*, *Saurauria nepalensis* and *Spondias pinnata*.

About 12 economically important plant species we re recorded from the study area in Demwe Upper Hydroelectric Project. These species include *Clerodendron colebrookianum, Ficus cunia, Ficus roxburghii, Macaranga* sp., *Nephrolepis cordifolia, Pandanus odoratissima, Rubus spp., Terminalia myriocarpa, Thysanolaena maxima, Saurauria nepalensis, Sapium baccatum and Spondias axillaries.*

Ten economically important plant species were recorded from the study area in Demwe Lower Hydroelectric Project. Plant of economical importance such as timber (*Terminalia myriocarpa*, *Dalbergia sissoo,),* medicinal *(Nephrolepis cordifolia, Spondias pinnata*), edible fruits (*Ficus roxburhghii, Rubus* sp.*)* and *Macaranga* spp. known for fuel wood value were commonly seen here and there at the project site.

7.11 FLORA UNDER THREATENED CATEGORY

The lower elevations of the study area are presently degraded due to high human pressure, large scale lopping and removal of fodder and timber species, grazing, construction of road, etc. Nayar and Sastry (1987-1990) have reported 35 species of rare and endangered plant species from Arunachal Pradesh. Of these threatened species *Acer oblongum* var. *microcarpum, Begonia burkillii, Calanthe manii, Dioscorea deltoidea, Paphiopedilum wardii* and *Phoenix rupicola* have been reported from low hills in the altitudinal range of 300-1200 m. The details are given in table-7.14. There is a possibility that some of these species may be present in the project areas though the present surveys were not able to record these in the field. During the course of survey, only one species i.e., *Lagerstroemia muniticarpa* classified as endangered plant species as per IUCN Red list.

TABLE-7.14
Rare, vulnerable and endangered plants reported from secondary literature in the Study Area

S. No.	Species	Family	Altitude (m)	Habit	Status
1.	*Acer oblongum* var. *microcarpum*	Acerceae	500-1200	Tree	Endangered
2.	*Begonia burkillii*	Begoniaceae	300-1000	Herb	Rare
3.	*Calanthe manii*	Orchidaceae	Up to 1000	Herb	Rare
4.	*Dioscorea deltoidea*	Dioscoreaceae	300-3000	Climber	Endangered
5.	*Paphiopedilum wardii*	Orchidaceae	Up to 1000	Herb	Rare
6.	*Phoenix rupicola*	Arecaceae	Up to 450	tree	Rare

Source: CEIA Study, Demwe Lower hydroelectric project

7.12 PARASITIC FLORA

As per the review of secondary data, few parasitic plant species are reported. These plant species belong to the families Cuscutaceae and Loranthaceae. *Cuscuta reflexa* (Cuscutaceaae) was found growing on wide range of hosts in the area namely, *Debregeasia longifolia* and *Rhus chinensis*. *Scurrula elata* was found growing as parasite on *Ficus* spp. in the area.

7.13 EPIPHYTES

As per the review of secondary data, epiphytes belonging mainly to family

Orchidaceae and Moraceae are reported. There is also rich growth of epiphytic ferns. A number of orchids belonging to the genera *Bulbophyllum*, *Coelogyne*, *Cymbidium*, *Dendrobium*, etc., were observed hanging on the trees. The epiphytic ferns found in the area include species of *Lepisorus*, Polypodioides, *Pyrrosia*, *Vittaria*, etc. A large number of non-vascular epiphytes such as lichens and a variety of mosses also covered considerable pace on the bark of the trees in the area.

7.14 LOWER PLANT DIVERSITY (CRYPTOGAMS)

Cryptogamic flora of Arunachal Pradesh is very rich with a diverse species composition. However, studies on this component of the flora are largely lacking. As many as 54 species of algae belonging to 23 genera have been reported from the area (refer Table-7.15). The lichen flora of Arunachal Pradesh is also rich in species composition with nearly 331 species of lichens belonging to 72 genera and 41 families recorded from the state. Pteridophytes are important constituents of the floristics of Arunachal Pradesh. The Botanical Survey of India has recorded about 452 species of fern and fern allies from Arunachal Pradesh Himalaya.

TABLE-7.15
Some of the common pteridophytes of the Study Area
(based on available literature)

S. No.	Species	Family	Habit	Altitude (m)
1.	*Equisetum diffusum*	Equisetaceae	herb	Up to 3000
2.	*Selaginella indica*	Selaginellaceae	herb	700-2800
3.	*Marsilea minuta*	Marsileaceae	herb	Up to 1200
4.	*Alsophila spinulosa*	Cyatheaceae	herb	Up 300-1500
7.	*Adiantum capillus-*	*veneris* Adiantaceae	herb	Up to 1600
8	*Vittaria flexuosa*	Vittariaceae Epiphytic	herb	300-4000
9.	*Pteris vittata*	Pteridaceae	herb	Up to 1500
10.	*Pyrrosia adnascens*	Polypodiaceae	epi. Fern	800-1200
11.	*P. nuda*	Polypodiaceae	epi. Fern	Up to1600
12.	*Colysis pedunculata*	Polypodiaceae	epi. Fern	Up to 1200

Source: CEIA Report, Lower Demwe Hydroelectric Project

7.15 FAUNA

The fauna of eastern Himalaya is mainly governed by the species of southern China, Indo-china and Indo-Malaya regions. Species, viz. *Elaphus maximus*, *Babalus bubalis*, *Bos gaurus*, hornbill species, Pittas species, Cobras etc. inhabit the monsoon forest below 1000 m, and have close affinity with that of the Indo-Malayan region. The north part of Eastern Himalaya is close to palaearctic region in the faunal composition. It includes animal species - *Uncia uncia*, *Ursus arctos*, Cam's iupus and many species of alpine ungulates.

Mammals

About 50 mammalian species are reported from the study area. The list is enclosed as Table-7.16. The family Felidae is largest, represented by 6 species followed by Bovidae and Sciuridae. Each of the families like Hotobatidae, Loridae, Mustelidae, Suidae, Moschidae, Hystricidae, Soricidae, Tupaiidae and Spalacidae are represented by a single species.

Primates

Primates is represented by 5 species belonging to 3 families (Refer Table 7.16). Hoolock gibbon and Slow loris inhabit tropical dense forest, upto an elevation of 800 m above mean sea level. Hoolock gibbon is reported frequently from the surroundings of the human settlements on the fringe areas near Kamlang Wildlife Sanctuary. Both the species have been included in the Schedule I. Hoolock gibbon is also categorized as 'endangered' species (ZSI, 1994). Common langur, Assames macaque and Rhesus macaque inhabit open forest and settlement areas. They are distributed up to an elevation of 2000 m above mean sea level.

Carnivora

Carnivora is the largest order in the project areas, which comprises of 18 species belonging to 6 families (refer Table-7.16). Most of the species of cat and dog families (Common leopard, Couded leopard, Leopard cat, Jungle cat, Fishing cat, Jackal, Wild dog) are widely distributed up to elevation of 1500 m. Tiger is restricted to the low reaches (up to 400 m) whereas bear species inhabit the area above 1000 m elevation. ZSI (2006) showed its presence in the Arunachal Pradesh, however, it is not included in the State Forest Working Plan of the area. Local people also deny the presence of Tiger in the study area. All civet species are found in the dense forest and are rarely sighted. Mongoose dwells in open areas; and is observed up to 800 m elevation. Common leopard, Fishing cat and Leopard cat are the most hunted animals. Tribes use their skin and jaws for ornaments.

Tiger and Himalayan black bear are 'threatened' species, categorized as 'endangered' and Vulnerable', respectively. Locally, Tiger, Common leopard, Clouded feopard, Leopard cat, Fishing cat and Black bear have been included in 'threatened' category, in which Clouded leopard is 'endangered' and remaining are 'vulnerable' (ZSI. 1994). On the basis of conservation prioritization, 8 species are included under the Schedule I and 6 are under the Schedule II (Refer Table 7.16).

Proboscidae

Proboscidae is represented by Asian elephant, which inhabits foothill stretch (up to 300m elevation) of Lohit river. It is restricted to left wards of Kamlang river. A herd of 3-5 individuals is sighted commonly by the villagers in the forest near Wakro (more than 10 km from project area). Asian elephant is locally Vulnerable' and classified under the Schedule I.

Artiodactyla

Artiodactyla is comprised of 8 species belonging to the families Bovidae, Cervidae, Moschidae and Suidae (Refer Table-7.16). Mithun, Goral, Barking deer, Serow, Hog deer and Wild boar inhabit the project areas and its surrounding. Mithun is common, semi-domesticated cattle in the region. Wild buffalo is restricted in the lower reaches of Kamlang sanctuary while Goral, Barking deer, Serow, Hog deer and Wild boar are distributed up to 1000 m elevation. Takin and Musk deer are found at higher altitudes of the study area; Takin inhabits the elevation range between 2100 -3000 m whereas musk deer is found above 3000 m elevation range. ZSI (1994) criterion includes Musk deer and Wild Boar under the 'endangered' category and Serow as Vulnerable'. Except Mithun all species have been listed in schedule (Table-7.16). Only Takin is considered as endemic species of eastern Himalaya.

Lagomorpha

Lagomorpha is represented by a single species Indian hare. It inhabits scrubs forest and distributed from foothills to 1200 m. It is a game animal, hunted by tribes for its skin. It is categorized under the Schedule IV.

Pholidota

Chinese pangolin and Indian pangolin have earlier been reported from the lower reaches of the study area. Both species belong to the family Manidae. They are distributed up to 300 m. Indian pangolin is locally 'vulnerable' species (ZSI, 1994) whereas Chinese pangolin has been placed under the Schedule I (WPA, 1972).

Rodentia

Rodentia is comprised of rats, porcupine, squirrels and shrews. Rats are widely distributed and are very common in the study area. Indian porcupine is distributed up to 1000 m elevation and inhabits open areas. Squirrels (*Tamiops macclell* and *Petaurista magnific*, *Petauhsta petaurist*, etc.) and shrew (*Tupaia belangeri* and *Soriculus leucops*) inhabit dense forests. None of the rodent species is globally and locally threatened. Most, of them have been placed under the Schedule V and considered as ‘Vermin' (pest).

Chiroptera

All bat species are restricted to the lower reaches. They are nocturnal and invade citrus orchards in the region. They have been placed under the Schedule V.

TABLE-7.16
List of mammal species reported from the study area

Common name	Scientific name	IUCN	ZSI	WPA
Family: Hylobatidae				
Hoolock gibbon	*Bunopithecus hoolock*		EN	I
Family: Loridae				
Slow loris	*Nycticebus coucang*		IK	I
Family: Cercopithacidae				
Common langur	*Semnopithecus entellus*			II
Assamese macaque	*Macaca assamensis*			II
Rhesus macaque	*Macaca mulatta*			II
Family: Felidae				
Tiger	*Panthera tigris tigris*	EN	VU	I
Common leopard	*Panthera pardus*		VU	I

Common name	**Scientific name**	**IUCN**	**ZSI**	**WPA**
Clouded leopard	*Neofelis nebulosa*		EN	
Leopard cat	*Prionailurus bengalensis*		VU	I
Fishing cat	*Prionailurus viverrinus*		VU	I
Jungle cat	*Felis chaus*			II
Golden cat	*Catopuma temmincki*			I
Family: Canidae				
Golden jackal	*Canis aureus*			II
Indian fox	*Vulpes bengalensis*			II
Wild dog	*Cuon alpinus*			
Family: Ursidae				
Himalayan Black Bear	*Ursus thibetanusi*	VU		I
Sloth Bear	*Melursus ursinus*			I
Family: Viverridae				
Large Indian Civet	*Viverra zibetha*			
Common Palm Civet	*Paradoxurus hermaphroditus*			
Small Indian Civet	*Viverricula indica*			
Family: Herpestidae				
Common mongoose	*Herpestes edwardsii*			IV
Family: Mustelidae				
Eurasian otter	*Lutra lutra*			IV
Family: Elephantidae				
Asian elephant	*Elephas maximus*		VU	I
Family Bovidae:				
Mithun	*Bos frontalis*			
Goral	*Nemorhaedus goral*			III
Mainland Serow	*Nemorhaedus sumatraensis*		VU	I
Takin	*Budorcas taxicolor*		IK	I
Family: Cervidae				
Barking deer	*Muntiacus muntjak*			III
Hog deer	*Axis porcinus*			III
Family : Moschidae				
Himalayan musk deer	*Moschus chrysogaster*		EN	I
Family: Suidae				
Wild boar	*Sus scrofa*	IK	EN	III
Family: Leporidae				
Indian hare	*Lepus nigricollis*			IV
Family: Manidae				
Indian pangolin	*Manis crassicaudata*		VU	
Chinese pangolin	*Manis pentadactyla*		IK	I
Family: Hystricidae				
Indian porcupine	*Hystrix indica*	VU		IV

Common name	Scientific name	IUCN	ZSI	WPA
Family: Spalacidae				
Bay bamboo rat	*Cannomys badius*			
Family : Sciuridae				
Himalayan stripped squirrel	*Tamiops macclellandi*			
Hodgson's flying squirrel.	*Petaurista magnificus*			
Red Giant flying squirrel	*Petaurista petaurista*			
Particolored flying squirrel	*Hylopetes alboniger*			
Orange bellied Himalayan squirrel	*Dremomys lokriah*			
Hoary bellied Himalayan squirrel.	*Callosciurus pygerythrus*			
Family: Muridae				
Large bandicoot-rat	*Bandicota indica*			V
House rat	*Rattus rattus*			V
White bellied rat	*Niviventer niviventer*			V
Family: Tupalidae				
Northern tree shrew	*Tupaia belangeri*			V
Family: Soricidae				
Indian long tailed shrew	*Soriculus leucops*			V
Family: Vespertilionidae				
Indian pipistrelle	*Pipistrellus coromandra*			V
Inidan pygmy bat	*Pipistrellus tenuis*			V
Nepalese whiskered bat	*Myotis muricola*			V

Source: CEIA Report, Lower Demwe Hydroelectric Project

7.16 AVI-FAUNA

The basin study area also has a good representation of avian diversity harbouring more than 69 species of bird species belonging to 26 families. The commonly observed avifauna within the study area includes eagles, pheasants, hoopoe, barbets, woodpeckers, hornbills, pigeons, doves, tits, flycatchers, bulbuls, thrushes, laughing thrushes, shrikes, redstarts, drongo, crow, wagtails, forktails, minivets, sunbirds, swallow, tree pies, etc.. About 52% of the total species are widespread resident, followed by the sparse resident (39%). The remaining species belong to the winter and summer visitors.

Pelecaniformes

Order Pelecaniformes is represented by family Phalacrocoridae with a species - Large cormorant. It inhabits open areas near river zones up to 1000m elevation. Large cormorant is widespread resident in the distribution It is abundant in the lower reaches of Lohit valley.

Gruiformes

Gruiformes comprises of 2 species (White-breasted water hen and Moorhen), belong to family Rallidae. White-breasted water hen is very common in the foothills and Kamlang Wildlife Sanctuary. Both species are widespread resident and have been placed under the Schedule IV.

Galliformes

Family Phasianidae represents the order Galliformes in the study area. It comprises of Mishmi monal pheasant, Red jungle fowl, Kaleej pheasant and Grey peacock pheasant. Mishmi monal pheasant inhabits the elevation zone between 2000 – 3500 m in the Lohit valley whereas Grey peacock pheasant descends up to 1000 m. Latter was sighted during the field survey near the Tidding area. Kaleej pheasant ascends up to 1000 m while Red jungle fowl is restricted to the foothills. All species are hunted for their flesh and feathers. Mishmi monal and Grey peacock pheasant have been categorized as 'threatened' (ZSI, 1994) and Schedule I species (WPA, 1972) (Table 7.17).

Falconiformes

All species of this group belong to the family Accipitridae. They are distributed up to 2000 m in the study area. Changeable hawk eagle and Mountain hawk eagle are widespread resident while Crested serpent eagle and black eagle are sparse resident in the distribution habit. All species are placed under the Schedule I.

Piciformes

Order Piciformes includes families Picidae and Megalaimidae, represented by Grey woodpecker and Great hill barbet, respectively. Both species are widespread resident.

Upupiformes

Upupiformes is represented by Common hoopoe (Upidae). They are very common in the area and dwells near settlements and open areas up to 2000 m. Common hoopoe is widespread resident and winter visitor.

Bucerotiformes

Bucerotiformes comprises of Assam Wreathed hornbill, Rufousnecked hornbill and Great Indian pied hornbill in the area. Former two species are 'vulnerable' while later is 'endangered'. They inhabit dense forests of the tropical eco-zone. All species have been categorized under the Schedule I of Wildlife Protection Act (1972). Hornbills are most vulnerable group in the Arunachal Pradesh including Lohit valley. They are hunted intensively for their beaks and feathers. These organs are used as ornaments and trophies among the tribes.

Columbiformes

Columbiformes includes 8 species, belong to the family Columbidae. Rock pigeon, Spotted dove, Oriental turtle dove and Emerald dove dwell in open areas, agricultural fields and settlement areas. They are widespread resident and widely distributed. They are also hunted for their flesh. Other species of pigeons inhabit dense and open forests; they are sparse resident. All species of pigeons and doves are categorized under the Schedule IV.

Cuculiformes

This group is comprised of cuckoos, koel and coucals belonging to the families Cuculidae and Centropotidae. The Common koel and Greater coucal is widespread resident while remaining species are sparse resident. All are Schedule IV species.

Passeriformes

Passeriformes is the largest Order, accounts for 56.7% of the total species in the area under discussion. It comprises of 14 families. Muscicapidae is largest family, followed by the Carvidae. Most of the species are widely distributed. House sparrow, Russet sparrow, Jungle crow, Indian Myna, White wagtail, Blue whistling thrush, White-capped redstart, Plumbeous redstart, Grey hooded warbler, Red-vented bulbul and Rufous backed shrike were most common species of Passeriformes in the project areas. Except crow, all species belong to the Schedule IV of Wildlife Protection Act (1972).

TABLE-7.17
List of various avifaunal species reported in the study area

Family/Common Name	**Scientific Name**	**Distribution**	**Conservation Status**	
		Habit	**WPA (1972)**	**ZSI(1994)**
Phalacrocoridae				
Large cormorant	*Phalacrocorax corbo sirensis*		R	IV
Rallidae				
White-breasted water hen	*Amaurornis phoenicurus*	R	IV	
Moorhen	*Gallinula chloropus*	R	IV	
Jacanidae				
Bronze winged jacana	*Metopidius indicus*	R	IV	
Phasianidae				
Mishmi monal pheasant	*Lophophorus sclateri*	R	I	EN
Kaleej pheasant	*Lophura leucomelana*	R	-	EN
Grey peacock pheasant	*Polyplectron bicalcaratum*	r	I	VU
Redjungle fowl	*Gallus gallus*	R	-	
Accipitridae				

Mountain hawk eagle	*Spizaetus nipalensis*	r	I	
Changeable hawk Eagle	*S. cirrhatus*	R	I	
Black eagle	*Ictinaetus malayensis*	r	I	
Crested serpent eagle	*Spilornis cheela*	R	I	
Picidae				
Grey-headed woodpecker	*Picus canus*	R	IV	
Megalaimidae				
Great hill barbet	*Megalaima virens*	R	IV	

Family/Common Name Conservation Status	**Scientific Name**	**Distribution**		
		Habit	**WPA (1972)**	**ZSI(1994)**
Upupidae				
Common hoopoe	*Upupa epops*	RW	IV	
Bucerotidae				
Assam Wreathed hornbill	*Rhyticeros undulates*	r	I	VU
Great Indian pied hornbill	*Buceros bicornis*	R	I	EN
Rufousnecked hornbill	*Aceros nipalensis*	R	I	VU
Columbidae				
Rock pigeon	*Columba livia*	R	IV	
Ashy wood pigeon	*C. pulchricollis*	r	IV	
Speckled wood pigeon	*C. hodgsonii*	r	IV	
Pintail green pigeon	*Treron apicauda*	r	IV	
Green imperial pigeon	*Ducula aenea*	r	IV	
Mountain imperial pigeon	*D. badia*			
Spotted dove	*Streptopelia chinensis*	R	IV	
Emerald dove	*Chalcophaps indica*	R	IV	
Cuculidae				
Common hawk cuckoo	*Hierococcyx varius*	r	IV	
Pied crested cuckoo	*Clamator jacobinus*	rs	IV	
Common koel	*Eudynamys scolopacea*	R	IV	
Centropodidae				
Lesser coucal	*Centropus bengalensis*	r	IV	
Greater coucal	*C. sinensis*	R	IV	
Aegithalidae				
Green backed tit	*Parus monticolus*	R	IV	
Brown crested tit	*P. dichrous*	R	IV	
Grey tit	*P. major*	R	IV	
Sittidae				
Wall creeper	*Tichodroma muraria*	rw	IV	
Nectariniidae				

Mrs. Gould’s sunbird	*Aethopyga gouldiae*	r	IV	
Purple sunbird	*Nectarinia asiatica*	R	IV	
Sturniidae				
Common myna	*Acridotheres tristis*	R	IV	
Hill myna	*Gracula religiosa*	r	IV	
Hirundinidae				
Wiretailed swallow	*Hirundo smithii*	R	IV	
Cicclidae				
Brown dipper	*Cinclus pallasii*	R	IV	

Family/Common Name	**Scientific Name**	**Distribution**	**Conservation Status**	
		Habit	**WPA (1972)**	**ZSI(1994)**
Pycnonotidae				
Red vented bulbul	*Pycnonotus cafer*	R	IV	
Striated green bulbul	*P. striatus*	r	IV	
Mountain bulbul	*Hypsipetes mcclellandii*	r	IV	
Black bulbul	*H. leucocephalus*	R	IV	
Laniidae				
Rufous backed shrike	*Lanius schach*	R	IV	
Grey shrike	*L. tephronotus*	rW	IV	
Muscicapidae				
Blue whistling thrush	*Myophonus caeruleus*	R	IV	
Grey winged black bird	*Turdus boulboul*	r	IV	
Slaty backed forktail	*Enicurus schistaceus*	r	IV	
Little forktail	*E. scouleri*	r	IV	
White-capped Redstart	*Chaimarrornis leucocephalus*	r	IV	
Plumbeous redstart	*Rhyacornis fuliginosus*	r	IV	
Paradise flycatcher	*Terpsiphone paradisi*	R	IV	
Coraciidae				
Indian rollar	*Coracias benghalensis*	r	IV	
Carvidae				
Bronzed drongo	*Dicrurus aeneus*	r	IV	
Large billed crow	*Corvus macrorhynchos*	R	V	
Himalayan treepie	*Dendrocitta formosae*	R	IV	
Maroon oriole	*Oriolus traillii*	r	IV	
Black headed oriole	*O. xanthornus*	r	IV	
Scarlet minivet	*Pericrocotus flammeus*	R	IV	
Sylviidae				
Striated laughing thrush	*Garrulax striatus*	r	IV	
Greater laughing thrush	*G. pectoralis*	r	IV	
Grey hooded warbler	*Seicercus poliogenys*	r	IV	

Large-billed leaf warbler	*Phylloscopus magnirostris*	rw	IV
Passeridae			
Russet sparrow	*Passer rutilans*	R	IV
Tree sparrow	*P. montanus*	R	IV
White wagtail	*Motacilla alba*	rW	IV
Fringillidae			
Crested bunting	*Melophus lathami*	R	IV

R- Common Resident; W - Widespread; r - Resident; s - Sparse
Source: CEIA Report, Lower Demwe Hydroelectric Project

7.17 HERPETOFAUNA

About 39 species of Amphibia and 78 species of reptiles have been reported from Arunachal Pradesh (Sarkar and Ray, 2006; Sanyal and Gayen, 2006). However, the list of the species present in the study area is given in Table-7.18. A total of 10 amphibian species, which comprises of toads and frogs are reported from the study area. *Rana* spp. and *Bufo meianostictus* are very common in the study area. None of the frog and toad species in the study areas is 'threatened' and endemic to Arunachal Pradesh.

Reptifian fauna is comprised of 24 species belonging to 8 families. Sun skink, Forest skink, Khasi lizard, house lizard, common krait, Indian monitor, pit viper, rat snake are most common within the study area. Python and Indian monitor lizard have been categorized as 'endangered' species (ZSI, 1994) (Table-7.18). Former two species have also been placed under the Schedule I while Indian monitor lizard, Russell's viper, Rat snake. Cobra and King cobra are categorized as Schedule II species.

TABLE-7.18
Composition and status of the herpetofauna reported in the study area

Family/Common name	Scientific name	Conservation Status	
		(ZSI, 1994)	(WPA, 1972)
Amphibia			
Bufonidae			
Common toad	*Bufo melanostictus*	-	-
Himalayan toad	*Bufo himalayana*	-	-

Pelobatidae			
Burmese Spadefoot toad	*Megophrys parva*	-	-
Ranidae		**-**	**-**
Meghalaya stream frog	*Amolops afghanus*	-	-
Daniel's Oriental Stream frog	*Rana danieli*	-	-
Yembung Sucker Frog	*Rana gerbillus*	-	-
Taipei frog	*Rana taipehensis*	-	-
Silver-lined paddy frog	*Rana erythraea*	-	-
Rhacophoridae			
Pied theloderma	*Philautus annandalii*	-	-

Family/Common name	**Scientific name**	**Conservation Status**	
		(ZSI, 1994)	**(WPA, 1972)**
Twin-spotted Flying Frog	*Rhacophorus bipunctatus*	-	-
Reptiles			
Scincidae			
Sikkim sunskink	*Scinella sikimmensis*	-	-
Large Forest-skink	*Sphenomorphus indicum*	-	-
Writhing skinks	*Lygosoma* sp	-	-
Gekkoniade			
Khasi lizard	Cyrtodactylus khasiensis	-	-
Brook's House Gecko	Hemidactylus brookii	-	-
House geckos	*H. frenatus*	-	-
Laceridae			
Asian grass lizard	*Takydromus sexlineatus*	-	-
Varanidae			
Indian monitor lizard	*Varanus bengalensis*	EN	II
Elapidae			
Common krait	*Bungarus niger*	-	-
Banded krait	B. *fasciatus*	-	-
Cobra	*Naja kaouthia*	-	II
King cobra	*Ophiophagus hannah*	-	II
Viperidae			
Bamboo pit viper	*Trimeresurus* spp	-	-
Russell’s viper	*Vipera russelli*	-	II
Brown-spotted pitviper	*Protobothrops mucrosquamatus*		- -
Jerdon’s pitviper	*Protobothrops jerdoni*	-	-
Mountain pitviper	*Ovophis monticola*	-	-
Boidae			
Python	*Python molurus bivettatus*		EN I
Colubridae			

Green keelback	*Macropisthodon plumbicolor*	-	-
Common worm snake	*Typlina branmina*	-	-
Common wolf snake	*Lycodon aulicus*	-	-
Striped racer	*Elaphe taeniura*	-	-
Rat snake	*Ptyas mucosus*	-	II
Green rat snake	*Elaphe prasina*	-	-

Source: CEIA Report, Lower Demwe Hydroelectric Project

7.18 PROTECTED AREAS

The Kamlang Wildlife Sanctuary (KWLS) has approximately 783 sq km area and it falls in the south-eastern part of Lohit district. The geographical location of the Sanctuary is $20^{0}4'$-$28^{0}00'$ N latitudes and $96^{0}20'$-$96^{0}55'$ E longitudes. Lang and Lati rivers form the boundary of the Sanctuary in the north & west respectively with Tawe river on the east and in the south the district boundaries of Lohit and Changlang district surround the Sanctuary. In the south, the KWLS is continuous to the Namdapha National Park.

The nearest project in the vicinity of KWLS is Demwe Lower HEP and dam site of which is located about 10 km from the boundary of KWLS on Lang River. The location of Demwe Lower Hydroelctric project w.r.t. Kamlang Wildlife Sanctuary is given in Figure-7.2. The nearest boundary of KWLS with respect to the Dam site of Demwe Lower HEP is located about 11.8 km away (along the river) at the confluence of Lang and Tawai river at EL 425 m (tributaries of River Lohit) on the left bank of the Lohit river. There is no existing direct road approach & footpath on Left Bank of Lohit River from the project area to the nearest boundary of KWLS, and further no roads have been proposed on Left bank of River Lohit by the project developer. Also, due to steep mountain range of more than 6000 feet separates the project area from KWLS making the Sanctuary inaccessible from the project site. Further, most of the construction activities are proposed in the vicinity of the Dam site which is located around 11.8 km along the river from the nearest boundary of the Kamlang Wildlife

Sanctuary on Lang River. Project reservoir would be the nearest project component to the KWLS only during Operation Phase, which has to be maintained as Protected Area. In the eastern, western and northern boundaries of KWLS is surrounded by natural barriers mostly in the form the of rivers/deep gorges of width varying 30-100 m & high ridges and in southern side the boundary of Kamlang Wildlife Sanctuary coincides with Namdapha National Park. Considering the location of the KWLS no adverse impacts are foreseen on the KWLS due the Demwe Lower HE Project during construction as well as in operation phase.

As per assessment made by the field staff of Kamlang Wildlife Range; Wakro, and other information from secondary sources like research papers, villagers, etc, it is expected as many as 61 species of mammals, 105 species of birds and 20 species of reptiles present in the Kamlang Wildlife Sanctuary and Namdapha National Park. The census of elephant during 2004 and tiger in 2006 confirmed the presence of pachyderm and tigers inside the Sanctuary. There are also other mammals like leopard, hoolock gibbon, stumped tailed macaque, beers, civets, flying squirrels, etc. Out of 15 species of piramates found in India, six species (*Semnopitheous entellus, Macaca mulata, M. arctoides, M. assamensis, Bunopithecus hollock, Nycticebus coucang*) are found in the Kamlang Wildlife Sanctuary. *Hoolock gibbon* and *N. coucong* are kept in schedule I whereas other species are in schedule II and III of Wildlife Protection Act of India.

The mammalian species, viz. Serow, Goral, Indian Wild Boar, Barking deer, Clouded leopard, Common leopard, Fishing cat, Jungle cat, Leopard cat, Jackal, Civets, Common otter, and Yellow throated martin, Assamese Macaque and Common langur, share their habitat with the study area of proposed project.

The list of major faunal species reported in Kamlang Wildlife Sanctuary is given in Table-7.19. The avifauna of Kamlang Wildlife Sanctuary is given in Table-7.20.

TABLE-7.19

List of major faunal species reported in Kamlang Wildlife Sanctuary

S.No.	Scientific Name	Common Name/Local Name
	ARTIODACTYLA	
1	*Bos gaurus*	Gaur

S.No.	Scientific Name	Common Name/Local Name
2	*Bubalus bubalis*	Wild buffalo
3	*Budorcas taxicolor*	Mishmi takin
4	*Capricomis sumatraensis*	Serow
5	*Nemorhaedus goral*	Goral
6	*Sus scrofa*	Indian wild boar
7	*Cervus unicolor*	Sambar
8	*Axis procinus*	Hog Deer
9	*Muntiacus muntjak*	Muntjak or Barking deer
10	*Moschus moschiferus*	Musk deer
	PROBOSCIDEA	
1	*Elephas maximus*	Asiatic elephant
	CARNIVORA	
1	*Panthera tigris tigris*	Tiger
2	*P. pardus*	Leopard
3	*P. uncia*	Snow leopard
4	*Neofelis nebulosa*	Clouded leopard
5	*Felis marmorata*	Marbled cat
6	*F. temminckii*	Golden cat
7	*F. viverrina*	Fishing Cat
8	*F. bengalensis*	Leopard cat
9	*F .chaus*	jungle cat
10	*Cuon alpinus*	Indian wild dog or Dhole
11	*Canis aureus*	Jackel
12	*Vulpes bengalensis*	Indian fox
13	*Selenarctors thibetanus*	Himalayuan black bear
14	*Melursus ursinus*	Sloth bear
15	*Ailurus fulgens*	Red panda or Car bear
16	*Vivericula indica*	small indian civet
17	*Viverra zibetha*	Large indian civet
18	*Paguma larvata*	Himalayan palm civet
19	*Arctictis binturong*	Binturonga or Bear cat
20	*Lutra lutra*	common otter
21	*Aonyxcinerea nimal*	Clawless otter
22	*Martes flavigula*	Yellow throated marten
23	*Herpestes urva*	Crabeating mongoose
	PRIMATES	
1	*Hylobates hoolock*	Hoolock
2	*Macaca assamensis*	Assamese macaque
3	*Macaca mulatta*	Rhesus macaque
4	*Macaca arctoides*	stump tailed macaque
5	*Semnopithecus entellus*	Common langur

S.No.	Scientific Name	Common Name/Local Name
6	*Nycticebus coucang*	slow loris
	INSECTIVORA	
1	*Soccalus griffittii*	Common shrew
	CHIROPTERA	
1	*Rousettus leschenaulti*	Fulvous bat or leschenault's rdousette
2	*Cynopterus angulatus*	Eastern fruit bat
3	*Megaerops ecaudatus*	Tailless Fruit bat
4	*Macroglossus minumus*	Long tongued fruit bat
5	*Rhinolophus luctus*	Horseshoe bat
	RODENTIA	
1	*Ratufa bicolour gigantea*	Malayan giant squirrel
2	*Petaurista petaurista*	Common giant flying squirrel
3	*Biswamopterus biswasi*	Namdapha flying squirrel
4	*Callosciurus erytharaeus*	Pallas squirrel
5	*Callosciiurus pygerythrus*	Hoary bellied Himalayan squirrel
6	*Tamiop macclellandi*	Himalayan giant squirrel
7	*Dremomys rufigensis indian*	Red-cheered squirrel
8	*Procupine (Hystrix indica)*	
9	*Mus booduga*	Indian field mouse
10	*Rattus rattus*	Common house rat
	PHILODOTA	
1	*Manis crassicaudata*	Indian pangolin
2	*Manus pentadactyla*	Chinese pangolin

Source: CEIA Report, Lower Demwe Hydroelectric Project

TABLE-7.20
List of major avi-fauna reported in Kamlang Wildlife Sanctuary

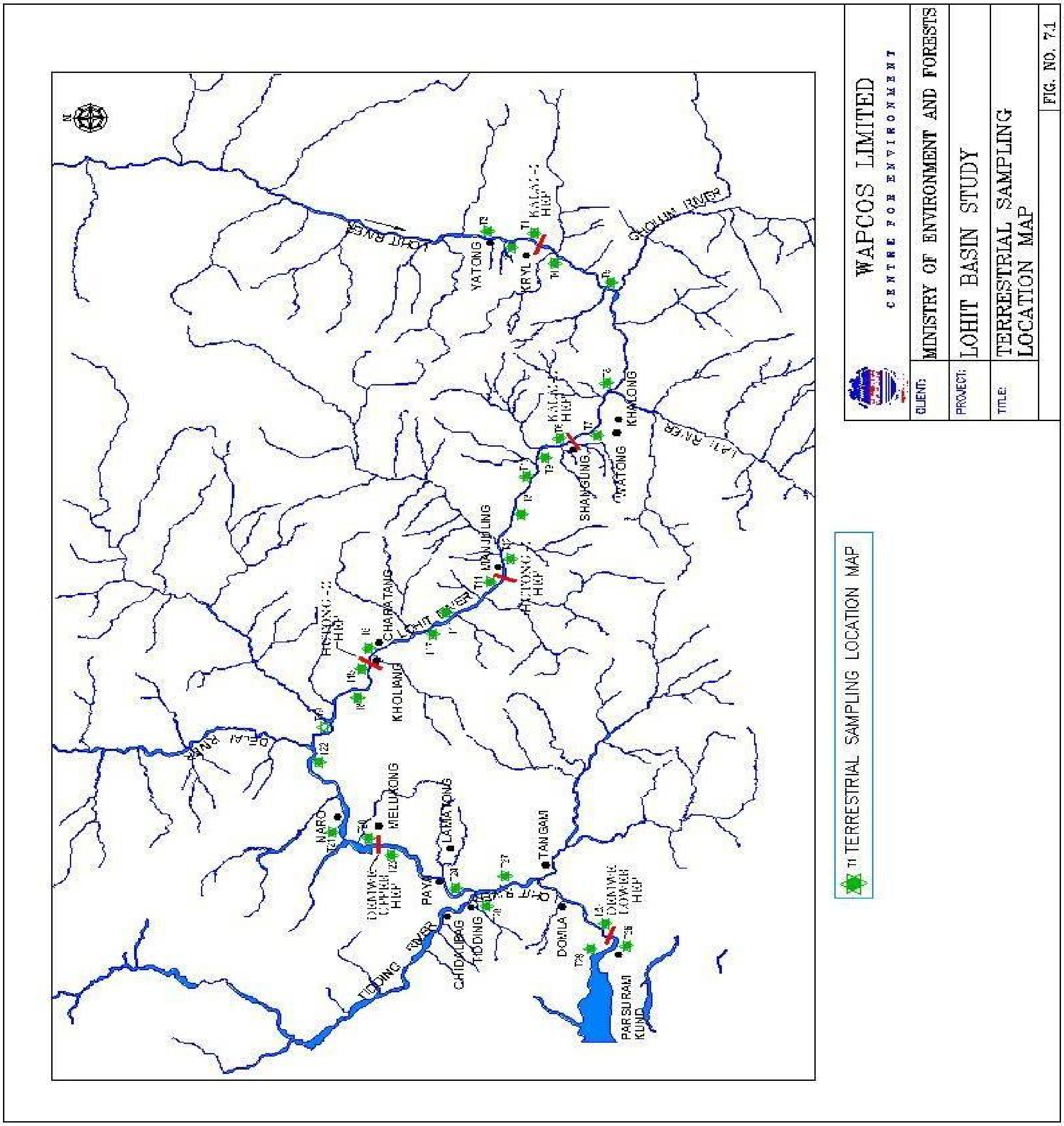
S. No.	Scientific Name	Common Name/Local Name
	PELECANIFORMES	
1	*Phalacrocorax carbosirensis*	Large carmorant
	FALCONIFORMES	
1	*Falco peregrinus*	Sharin
2	*(F.severus*	Indian severus or oriental hobby
3	*Ictinaetus malayensis*	Black eagle
4	*Icthyophaga nana*	Lesser fishing eagle
5	*Spizaetus nipalensis*	Feathertoed or mountain hawkeagel
6	*Spilornis cheela*	Crested serpent eagle
	GALLIFORMES	
1	*Gallus gallus*	Red junglefowl

S. No.	Scientific Name	Common Name/Local Name
2	*Lopohura leucomelana*	Kalij pheasant
3	*Polyplectron bicalacaratum*	Grey peacock-pheasant
	COLUMBIFORMES	
1	*Chalcophaps indica*	Emerald dove
2	*Ducula sensex*	Imperial pigeon
3	*D.badia*	Maroonbacked or mountain imperial pigeon
4	*Streptopelia chinesis*	Spotted dove
5	*Treron apicauda*	Pintailed green pigeon
		Great Indian Hornbill
		Oriental Pied Hornbill (AVES)
		Large Rocket tailed Drongo
		Bronzed drongo
	STRIGIFORMES	
1	*Phodilus badius*	Bay Owl
2	*Glaucidium cuculoides*	Asian barred owlet
	PICIFORMES	
1	*Chrysocolaptes lucidus*	Greater goldenback woodpecker
2	*Dinopium benghalense*	Black-rumped goldenback
3	*Megalaima virens*	Great barbet
4	*M.asiatica*	Blue-throated barbet
5	*Celeus brachurus*	Rufous woodpecker
6	*Picumnus innominatus*	Speckled piculet
7	*Picus canus*	Greyheaded woodpecker
8	*P.chlorolophus*	Small chlorolophus(or lesser yellownape
9	*Picoides mecod rufous*	Fulvous-breasted pied woodpecker
10	*Sasia ochraeea*	White-browed Piculet
	CARPRIMULGIFORMES	
1	*Trachostomus hodgson*	Hodgson's fromgmouth
	PASSERIFORMES	
1	*Acridotdheres tristis*	Indian myna
2	*A.fuscus lora (Aegithina tiphia)*	Jungle myna
3	*Aethopyga saturata*	Black-throated sunbird
4	*Alcippe nipalensis*	Quaker babbler or Nepal fulvertta
5	*Anthus hodgsoni*	Indian tree pipit
6	*Artamus fuscus*	Greater racketail or ashy wood swallow
7	*Arachnothera longirostra*	Little spiderhunter
8	*A.magna*	Streaked spiderhunter
9	*Brachypteryx leucophrys*	Lesser shortwing

S. No.	Scientific Name	Common Name/Local Name
10	*B.cryfical*	Namdapha shortwing
11	*Chloropsis hardwickii*	Orange-bellied leafbird
12	*Corvus macrorhynchos*	Jungle or large-billed crow
13	*Copsychus saularis*	Magpie robin
14	*Criniger flaveolus*	White-tdhroatee bulbul
15	*Dendrocitta frontalis*	Blackbrown or collared treepie
16	*Dicrurus aeneus*	Bronzed drongo
17	*D.paradiseus*	Large rackettailed drongo
18	*Deaecum Cruentatum*	Scarletbacked flowerpecker
19	*Enicurus schistaceus*	Slaty-backed forktail
20	*Garrulax pectoralis*	
21	*G.leucolophus*	Whitecrested laughingthrus
22	*G.Chinensis*	Ogle's laughrush
23	*G.delesserti*	
24	*G.ruficollis*	Rufous-necked laughingthrush
25	*G.subunicolor*	Plain coloured or scaly laughingthrush
26	*G.proeniceus*	Crimson-winged laughingthrush
27	*Gampso rhynchus rufulus*	White-headed shrike lbabbler
28	*Gracula religiosa*	Hill myna
29	*Hypsipetes favalal*	Ashy bulbul
30	*H.madagascariensis*	Black bulbul
31	*Irena puella*	Fairy bluebird
32	*Lanius tepjphronotus*	Greey-backs shrike
33	*Leiothrix argentauris*	Silvereared mesia
34	*Melanochlora sultanea*	Sultantit
35	*Niltava grandis*	large nitava
36	*N.sundara*	Rufousbellied niltava
37	*Megalurus palustris*	Striated marsh warbler
38	*Myopnonus caeruleus*	Blue whistling thrush
39	*Nepothera brevicaudata*	Streaked wren-babbler
40	*Orthotoremus atrogularis*	Goldenheaded or mountain tailorbird
41	*Oriolus xanthornus*	Black-headed oriole
42	*Parus major*	Great tit
43	*Passer montanus*	Tree sparrow
44	*Pericrocotus flammeus*	Scarlet minivet
45	*Phoenicurrus auroreus*	Daurian reastrat
46	*Phylloscopus cantator*	Yellow-throated leaf warbler
47	*Pnoepyga pusilla*	wren-babbler
48	*Pomatorhinus ferruginosus*	Corabilled scimitat babbler

S. No.	Scientific Name	Common Name/Local Name
	namdapha	
49	*Pycnonotos melanicterus*	Black creasted yellow bulbul
50	*P.cafer*	Red-wented bulbul
51	*Mirafra assamica*	Rufous-winged bushlark
52	*Rhipidura albocollis*	White-Throated fantail flycatcher
53	*Macronous gularis*	Yellowbreasted babbler or striped titbabbler
54	*Sturnus malabricus*	Chestnut myna or chestnut-tailestrarling
55	*S.contra*	pied myna
56	*S.nigriceps*	Red-headed 0r Grey throated babbler
57	*Tesia olivea*	Slary-bellied ground warbler
58	*Tephrodonis gularis*	Large wood strike
59	*Turdoides striatus*	Jungle babbler

Source: CEIA Report, Lower Demwe Hydroelectric Project


WAPCOS LIMITED
CENTRE FOR ENVIRONMENT
CLIENT:
MINISTRY OF ENVIRONMENT AND FORESTS
PROJECT:
LOHIT BASIN STUDY
TITLE:
TERRESTRIAL SAMPLING LOCATION MAP
FIG. NO. 7.1
T1 TERRESTRIAL SAMPLING LOCATION MAP
LOHIT RIVER
GHOLUM RIVER
LATI RIVER
DELAI RIVER
TIDDING RIVER
YATONG
KRYL
KHALONG
WATONG
SHANGUNG
CHAPATANG
KHOLIANG
NARO
MELIUKONG
LAMATONG
PAYA
TIDDING
CHIDALIBAG
TANGAM
DOMLA
PARSURAM KUND

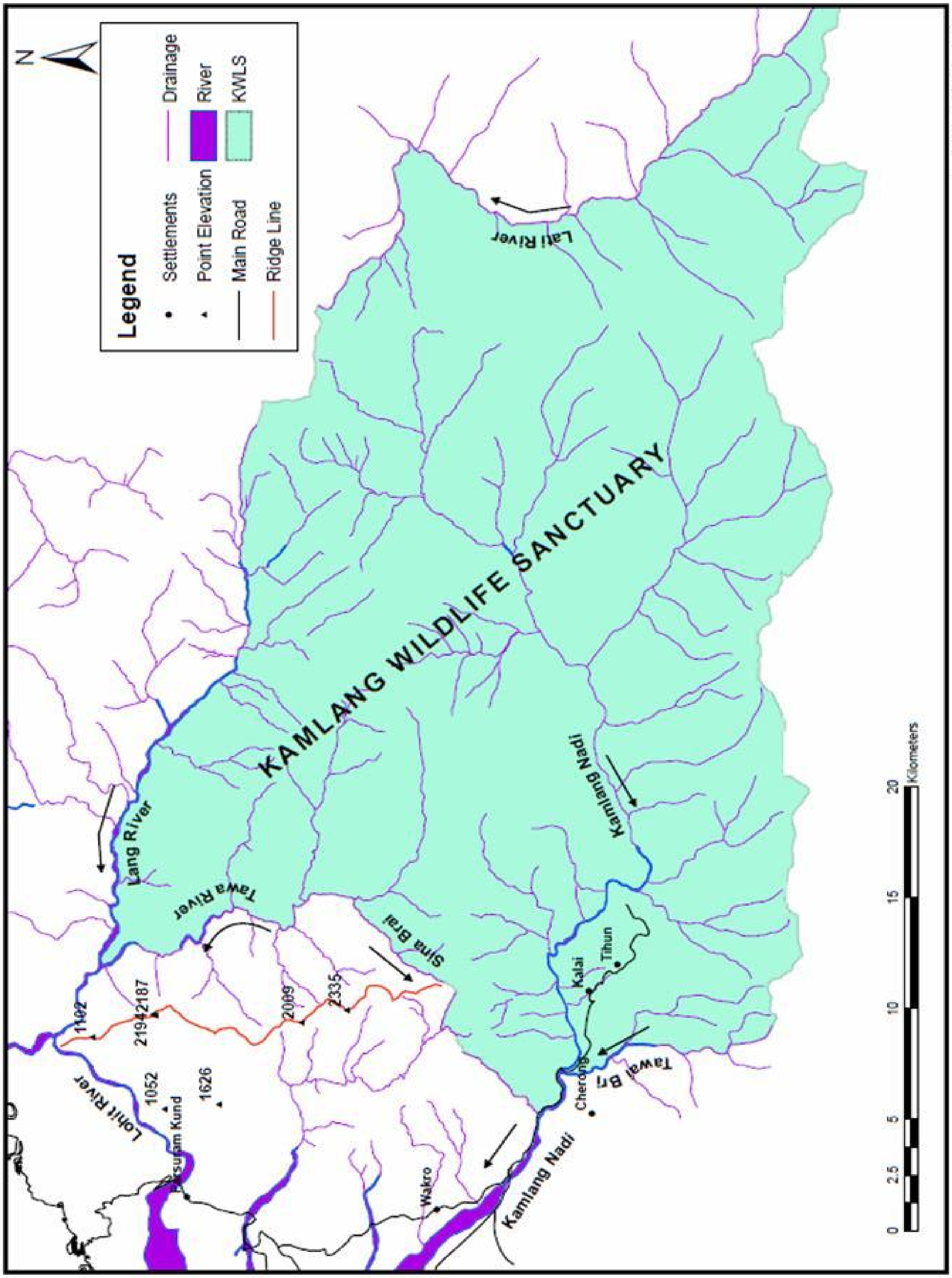

N
Legend
Settlements
Point Elevation
Main Road
Ridge Line
Drainage
River
KWLS
KAMLANG WILDLIFE SANCTUARY
Lati River
Lang River
Tawa River
Sina Brai
Kamlang Nadi
Tawai Bri
Lohit River
Parsuram Kund
Wakro
Cherong
Kalai
Tihun
1192
2194
2187
2009
2335
1052
1626
Kamlang Nadi
0
2.5
5
10
15
20
Kilometers

FIG. NO. 7.2

CHAPTER-8
PREDICTION OF IMPACTS

8.1 INTRODUCTION

Prediction is essentially a process to forecast the future environmental conditions of the projects area that might be expected to occur because of implementation of the project. Impact of project activities has been predicted using mathematical models and overlay technique (super-imposition of activity on environmental parameter). For intangible impacts qualitative assessment has been done.

8.2 LENGTH OF RIVER WITH NORMAL FLOW

The impact on hydrologic regime is on account of change in the free flowing condition of the river. The total length of Lohit river in the study area, i.e., stretch of Lohit Basin in Indian portion from international boundary to Brahmkund is 144.2 km. With the construction of the proposed hydroelectric projects including Anjaw hydroelectric project, free flowing river shall be available from international boundary for a length of 42.4 km in a stretch of 144.2 km upto dam site of Demwe Lower HEP. The details of length of River Lohit and the proposed hydroelectric projects in the study area is given in Table-8.1. The details of length of free flow of River Lohit in the study area on commissioning of the proposed six hydroelectric projects are given in Table-8.2.

TABLE-8.1

Details of length of River Lohit and Projects in the study area

S. No.	Stretch	Distance Km
1	Free flowing stretch from International boundary to submergence of Kalai Stage 1	32
2	Submergence of Kalai Stage 1 HEP	17
3	Free flowing stretch between Kalai stage 1 and Kalai stage 2 HEP	1
4	Submergence of Kalai stage 2 HEP	20
5	Free flowing stretch between Kalai stage 2 and Hutong stage 1 HEP	2
6	Submergence of Hutong stage 1 HEP	3
7	Intervening stretch between Hutong stage 1 and submergence of Hutong stage 2 HEP	4.5

S. No.	Stretch	Distance Km
	over which HRT is proposed	
8	Submergence of Hutong stage 2 HEP	12.5
9	Free flowing stretch between Hutong stage 2 and Anjaw Project	1.8
10	Submergence of Anjaw project	4.8
11	Free flowing stretch betweenAnjaw HEP and Demwe Upper HEP	3.8
12	Submergence of Demwe Upper HEP	17
13	Free flowing stretch between Demwe Upper and Demwe Lower HEP	1.8
14	Submergence of Demwe Lower HEP	23
	Total	**144.2**

TABLE-8.2
Details of length of free flow of River Lohit in the study area

S. No.	Projects	Length of free flow of river (km)
1.	International boundary to submergence of Kalai Stage 1	32.0
2.	Between Kalai HEP Stage-1 and Kalai HEP Stage-2	1.0
3.	Between Kalai HEP Stage-2 and Hutong HEP Stage-1	2.0
5.	Between Hutong HEP Stage-2 and Anjaw HEP	1.8
6.	Between Anjaw HEP and Demwe Upper HEP	3.8
7.	Between Demwe Upper HEP and Demwe Lower HEP	1.8
	Total	**42.4**

The river which in the present stage (pre-project scenario) is flowing freely over a stretch of 144.2 km, will get converted into a series of reservoir and free flowing length of the river will be in order of 42.4 km i.e. about 30 % of river stretch. The conversion of free flowing river into reservoirs is likely to have an adverse impact on riverine ecology.

Normally, under such circumstances, adverse impacts on water quality is also anticipated, on account of increase in the residence time in the reservoir. In the study area, the pollution is virtually negligible, on account of low population density, low cropping intensity with minimal use of agro-chemicals and absence of industries in the area. Thus, water pollution is low, and as a result no major impacts on reservoir water quality are anticipated.

8.3 MODIFICATION IN HYDROLOGIC REGIME

Except Hutong hydroelectric project stage-1, all other projects have a dam/barrage toe power house. All the proposed hydroelectric except Anjaw HE project would require filling up reservoir upto its live storage capacity, which would then be used for peaking power. In Anjaw HE project, no live storage has been provided and hence no peaking is proposed.

The discharge for 90% dependable year for various hydroelectric project proposed in the study area is given in Table-8.3. The number of hours of peaking available in the proposed projects is given in Tables 8.4 to 8.6.

TABLE-8.3
Discharge for 90% dependable year for various Hydroelectric Projects

Month		Kalai HEP Stage-1	Kalai HEP Stage-2	Hutong HEP Stage-1	Hutong HEP Stage-2	Demwe Upper HEP	Demwe Lower HEP
June	I	695.12	1184.76	1192.87	1224.88	1072	1126
	II	767.36	1225.83	1233.91	1267	1578	1657
	III	756.05	1445.66	1455.55	1494.59	1737	1824
July	I	1002.64	2123.64	2138.15	2195.51	2142	2249
	II	1023.38	1909.37	1922.42	1973.99	1277	1341
	III	781.37	1634.58	1645.75	1689.9	918	964
August	I	819.29	1152.46	1160.34	1191.46	745	783
	II	816.91	1121.49	1129.17	1159.45	688	723
	III	616.19	1018.76	1025.83	1053.24	726	762
September	I	553.61	747.84	752.96	773.15	727	764
	II	526.8	652.71	657.18	674,81	697	732
	III	913.31	632.43	636.76	653.84	601	631
October	I	622.18	529.76	533.39	547.69	556	584
	II	399	468.63	471.73	484.38	527	553
	III	374.18	374.37	376.93	387.04	493	517
November	I	345.66	355.66	358.09	367.7	439	461
	II	316.13	305.17	307.26	315.5	418	438
	III	284.9	291.13	293.12	300.98	398	418
December	I	268.99	420.44	423.31	434.67	382	401
	II	256.2	385.85	388.49	398.91	365	383
	III	240.43	392.06	397.74	405.33	351	368
	I	225.49	267.68	269.5	276.73	341	358

Month		Kalai HEP Stage-1	Kalai HEP Stage-2	Hutong HEP Stage-1	Hutong HEP Stage-2	Demwe Upper HEP	Demwe Lower HEP
January	II	203.35	276.7	278.58	286.06	340	357
	III	216.93	225.72	227.26	233.36	341	358
February	I	221.81	218.38	219.88	225.77	315	330
	II	224.6	224.47	226.01	232.06	310	325
	III	226.21	302.18	304.24	312.4	320	336
March	I	217.62	169.7	170.86	175.44	353	371
	II	257.71	199.42	200.78	206.16	314	330
	III	246.99	220.3	221.81	227.75	603	634
April	I	419.78	471.07	474.29	487.01	600	630
	II	445.8	568.77	572.66	588.02	819	860
	III	449.27	608.81	612.98	629.42	951	998
May	I	570.08	710.9	715.77	734.96	780	820
	II	748.43	800.15	805.53	837.24	740	777
	III	764.87	814.92	820.5	842.51	852	895

TABLE-8.4
Number of hours of peaking available in 90% dependable year for Kalai HEP, stage-1

Month		Discharge in 90% Dependable year (cumec)	Rated dischrage (cumec)	Time available for peaking power (hrs.)
June	I	695.12	1033.05	16.1
	II	767.36	1033.05	17.8
	III	756.05	1033.05	17.6
July	I	1002.64	1033.05	23.3
	II	1023.38	1033.05	23.8
	III	781.37	1033.05	18.2
August	I	819.29	1033.05	19.0
	II	816.91	1033.05	19.0
	III	616.19	1033.05	14.3
September	I	553.61	1033.05	12.9
	II	526.8	1033.05	12.2
	III	913.31	1033.05	21.2
	I	622.18	1033.05	14.5

Month		Discharge in 90% Dependable year (cumec)	Rated dischrage (cumec)	Time available for peaking power (hrs.)
October	II	399	1033.05	9.3
	III	374.18	1033.05	8.7
November	I	345.66	1033.05	8.0
	II	316.13	1033.05	7.3
	III	284.9	1033.05	6.6
December	I	268.99	1033.05	6.2
	II	256.2	1033.05	6.0
	III	240.43	1033.05	5.6
January	I	225.49	1033.05	5.2
	II	203.35	1033.05	4.7
	III	216.93	1033.05	5.0
February	I	221.81	1033.05	5.2
	II	224.6	1033.05	5.2
	III	226.21	1033.05	5.3
March	I	217.62	1033.05	5.1
	II	257.71	1033.05	6.0
	III	246.99	1033.05	5.7
April	I	419.78	1033.05	9.8
	II	445.8	1033.05	10.4
	III	449.27	1033.05	10.4
May	I	570.08	1033.05	13.2
	II	748.43	1033.05	17.4
	III	764.87	1033.05	17.8

TABLE-8.5
Number of hours of peaking available in 90% dependable year for Kalai HEP, stage-2

Month		Discharge in 90% Dependable year (cumec)	Rated dischrage (cumec)	Time available for peaking power (hrs.)
June	I	1184.76	1112.27	24.0
	II	1225.83	1112.27	24.0
	III	1445.66	1112.27	24.0
	I	2123.64	1112.27	24.0

Month		Discharge in 90% Dependable year (cumec)	Rated dischrage (cumec)	Time available for peaking power (hrs.)
July	II	1909.37	1112.27	24.0
	III	1634.58	1112.27	24.0
August	I	1152.46	1112.27	24.0
	II	1121.49	1112.27	24.0
	III	1018.76	1112.27	22.0
September	I	747.84	1112.27	16.1
	II	652.71	1112.27	14.1
	III	632.43	1112.27	13.6
October	I	529.76	1112.27	11.4
	II	468.63	1112.27	10.1
	III	374.37	1112.27	8.1
November	I	355.66	1112.27	7.7
	II	305.17	1112.27	6.6
	III	291.13	1112.27	6.3
December	I	420.44	1112.27	9.1
	II	385.85	1112.27	8.3
	III	392.06	1112.27	8.5
January	I	267.68	1112.27	5.8
	II	276.7	1112.27	6.0
	III	225.72	1112.27	4.9
February	I	218.38	1112.27	4.7
	II	224.47	1112.27	4.8
	III	302.18	1112.27	6.5
March	I	169.7	1112.27	3.7
	II	199.42	1112.27	4.3
	III	220.3	1112.27	4.8
April	I	471.07	1112.27	10.2
	II	568.77	1112.27	12.3
	III	608.81	1112.27	13.1
May	I	710.9	1112.27	15.3
	II	800.15	1112.27	17.3
	III	814.92	1112.27	17.6

TABLE-8.6
Number of hours of peaking available in 90% dependable year for Hutong HEP, stage-1

Month		Discharge in 90% Dependable year (cumec)	Rated dischrage (cumec)	Time availabe for peaking power (hrs.)
June	I	1192.87	1423.02	20.1
	II	1233.91	1423.02	20.8
	III	1455.55	1423.02	24.0
July	I	2138.15	1423.02	24.0
	II	1922.42	1423.02	24.0
	III	1645.75	1423.02	24.0
August	I	1160.34	1423.02	19.6
	II	1129.17	1423.02	19.0
	III	1025.83	1423.02	17.3
September	I	752.96	1423.02	12.7
	II	657.18	1423.02	11.1
	III	636.76	1423.02	10.7
October	I	533.39	1423.02	9.0
	II	471.73	1423.02	8.0
	III	376.93	1423.02	6.4
November	I	358.09	1423.02	6.0
	II	307.26	1423.02	5.2
	III	293.12	1423.02	4.9
December	I	423.31	1423.02	7.1
	II	388.49	1423.02	6.6
	III	397.74	1423.02	6.7
January	I	269.5	1423.02	4.5
	II	278.58	1423.02	4.7
	III	227.26	1423.02	3.8
February	I	219.88	1423.02	3.7
	II	226.01	1423.02	3.8
	III	304.24	1423.02	5.1
March	I	170.86	1423.02	2.9
	II	200.78	1423.02	3.4
	III	221.81	1423.02	3.7

Month		Discharge in 90% Dependable year (cumec)	Rated dischrage (cumec)	Time availabe for peaking power (hrs.)
April	I	474.29	1423.02	8.0
	II	572.66	1423.02	9.7
	III	612.98	1423.02	10.3
May	I	715.77	1423.02	12.1
	II	805.53	1423.02	13.6
	III	820.5	1423.02	13.8

TABLE-8.7
Number of hours of peaking available in 90% dependable year for Hutong HEP, stage-2

Month		Discharge in 90% Dependable year (cumec)	Rated dischrage (cumec)	Time availabe for peaking power (hrs.)
June	I	1224.88	1423.02	20.7
	II	1267	1423.02	21.4
	III	1494.59	1423.02	24.0
July	I	2195.51	1423.02	24.0
	II	1973.99	1423.02	24.0
	III	1689.9	1423.02	24.0
August	I	1191.46	1423.02	20.1
	II	1159.45	1423.02	19.6
	III	1053.24	1423.02	17.8
September	I	773.15	1423.02	13.0
	II	674.81	1423.02	11.4
	III	653.84	1423.02	11.0
October	I	547.69	1423.02	9.2
	II	484.38	1423.02	8.2
	III	387.04	1423.02	6.5
November	I	367.7	1423.02	6.2
	II	315.5	1423.02	5.3
	III	300.98	1423.02	5.1
December	I	434.67	1423.02	7.3
	II	398.91	1423.02	6.7
	III	405.33	1423.02	6.8

Month		Discharge in 90% Dependable year (cumec)	Rated dischrage (cumec)	Time availabe for peaking power (hrs.)
January	I	276.73	1423.02	4.7
	II	286.06	1423.02	4.8
	III	233.36	1423.02	3.9
February	I	225.77	1423.02	3.8
	II	232.06	1423.02	3.9
	III	312.4	1423.02	5.3
March	I	175.44	1423.02	3.0
	II	206.16	1423.02	3.5
	III	227.75	1423.02	3.8
April	I	487.01	1423.02	8.2
	II	588.02	1423.02	9.9
	III	629.42	1423.02	10.6
May	I	734.96	1423.02	12.4
	II	837.24	1423.02	14.1
	III	842.51	1423.02	14.2

TABLE-8.8

Number of hours of peaking available in 90% dependable year for Demwe Upper HEP

Month		Discharge in 90% Dependable year (cumec)	Rated dischrage (cumec)	Time availabe for peaking power (hrs.)
June	I	1072	1513	17.0
	II	1578	1513	24.0
	III	1737	1513	24.0
July	I	2142	1513	24.0
	II	1277	1513	20.3
	III	918	1513	14.6
August	I	745	1513	11.8
	II	688	1513	10.9
	III	726	1513	11.5

Month		**Discharge in 90% Dependable year (cumec)**	**Rated dischrage (cumec)**	**Time availabe for peaking power (hrs.)**
September	I	727	1513	11.5
	II	697	1513	11.1
	III	601	1513	9.5
October	I	556	1513	8.8
	II	527	1513	8.4
	III	493	1513	7.8
November	I	439	1513	7.0
	II	418	1513	6.6
	III	398	1513	6.3
December	I	382	1513	6.1
	II	365	1513	5.8
	III	351	1513	5.6
January	I	341	1513	5.4
	II	340	1513	5.4
	III	341	1513	5.4
February	I	315	1513	5.0
	II	310	1513	4.9
	III	320	1513	5.1
March	I	353	1513	5.6
	II	314	1513	5.0
	III	603	1513	9.6
April	I	600	1513	9.5
	II	819	1513	13.0
	III	951	1513	15.1
May	I	780	1513	12.4
	II	740	1513	11.7
	III	852	1513	13.5

TABLE-8.9
Number of hours of peaking available in 90% dependable year for Demwe Lower HEP

.Month		Discharge in 90% Dependable year (cumec)	Dischrage (cumec)	Time availabe for peaking power (hrs.)
June	I	1126	2085	13.0
	II	1657	2085	19.1
	III	1824	2085	21.0
July	I	2249	2085	24.0
	II	1341	2085	15.4
	III	964	2085	11.1
August	I	783	2085	9.0
	II	723	2085	8.3
	III	762	2085	8.8
September	I	764	2085	8.8
	II	732	2085	8.4
	III	631	2085	7.3
October	I	584	1729	8.1
	II	553	1729	7.7
	III	517	1729	7.2
November	I	461	1729	6.4
	II	438	1729	6.1
	III	418	1729	5.8
December	I	401	1729	5.6
	II	383	1729	5.3
	III	368	1729	5.1
January	I	358	1729	5.0
	II	357	1729	5.0
	III	358	1729	5.0
February	I	330	1729	4.6
	II	325	1729	4.5
	III	336	1729	4.7
	I	371	1729	5.2

.Month		Discharge in 90% Dependable year (cumec)	Dischrage (cumec)	Time availabe for peaking power (hrs.)
March	II	330	1729	4.6
	III	634	1729	8.8
April	I	630	1729	8.7
	II	860	1729	11.9
	III	998	1729	13.9
May	I	820	1729	11.4
	II	777	1729	10.8
	III	895	1729	12.4

Note: As directed by CEA, Demwe Lower HEP will operate on MDDL during monsoon season (June to September) and for other season the project will operate at FRL i.e. during monsoon season project will operate at rated discharge of 2085 cumec whereas for other season it will operate at design discharge of 1729 cumec

Kalai hydroelectric Project Stage-1

It can be seen from Table 8.3 that number of hours for which peaking power will be available, in 90% dependable year shall range from 12.2 to 23.8 hours in the monsoon season from May to September. In the months of October and April, peaking will be available for a period of 8.7 to 14.5 hours and 9.8 to 10.4 hours respectively.

In lean season, from November to March peaking will be available for a period of 4.7 to 8.0 hours in 90% dependable year. It can be observed that in lean season, river water will be stored for a period of 16 to 19 hours. As a result, downstream stretch of river from the dam site will be remain dry for a period of 16 to 19 hours, which will be followed by a continuous flow equal to rated discharge of 1033 cumec for a period of 5 to 8 hours.

Kalai hydroelectric Project Stage-2

In Kalai hydroelectric project stage-2, peaking power will be available for a period of 13.6 hours to 24 hours for 90% dependable year in monsoon season. In the months of October and April, peaking power is available for a period of 8.1 to 13.1 hours. In lean season, peaking power is available for a period of 3.7 to 9.1 hours in

90% dependable year. Thus, in lean season river water will be stored for a period of 15 to 20 hours. As a result, downstream stretch of river from the dam site will remain dry for a period of 15 to 20 hours. This will be followed by a continuous flow of 1112.27 cumec (rated discharge) for a period of 4 to 9 hours.

Hutong Hydroelectric Project Stage-1

As per the details given in Table-8.5, peaking power will be available for a period of 10.7 to 24 hours for 90% dependable year in monsoon season. In lean season, peaking power will be available for a period of 2.9 to 7.1 hours. Thus, in lean season, river water will be stored in the reservoir for a period of 17 to 21 hours. As a result, river will remain dry for the corresponding period downstream of dam site. This will be followed by a continuous discharge of 1423 cumec (rated discharge) for a period of 3 to 7 hours.

Hutong Hydroelectric Project Stage-2

The details of number of hours of availability of peaking power available in 90% dependable year in monsoon season for Hutong Hydroelectric Project, stage-2 shall range from 11 to 24 hours. In lean season, the number of hours for which peaking power will be available shall range from 3 to 7.3 hours. Thus, river water will be stored for a period of 17 to 21 hours, resulting in drying of river Lohit downstream of dam site. This will be following by a continuous discharge of 1423 cumec for a period of 3 to7 hours.

Demwe Upper Hydroelectric Project

The number of hours of availability of peaking power for Demwe Upper hydroelectric project in 90% dependable year is expected to be 9.5 to 24 hours in monsoon season. On the other hand, peaking power will be available for 4.9 to 9.6 hours in lean season. Thus, river flow will be used to fill up the reservoir in lean season for 14 to 19 hours. Thus, river will remain dry for this period in lean season. This will be followed by a continuous discharge of 1513 cumec of about 5 to 10 hours.

Demwe Lower Hydroelectric Project

The details of number of hours of availability of peaking power for Demwe Lower hydroelectric project are given in Table-8.8. The number of peaking power availability in monsoon and lean season shall be 7.3 to 24 hours and 4.5 to 13.9 hours respectively. As a result in lean season the river will remain dry for a period of 10 to 19 hours followed by 5 to 14 hours of design discharge (1729 cumec).

8.4 IMPACTS ON AQUATIC ECOLOGY DUE TO MODIFICATION OF FLOW REGIME

As mentioned earlier in section 8.3, the operation of a hydroelectric project, would affect the hydrologic regime. The proposed hydroelectric projects in the basin area too will have similar impacts on hydrologic regime, with a corresponding impact on riverine ecology including fisheries.

The free flowing water regime will be disturbed over a stretch of about 144.2 km. The proposed dams will store water to enable peaking power generation. As a result, barring for a period from November to March, the river Lohit will have relatively less water flow for few hours daily for generation of peaking power. This storage period will result in drying up of the river, downstream of the dam sites. The dry period will be followed by a wet or flow period with uniform flow corresponding to the number of units/turbines generating hydropower. Thus, the riverine ecology will be severely affected on account of modification in hydrologic regime. This change can have significant impact on the riverine fisheries affecting physiological readiness to migrate, mature and spawn. To mitigate this impact, Environmental Flows have been recommended in Chapter-9 of this report. Thus, with the release of Environmental Flows, there will always be adequate flow in the river for sustenance of riverine ecology.

Similarly, drying of the river bed will lead to exposure of spawning substrates resulting in exposure and desiccation of fish eggs as well. A comprehensive fisheries managemnt plan should be formulated to mitigate the adverse impacts on the fish species as well as adequate environmental flow should be released continously downstream for sustenance of aquatic ecology.

The presence of variety of species makes it impossible to consider flow needs individually it is convenient to operate at some level of aggregation, the most convenient of which is a simple behavioral, ecological or functional guild structure. Ecological guilds have been defined differently in various parts of the world. Regier, Welcomme, Steedman & Henderson (1989) proposed an early classification based on the traditional South East Asian usage for tropical systems, and Bain, Finn and Booke (1988) developed a classification of functional groupings for US rivers. Aarts, Van den Brink and Nienhuis (2004) summarize the classification for major European rivers. The combined elements of these together with some of Balon's (1975) reproductive guilds to illustrate the way in which each of the guilds responds to characteristic changes in the river that result from changes in flow is given in Table-8.10. The three main groups of fish and their sub-groups respond to changes to natural hydrographs that result from increased control over water in very different ways, which generally favor eurytopic species at the expense of the limnophilic and rheophilic ones.

TABLE – 8.10
Response of the main behavioural guilds to changes in flow regimes.

Behavioural guild	**Typical behaviour**		**Reaction to changes in hydrograph**
	General	**Specific**	
Black fish – limnophilic species	• Floodplain residents move little between floodplain pools, swamps and inundated floodplain. • Repeat breeders with specialized reproductive behaviour. • Predominantly polyphils, nest builders, parental care takers or live bearers. • Tolerant of low dissolved oxygen or anoxia (auxiliary breathing adaptations)	**A)** • Tolerant of low dissolved oxygen tensions only	• Tend to disappear when floodplain disconnected and desiccated through poldering and levee construction. • May increase in number in shallow, isolated wetlands, rice-fields and drainage ditches.
		A. B) • Tolerant of Complete Anoxia	• Persist in residual floodplain water bodies • Principal component of rice field and ditch faunas
White fish – rheophilic species	• Long distance migrants • One breeding season a year • Intolerant of low oxygen.	**B. A)** • Main channel residents not entering floodplain • Predominantly psammophils, lithophils or pelagophils. • Often have drifting eggs and larvae	• Tend to disappear when river dammed and prevents migration When timing of flood inappropriate to their breeding seasonality and If flow excessive or too slow for the needs of drifting larvae.

Behavioural guild	Typical behaviour		Reaction to changes in hydrograph
	General	Specific	
		C. B) • Use floodplain for breeding, nursery grounds and feeding of juvenile and adult fish • Predominantly phytophils • Usually spawn at floodplain margin or on floodplain; sometimes have drifting eggs and larvae	• Tend to disappear when river dammed and prevents migration, • Damaged when access to floodplain denied to developing fry and juveniles.
Grey fish – eurytopic species	• Tolerant of low dissolved oxygen • Repeat breeders • Predominantly phytophils but some nesters or parental carers • Short distance migrants often with local populations.	**D. A)** • Occupy main channel generally benthic	• Able to adapt behaviourally to altered hydrograph • Generally increase in number as other species decline • Impacted negatively to flows that change depositional siltation processes and alter the nature of the bottom
		E. B) • Occupy riparian vegetation	• Able to adapt behaviourally to altered hydrograph • Generally increase in number as other species decline • Impacted negatively by flows and management that changes riparian structure

Behavioural guild	**Typical behaviour**		**Reaction to changes in hydrograph**
	General	**Specific**	
		F. C • Occupy larger and better oxygenated floodplain water bodies	• Sensitive to isolation of floodplain water body but can colonise river if flow slowed sufficiently • Often form basic colonizers of reservoirs and dams

As rivers change in response to human efforts to control flow they pass through a series of stages that can be characterized according to the degree of modification. The degree of modification is summarized in Table-8.11.

TABLE - 8.11
Characteristics of various developmental stages of a river, impacts on flood regimes and form of lowland rivers

Development stage	Flood regime	State of river channel	State of floodplain	Human habitation
Unmodified	Natural hydrograph with seasonal alternation of flood and dry seasons. Water quality is good	Freely meandering or anastomosing often with islands.	Usually forested interspersed with floodplain water bodies.	Migratory human settlement in temporary camps, on high ground only or in stilt houses
Slightly modified	Natural hydrograph with seasonal alternation of flood and dry seasons. Water quality is good	Freely meandering or anastomosing often with islands. Obstructions removed from channel. Some simplification of channels. Diverse	Some forests usually savannah with floodplain grasses	Human settlement in temporary camps on floodplain, villages on levees or stilt houses.
Modified	Natural hydrograph persists in many reaches of river but can be locally modified below dams with reduced amplitude and duration of seasonal floods. Can also be	Locally regulated with some damming and leveeing but with some reaches still relatively unregulated. Tendency to suppress branches in favour of a single main channel.	Floodplain partially modified, deforested: floodplain water bodies sometimes isolated. Local poldering and flood control structures	Human settlement beginning to intensify on artificially constructed mounds or areas protected by flood defences.

Development stage	Flood regime	State of river channel	State of floodplain	Human habitation
	modified around poldered areas. Water quality affected around settlements.	Some backwaters persist.		
Highly modified	Hydrograph completely modified suppressing and altering timing of flood peaks and quantity of water in system. Water quality often severely reduced in whole river	Often heavily dammed sometimes in cascades: Fully regulated and channelised often with reverted banks and dredged navigation channels, Backwaters eliminated. Habitat diversity low.	Floodplain dry or completely controlled with extensive drainage and irrigation canals. Off channel water bodies largely eliminated or isolated Maybe heavily poldered	Heavy human settlement of whole former floodplain area.

On completion of the proposed hydroelectric projects in the basin, would render river Lohit as modified, on account of:

- Hydrographs getting modified
- Modification of floods below dams.
- Conversion of free flowing stretch of river into reservoir.

Natural hydrograph persists in many reaches of river but can be locally modified below dams with reduced amplitude and duration of seasonal floods. However, no major impact on water quality is anticipated on account of modification in hydrologic regime, as there are no major sources of water pollution in the study area.

The modification of downstream river flow characteristics (regime) by an impoundment can have adverse effects upon fish species. These include impact on migration, spwaning grounds, survival of eggs & juveniles, food production etc.

Regulation of stream flow during the migratory period can alter the seasonal and daily dynamics of migration. Regulation of a river can lead to decrease in a migratory population.

8.5 IMPACTS ON FISHERIES DUE TO FLUCTUATIONS IN WATER LEVEL

Walker et al. (1979) related the disappearance of Tandanus tandanus in the Murray river, Australia to short-term fluctuations in water level caused by reservoir releases in response to downstream water user requirements. In the proposed hydroelectric projects, releases on account of peaking power requirement shall result in fluctuations in water level. This could result in reduction of native species.

The fluctuations of water-level and velocities due to power demand could have adverse effects on fish: spawning behaviour could be suppressed, juveniles could be swept downstream by high flows, sudden reductions in flow could leave eggs or juveniles stranded (Petts, 1988). Although, experimental data on the impacts on fish species present in river Lohit is not available but it can be predicted that daily fluctuation in water level will have adverse impacts on fisheries to some extent. Hence, a continous environment flow downstream should be maintained for minimizing the impacts and for the sustence of aquatic fauna.

8.6 IMPACTS ON FISH MIGRATION

Fish populations are highly dependent upon the characteristics of the aquatic habitat which supports all their biological functions. This dependence is most marked in migratory fish which require discrete environment for the main phases of their life cycle which are reproduction, production of juveniles, growth and sexual maturation. The fish composition in the project areas are represented by potadromous species i.e. the species which occur only in freshwater system and their reproduction and feeding zones are separated by distances that could vary from few meters to hundreds of kilometers. The building of a dam generally has an adverse impact on fish population, their migration, which can be stopped or delayed. Therefore a Comprehensive fisheries management plan along with mitigative measures like fish ladders, trapping and transportation, hatcheries etc., should be addressed as a part of EIA/EMP of individual projects.

The impact of river valley projects has been extensively studied for river Beas as a result of damming at Pong and Pandoh under the Beas-Sutlej Link Project. Sehgal and Sar (1989) and Sehgal (1990) have found subtle and irreversible changes in abiotic and biotic parameters. The migratory routes of *Tor putitora* and *Schizothorax richardsonii* have been obstructed due to construction of various dams. These species which were migrating to higher elevation were obstructed. *Schizothorax richardsonii* which used to migrate from higher reaches to lower reaches was unable to do so on account of construction of dam at Pandoh. The contribution of *Schizothorax richardsonii* in the river Beas reduced from 10.2 – 13.5% prior to construction of project between Mandi and Nodomn towns to 0.5 – 1% after the project was constructed. The commissioning of the proposed hydroelectric projects would adversly affect the migratory route of fisheries. The migration characteristics of various fish species observed in the study area is given in Table-8.12.

TABLE-8.12
Migration distance, spawning season and spawning substrate of some of the fish species

Family	Species	Migration distance	Spawning season	Spawning substrate
Cyprinidae	*Schizothorax richardsonii*	Short to Mid	Aug-Sep	Gravelly substrate
Cyprinidae	*Acrossocheilus hexagonolepis*	Short to Mid	May-July	Gravelly substrate
Cyprinidae	*Labeo pangusia*	Short to Mid	May -July	Gravelly substrate
Cyprinidae	*Chagunius chagunio*	Short to Mid	May-June	Gravelly substrate
Cyprinidae	*Tor putitora*	Long	Sep -Oct	Gravelly substrate
Cyprinidae	*Tor tor*	Long	Sep -Oct	Gravelly substrate
Cyprinidae	*Garra gotyla*	Short to Mid	May - Jul	Gravelly substrate

The species *Schizothorax richardsonii* and *Acrossocheilus hexagonolepis* migrate from lower elevation to higher elevation in summer months and return to lower elevation in winter months. These species were observed at various sampling locations of all proposed hydroelectric projects.

Construction of proposed dams would hamper the upward and downward migratory movement of various fish species in summer and winter seasons. It is likely that the migration of fish species namely, *Schizothorax richardsonii* and *Acrossocheilus hexagonolepis* in the stretch of 144.2 km would be affected on account of construction of the proposed hydroelectric projects. Likewise, migration of fish species from tributaries to river Lohit, would be affected on account of creation of reservoirs due to construction of proposed hydroelectric projects. Thus, the projects will lead to adverse impact on migratory fish species. The fish migration would be restricted only in the following stretches:

- Upstream of dam site of Kalai hydroelectric project, stage-1
- Downstream of dam site of Demwe Lower hydroelectric project
- Tributaries confluencing in the out falling with river Lohit between dam site of Kalai hydroelectric project, stage-1 and dam site of Demwe Lower hydroelectric project.

The fish species such as *Tor putitora*, *Tor tor* and *Labeo pangusia* migrate to lower elevation in summer months and undertake the reverse journey in winter months. These species were observed in the vicinity of the following projects:

- Hutong hydroelectric project, stage-1
- Hutong hydroelectric project, stage-2
- Demwe Upper hydroelectric project
- Demwe Lower hydroelectric project

These species are not reported in Kalai hydroelectric projects, which could be attributed to lower water temperature at higher elevations. The construction of the above referred four projects would impede the migratory movement of *Tor tor*, *Tor putitora* and *Labeo pangusia* and there may be possibility that their number would decrease. To mitigate the adverse impact on the migratory fishies appropritae & comprehensive fisheries mangement plan with measures like fish ladders, trapping and transportation, hatcheries etc., should be proposed as a part of EIA/EMP studies of respective projects.

8.7 IMPACTS ON FISHERIES DUE TO HYDRAULIC TURBINES

Fish can suffer major damage during their transit through hydraulic turbines or over spillways. Fish passing through hydraulic turbines are subject to various forms of stress likely to cause high mortality i.e., probability of shocks from moving or stationary parts of the turbine (guide vanes, vanes or blades on the wheel), sudden acceleration or deceleration, very sudden variations in pressure and cavitation.

The impacts of hydraulic turbines on snow trout, Mahaseer etc. have not been studied. However, numerous experiments have been conducted in various countries (USA, Canada, Sweden, Netherlands, Germany and France), mainly on juvenile salmonids and less frequently on clupeids and eels, to determine the mortality rate due to their passage through the main types of turbine (Bell, 1981; Monten, 1985; Eicher, 1987; Larinier and Dartiguelongue, 1989; EPRI, 1992).

The mortality rate for juvenile salmonids in Francis and Kaplan turbines varies greatly, depending on the properties of the wheel (diameter, speed of rotation, etc), their conditions of operation, the head, and the species and size of the fish concerned. The mortality rate varies from under 5% to over 90% in Francis turbines. On an average, it is lower in Kaplan turbines, from under 5% to approximately 20%. The difference between the two types of turbines is due to the fact that Francis turbines are generally installed under higher heads.

Impacts such as fish mortality are anticipated in the proposed hydroelectric projects as well. However, in absence of experimental data, quantification of impacts on this account cannot be made.

8.8 IMPACTS ON FISHERIES DUE TO SPILLWAYS

Passage through spillways may be a direct cause of injury or mortality, or an indirect cause (increased susceptibility of disorientated or shocked fish to predation). The mortality rate varies greatly from one location to another: between 0% and 4% for the Bonneville, McNary and John Day dams (about 30 m high spillways) on the Columbia River, 8% at the Glines dam (60 m high spillway) and 37% at the Lower Elwha dam (30 m high spillway) on the Elwha river for juvenile salmonids (Bell and Delacy, 1972; Ruggles and Murray, 1983).

Mortalities have several causes: shearing effects, abrasion against spillway surfaces, turbulence in the stilling basin at the base of the dam, sudden variations in velocity and pressure as the fish hits the water, physical impact against energy dissipators. The manner in which energy is dissipated in the spillway can have a determinant effect on fish mortality rates.

Experiments have shown that damage occurs (with injuries to gills, eyes and internal organs) when the impact velocity of the fish on the water surface in the downstream pool exceeds 16 m/s, whatever its size (Bell & Delacy, 1972). A column of water reaches the critical velocity for fish after a drop of 13 m. Beyond this limit injuries may become significant and mortality will increase rapidly in proportion to the drop (100% mortality for a drop of 50-60 m). In the proposed hydroelectric projects, except for Hutong hydroelectric project, stage 1,and Anjaw HEP the fall in water is more than 50-60 m in the other projects. Passage through a spillway under free-fall conditions (i.e. free from the column of water) is always less hazardous for small fish, insofar as their terminal velocity is less than the critical velocity. For larger fish, the hazards are identical whether they pass under free-fall conditions or are contained in the column of water.

8.9 IMPACTS ON FEEDING BIOLOGY AND GROWTH RATES OF FISH SPECIES

Studies on Golden Mahaseers in rivers Alaknanda, Nayar and Saung in Uttarakhand have seen that in extensively regulated river stretches of river Ganga, Mahaseer was found to consume relatively lesser animal matter (40-100%) as compared to fish species in free flowing rivers, e.g. Nayar (72.1 – 89.8%) or Saung (74.3 – 90%). Insects generally occur as macro zoobenthic community, the density of which was found to be lower in rivers with regulated flows. However, the food habits did not get altered to the extent of showing a shift from carnivorous to omnivorous diet. Similar impacts may also envisage in the study area as well as there are possibility of decrease in macro-zoobenthic community in the area studied due to the construction of proposed projects.

8.10 IMPACTS ON TERRESTRIAL FLORA

The direct impact of construction activity of a water resources project in a hilly terrain is generally limited to the vicinity of the construction sites. The project construction would also involve clearing of forest land etc. If the clearing activities are carried out in an unplanned manner, the portion of land may become devoid of vegetation resulting in the increased incidences of soil erosion, landslides etc.

8.10.1 Impacts due to loss of forests

The impacts due to loss of forests are listed as below**:**

- Acquisition of forest land
- Anthropogenic pressure
- Impacts due to increased accessibility

Acquisition of forest land

At the present level of investigation, the total land to be acquired for the project is not available. However, the land to be acquired for reservoir submergence is available. The density of trees in the submergence area of various hydroelectric projects is given in Table-8.13.

TABLE-8.13
Density of trees in submergence area of various Hydroelectric projects in the study area

S. No.	Project Name	Tree Density (ind./ha)	
		Dam site	Submergence area
1.	Kalai Hydroelectric Project, Stage-1	570	550
2.	Kalai Hydroelectric Project, Stage-2	515	610
3.	Hutong Hydroelectric Project, Stage-1	500	610
4.	Hutong Hydroelectric Project, Stage-2	645	615
5.	Demwe Upper Hydroelectric Project	420	695
6.	Demwe Lower hydroelectric Project	450	300

The tree density in Dam area & Submergence area of the Projects varies between 420-645 trees/ha and 300-695 trees/ha respectively.

Anthropogenic Pressure

The increase in population due to immigration of labour population during construction phase of the proposed hydroelectric projects will exert pressure on the natural ecosystem around the project area in terms of

- Increase in fuel-wood collection.
- Grazing pressure on the surrounding natural forest
- Pressure on economical plant species
- Degradation of natural habitat due to cutting of trees
- Overcrowding

About 2000-2500 technical staff, workers and other group of people are likely to congregate in the area during the peak phase of construction of each project. Thus, it can be assumed that about 12000-15000 persons are likely to congregate in the area during construction phase. Though, it is possible that all the projects may not get constructed at the same time. Workers and other population groups residing in the area may use fuel wood, if no alternate fuel is provided for whom alternate fuel could be provided.

Hence to minimize impacts, community kitchens be commissioned during construction phase by project proponents or contractors. These community kitchens shall use LPG or diesel as fuel. The other major impact on the flora in and around the project area would be due to increased level of human interferences. The workers may also cut trees to meet their requirements for construction of houses and other needs. Thus, if proper measures are not undertaken, adverse impacts on terrestrial flora is anticipated. Hence, as a mitigation measure, labour camps are proposed to be constructed by the contractor along with necessary facilities in each projects.

Impacts due to increased accessibility

During the project operation phase, accessibility to the area will improve due to construction of roads, which in turn may increase human interferences leading to marginal adverse impacts on the terrestrial ecosystem. The increased accessibility to the area can lead to increased human interferences. For mitigation of adverse effects, Forest and Wildlife Management plan need to be implemented in consultation with the forest department for each of the proposed hydroelectric projects.

8.11 IMPACTS ON ECONOMICALLY IMPORTANT PLANTS

The forests in Arunachal Pradesh are endowed with many useful plant species viz., timber yielding species, medicinal plants, bamboos, rattans, wild ornamental plants, etc. The state can be termed as a repository of medicinal plants (Haridasan *et al*. 1996). The indigenous people in the state live in close association with the forests and have accumulated a vast treasure of knowledge related to utilization of plants. This knowledge of medicinal plants is becoming a potential source of information for the pharmaceutical industries. The density of various economically important plant species in the submergence area of various hydroelectric projects is given in Table-8.14.

TABLE-8.14
Density of Economically important plant species observed at various sampling sites

S. No.	Species	Type of flora	Density in submergence area (no./ha)
A.	**Kalai Hydroelectric Project, Stage-1**		
1	*Ficus cunia*	Tree	170
2	*Macaranga denticulata*	Tree	20
3	*Nephrolepis cordifolia*	Herb	6000
4	*Alnus nepalensis*	Tree	30
5	*Rubus* spp.	Shrub	20
6	*Thysanolaena maxima*	Herb	12000
7	*Saurauria nepalensis*	Tree	30
B.	**Kalai Hydroelectric Project, Stage-2**		
1	*Ficus cunia*	Tree	80
2	*Macaranga denticulata*	Tree	-
3	*Nephrolepis cordifolia*	Herb	25000
4	*Pandanus odoratissima*	Tree	30
5	*Rubus* spp.	Shrub	20
6	*Thysanolaena maxima*	Herb	2500
7	*Saurauria nepalensis*	Tree	135
C.	**Hutong Hydroelectric Project, Stage-1**		
1	*Ficus cunia*	Tree	65
2	*Macaranga denticulata*	Tree	60
3	*Nephrolepis cordifolia*	Herb	37000
4	*Rubus* spp.	Shrub	80
5	*Thysanolaena maxima*	Herb	9000
D.	**Hutong Hydroelectric Project Stage-2**		
1	*Clerodendron colebrookianum*	Shrub	40
2	*Ficus cunia*	Tree	60
3	*Macaranga denticulata*	Tree	25
4	*Nephrolepis cordifolia*	Herb	8500
5	*Rubus* spp.	Shrub	35
6	*Terminalia myriocarpa*	Tree	-
7	*Thysanolaena maxima*	Herb	8500
8	*Saurauria nepalensis*	Tree	10
9	*Spondias axillaries*	Tree	5
E.	**Demwe Upper Hydroelectric Project**		
1	*Clerodendron colebrookianum*	Shrub	40
2	*Ficus cunia*	Tree	30
3	*Ficus roxburghii*	Tree	15

S. No.	Species	Type of flora	Density in submergence area (no./ha)
4	*Macaranga sp.*	Tree	35
5	*Nephrolepis cordifolia*	Herb	2500
6	*Pandanus odoratissima*		-
7	*Rubus* spp.	Shrub	20
8	*Terminalia myriocarpa*	Tree	20
9	*Thysanolaena maxima*	Herb	9000
10	*Saurauria nepalensis*	Tree	25
11	*Sapium baccatum*	Tree	-
12	*Spondias axillaries*	Tree	-
F.	**Demwe Lower Hydroelectric Project**		
1	*Syzygium cumini*	Shrub	-
2	*Ficus roxburghii*	Tree	-
3	*Macaranga* spp.	Tree	90
4	*Nephrolepis cordifolia*	Herb	
5	*Kydia calycina*	Tree	10
6	*Rubus* sp.	Shrub	40
7	*Terminalia myriocarpa*	Tree	20
8	*Dalbergia sissoo*	Tree	-
9	*Spondias pinnata*	Tree	-
10	*Emblica officinalis*	Tree	-

In Kalai Hydroelectric Project, Stage-1, seven economically important plant species were recorded. They were namely, *Ficus cunia*, *Macaranga denticuiata*, *Nephrolepis cordifolia*, *Alnus nepalensis*, *Rubus* spp., *Thysanolaena maxima* and *Saurauria nepalensis*.

At various sampling sites, Kalai Hydroelectric Project, Stage-2, various plants of economic importance such as timber, medicinal, edible fruits were commonly observed. *Canarium strictum* is a very good incense yielding tree and *Pandanus odoratissima* is a fiber yielding tree species. These are seen commonly here and there at the project sites.

Five economically important plants were recorded from Hutong Hydroelectric Project, Stage-1 viz., *Ficus cunia*, *Macaranga denticulata*, *Nephrolepis cordifolia*, *Rubus* spp. and *Thysanolaena maxima.*

About 9 economically important plant species were recorded from the study area in Hutong Hydroelectric Project, Stage-2. These include *Clerodendron colebrookianum*, *Ficus cunia*, *Macaranga denticulata*, *Nephrolepis cordifolia*, *Rubus* spp., *Terminalia* *myriocarpa*, *Thysanolaena maxima*, *Saurauria nepalensis* and *Spondias pinnata*.

About 12 economically important plant species were recorded from the study area in Demwe Upper Hydroelectric Project. These species include *Clerodendron colebrookianum, Ficus cunia, Ficus roxburghii, Macaranga sp., Nephrolepis cordifolia, Pandanus odoratissima, Rubus spp., Terminalia myriocarpa, Thysanolaena maxima, Saurauria nepalensis, Sapium baccatum and Spondias axillaries.*

Ten economically important plant species were recorded from the study area in Demwe Lower Hydroelectric Project. Plant of economical importance such as timber (*Terminalia myriocarpa*, *Dalbergia sissoo,),* medicinal *(Nephrolepis cordifolia, Spondias pinnata*), edible fruits (*Ficus roxburhghii, Rubus* sp.*)* and *Macaranga spp*. known for fuel wood value were commonly seen here and there at the project site.

8.12 FLORA UNDER THREATENED CATEGORY

During the course of survey, only one species i.e., *Lagerstroemia minuticarpa* classified as endangered plant species as per IUCN Red list was found in the submergence area of Hutong hydroelectric project, stage-2 and Demwe Upper hydroelectric project. The density of *Lagerstroemia minuticarpa* in Hutong hydroelectric project, stage-2 and Demwe Upper hydroelectric project is about 5 to 10 trees/ha respectively.

It can be concluded that the density of *Lagerstroemia minuticarpa* found in the submergene of in Hutong hydroelectric project, stage-2 and Demwe Upper hydroelectric project is quite low, i.e. 5 to 10 trees/ha. However, it is recommended that detailed studies be conducted as a part of EIA for Hutong Stage-2 and Demwe Upper hydroelectric project. As a part of the study, a detailed conservation plan to be prepared for conservation of *Lagerstroemia minuticarpa*.

The lower elevations of the study area are presently degraded due to high human pressure, large scale lopping and removal of fodder and timber species, grazing, construction of road, etc. Nayar and Sastry (1987-1990) have reported 35 species of rare and endangered plant species from Arunachal Pradesh. Of these threatened species *Acer oblongum* var. *microcarpum, Begonia burkillii, Calanthe manii, Dioscorea deltoidea, Paphiopedilum wardii* and *Phoenix rupicola* have been reported from low hills in the altitudinal range of 300-1200 m. The details are given in Table-

7.14 of Chapter-7 of this Report. The same is reported in Table-8.15. There is a possibility that some of these species would be present in the study area of basin though the present surveys were not able to record these in the field. Thus, it is recommended that a detailed study be conducted as a part of the CEIA study of proposed projects. If these species are available then a suitable conservation plan be prepared as a part of EMP of individual projects.

TABLE-8.15
Rare, vulnerable and endangered plants reported in the Study Area

S. No.	Species	Family	Altitude (m)	Habit	Status
1.	*Acer oblongum* var. *microcarpum*	Acerceae	500-1200	Tree	Endangered
2.	*Begonia burkillii*	Begoniaceae	300-1000	Herb	Rare
3.	*Calanthe manii*	Orchidaceae	Up to 1000	Herb	Rare
4.	*Dioscorea deltoidea*	Dioscoreaceae	300-3000	Climber	Endangered
5.	*Paphiopedilum wardii*	Orchidaceae	Up to 1000	Herb	Rare
6.	*Phoenix rupicola*	Arecaceae	Up to 450	Tree	Rare

Source: CEIA Report for Demwe Lower hydroelectric project

8.13 IMPACTS ON WILDLIFE

The land acquisition for various project appurtenances could lead to adverse impacts on wildlife. The sites selected for various project appurtenances, e.g. project colony, labour camps, muck disposal sites, roads, waste disposal sites, etc. should be:

- Free from dense vegetation
- Away from wildlife habitats including breeding sites
- Water holes for wildlife
- Away from river banks

The various hydroelectric projects are not expected to adversely affect the migratory routes of wildlife, because due to high flow , River Lohit itself acts barrier to wildlife movement in pre-project plans. Thus, there is no wildlife movement across river Lohit, even in the pre-project phase itself. The impacts due to blasting are another source of adverse impacts on wildlife during construction phase of any hydroelectric project. Similar adverse impacts are anticipated in the proposed projects as well. Thus, appropriate measures need to be implemented as a part of Environmental Management Plan of the EIA study for various projects.

8.14 IMPACTS ON PROTECTED AREAS

The Kamlang Wildlife Sanctuary (KWLS) is one of the 12 protected areas in Arunachal Pradesh raised for the protection and conservation of the biodiversity of the State. In the eastern, western and northern boundaries of KWLS is surrounded by natural barriers mostly in the form the of rivers/deep gorges of width varying 30-100 m and high ridges and in southern side the boundary of Kamlang Wildlife Sanctuary coincides with Namdapha National Park. The boundary of KWLS falls within the 10 km radius from the Dam site of the Demwe Lower H.E. Project. The location details vis-à-vis Demwe Lower Hydroelectric project are shown in Figure-7.2.

To avoid the submergence of KWLS Project has already been scaled down from 3000 MW with FRL at EL 490.0 m to 1750 MW with FRL at EL 424.8 m in consultation with the State Government and MoEF. All the projects components including submergence area are located outside of KWLS. The nearest boundary of KWLS with respect to the Dam site is located about 11.8 km away (along the river) at the confluence of Lang and Tawai river at EL 425 m (tributaries of River Lohit) on the left bank of the Lohit river. There is no existing direct road approach & footpath on Left Bank of Lohit River from the project area to the nearest boundary of KWLS, and further no roads have been proposed on Left bank of River Lohit by the project developer. Also, due to steep mountain range of more than 1800 m (6000 feet) separates the project area from KWLS making the Sanctuary inaccessible from the project site. Further, most of the construction activities are proposed in the vicinity of the Dam site which is located around 11.8 km along the river from the nearest boundary of the Kamlang Wildlife Sanctuary on Lang River. Project reservoir would be the nearest project component to the KWLS only during Operation Phase, which has to be maintained as Protected Area. Considering the location of the KWLS no adverse impacts are foreseen on the KWLS due the Demwe Lower HE Project during construction as well as in operation phase.

However, it is recommended that a detailed surveillance plan be implemented as a part of the Environmental Management Plan of Demwe Lower hydroelectric project that there are no adverse impacts due to increased human interferences during project construction phase.

8.15 IMPACTS DUE TO INCREASED VEHICULAR MOVEMENT

During construction phase, there will be significant increase in vehicular movement for transportation of construction material. At present, there is no vehicular movement near the project areas. During construction phase, increase in vehicular movement is expected.

As a part of study, impact on noise level due to increased vehicular movement was studied using Federal Highway Administration model for the projects. The results of modeling are outlined in Table-8.16.

TABLE-8.16
Increase in noise levels due to increased vehicular movement

Distance (m)	Ambient noise level dB (A)	Noise levels due to increased vehicular movement dB (A)	Increase in ambient noise level due to increased vehicular movement dB (A)
10	36	72	60
20	36	67	55
50	36	61	49
100	36	57	45
200	36	52	40
500	36	47	35
1000	36	44	31

Also, it is a known fact that there is a reduction in noise level as the sound wave passes through a barrier. The transmission loss values for common construction materials are given in Table-8.17.

TABLE-8.17
Transmission loss for common construction materials

Material	Thickness of construction material (inches)	Decrease in noise level dB(A)
Light concrete	4	38
	6	39
Dense concrete	4	40
Concrete block	4	32
	6	36
Brick	4	33
Granite	4	40

Thus, the walls of various houses will attenuate at least 30 dB (A) of noise. In addition there are attenuation due to the following factors.

- Air absorption
- Rain
- Atmospheric inhomogeneties.
- Vegetal cover

Thus, no increase in noise levels is anticipated as a result of various activities, during the projects construction phase. The noise generated due to blasting is not likely to have any effect on habitations. However, blasting can have adverse impact on wildlife, especially along the tunnel alignment. Adequate measures need to be undertaken to mitigate the adverse impacts on this account.

CHAPTER-9

ASSESSMENT OF ENVIRONMENTAL FLOWS

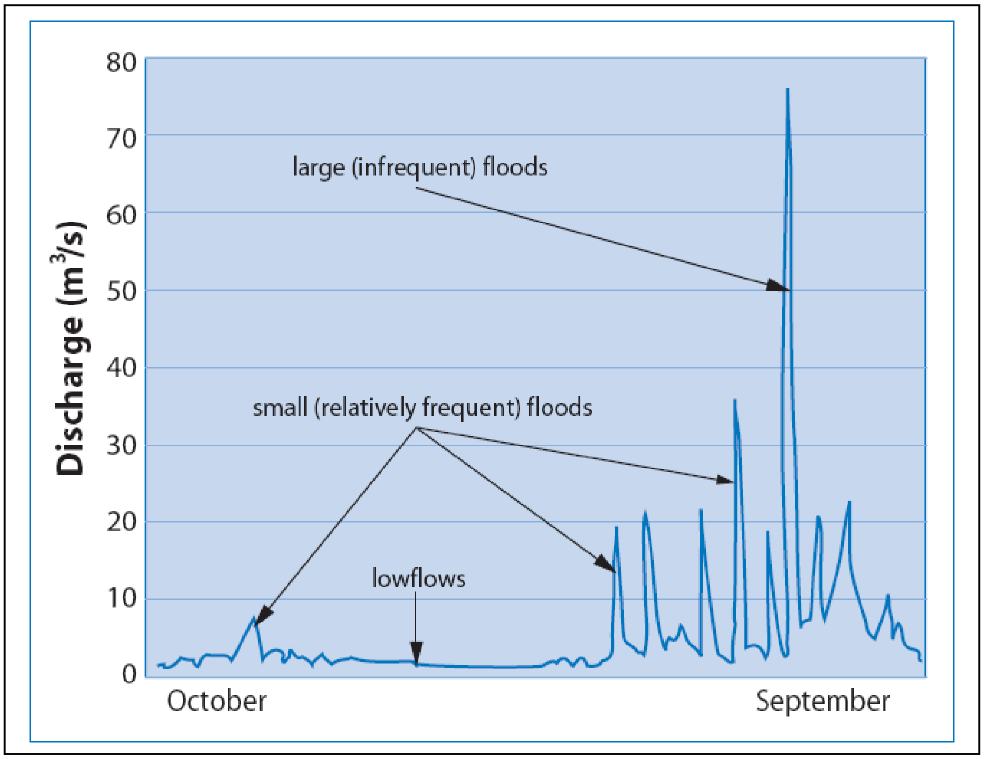
9.1 INTRODUCTION

Environmental Flows (EF) are the flows of water in rivers that are necessary to maintain aquatic ecosystems. In other words, a flow regime in the river, capable of sustaining a complex set of aquatic habitats and ecosystem processes are referred to as environmental flow. The EF is designed to maintain or upgrade a river in desired, agreed or pre-determined status referred to as an "environmental management class" ranging from A (Negligible modification from natural condition) to F (Critically modified ecosystem).

The process for determining or estimating EF is termed as Environmental Flow Assessment (EFA) and there are more than 200 techniques suggested in literature for the same. EFA techniques determine the volume and temporal distribution of EF. The difficulty of estimation EF values lies in the lack of understanding the relationship between river flow and the multiple components of river ecology and the scarcity of data concerned to these relationships. For example, required river flow conditions are available only for a target fish species in a given river basin and this information is very specific and not applicable under different circumstances. Different types of flows with different amount of discharge are spread through dry and wet seasons. This fact plays a very important issue in the interaction of river flow with the surrounded ecosystem. According, to flow, regime of a river can be divided into:

- ***Low flows*** (Base flow): this occurs through out the year and is more in the wet season than in the dry season and defines if river flow through out the year. The delayed flow that reaches a stream essentially as groundwater flow is also called base flow. In the annual hydrograph of a perennial stream the base flow is easily recognized as the slowly decreasing flow of the stream in rainless periods.
- ***Small floods***: they are small in size, (as compared with high floods) a few number per year and they have a small period of time (days or weeks) (Refer Figure-9.1).
- ***Large floods***: they are infrequently and the timing is very short (hours or days) (Refer Figure-9.1).

Figure-9.1: Typical Annual Hydrograph of daily flows in a river



Identification of these flow components and the understanding the ecosystem consequences of their loss or modification are one of the main objectives of Environmental Flow Assessment (EFA).

Further, flows in most of the river are being modified through impoundments such as dams and weirs, abstractions for agriculture, industrial and domestic supply, hydropower, drainage return flows and through structures for flood control. These interventions have had significant impacts, reducing the total flow of many rivers and affecting both; the seasonality of flows and the size and frequency of floods. In many cases, these modifications have adversely affected the river ecosystem, including the people living near the river banks. The river ecosystem includes both the channel and the floodplain. Regulations of river flows reduce or eliminate the linkage between the river and its floodplain margins.

With this background, it is important to recognize the importance of different flows in the river ecosystem. According to Brown (2003), flow in rivers is generally needed for various purposes such as to:

- maintain river flow conditions like flow velocity, water depth and acceptable turbidity levels, making it possible for the river purify itself (dilution of effluents and waste water).
- maintain low flow which support livelihood of the people (people who use the river for drinking, washing, bathing, fishing, recreation and tourism, etc).
- sustain both terrestrial and aquatic ecosystem. For example, low flow provides water to wild animals, maintain soil-moisture in the banks, etc. Small floods stimulate spawning in fish and allow passage for migratory fish and germination of seeds on river banks. Large floods deposits nutrients on the banks and distribute seeds.
- recharge groundwater and aquifers by large floods, which maintain the perennial nature of rivers acting as source of water during dry season. Further, large floods flush sediments and natural obstructions in the river course and maintain a sufficient deep channel for navigation.
- preserve estuarine conditions: low flows maintain the required salt-freshwater balance and prevented the incursion of salinity. Large floods maintain links with the by scouring estuaries.

In general, flows enabling the river to play its role in the cultural and spiritual live of the people. This is very important in Indian context as some religious festivals reduce the quality and quantity of flow.

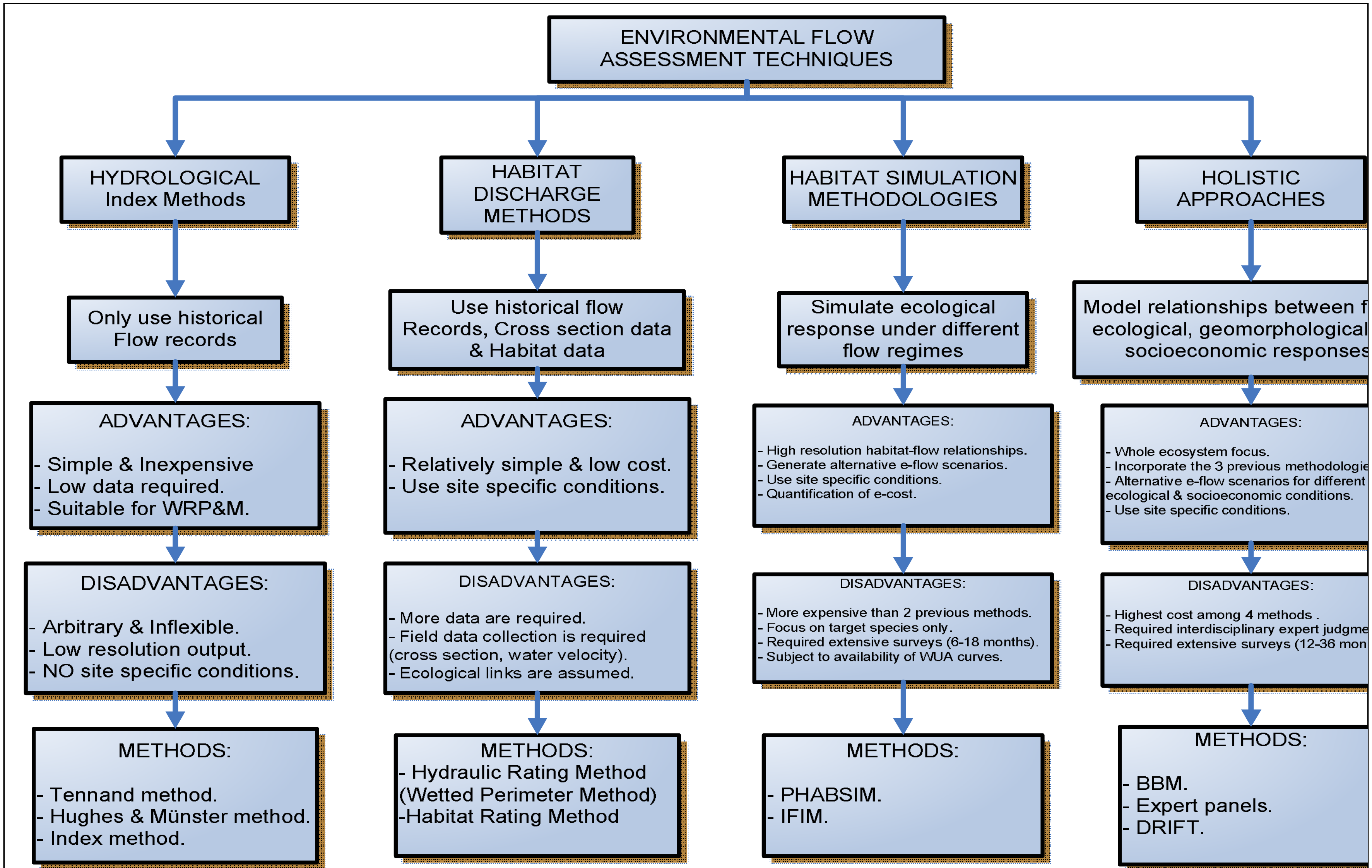
9.2 ENVIRONMENTAL FLOW ASSESSMENT TECHNIQUES.

In a recent review of international environmental flows assessment, Tharme (2003) recorded 207 different methods within 44 countries. Broadly, these can be divided into four categories:

- **Hydrological Index Methods** (or rule of thumb, threshold, or standard setting, desktop methods, or flow duration curve methods)
- **Habitat Discharge Methods** (hydraulic rating or habitant rating methods)
- **Habitat Simulation Methods**
- **Holistic Approaches**

Figure 9.2 summarizes these methodologies with respective advantages and disadvantages.

Figure-9.2 Environmental Flow Assessment (EFA) Techniques



9.3 SELECTION OF APPROPIATE TECHNIQUE

The appropriate technique for a particular project will depend on specific conditions, listed as below:

- availability and quality of data.
- location and extend of the study area.
- prevailing time and financial constraints.
- level of confidence required in the final output.

In general, a project-specific flow assessment for large or controversial projects, which are likely to call for considerable negotiation and tradeoffs between environment and development issues, require a more comprehensive approach as compared to flow assessment for coarse-scale planning, where a single number might suffice (Brown, 2006). Most of the data and understanding required for interactive approaches (Habitat simulation and Holistic methodologies) have to be acquired on site by site basis, considerably adding to the time, funding and expertise required for a flow assessment. Probably because of this, most applications have used prescriptive approaches (Hydrological and Hydraulic methodologies). This study is based on hydrologic and hydraulic based methodologies. The above referred methods are briefly described in the following paragraphs.

1. Hydrological Index Methods

These are the simplest and most widespread EFA methods. They are often referred to as desk-top or look-up table methods and they rely primarily on historical flow records; usually long-term virgin or naturalized, historical monthly or daily flow records, to derive EF recommendations (IWMI, 2007). Hydrological Index Methods provide a relatively rapid, non-resource intensive, but low resolution estimate of environmental flows. The methods are most appropriate at the planning level of water resources development, or in low controversy situations where they may be used as preliminary estimates. Hydrological Index methods may be used as tools within habitat simulation, holistic or combination environmental flow methodologies. They have been applied in developed and developing countries (IWMI, 2007).

Environmental flow is usually given as a percentage of average annual flow or as a percentile from the flow duration curve, on an annual, seasonal or monthly basis. The most frequently used methods under this category are:

(i) Tennant Method

This method was developed by Donald Tennant in Montana region in USA through several field observations and measurements. The Tennant study used 58 cross sections from 11 streams in Montana, Nebraska and Wyoming (Mann, 2006). The technique utilizes only the Average Annual Flow (AAF) for the stream. It then states that certain flows relate to the qualitative fish habitat rating, which is used to define the flow needed to protect fish habitat, expressed in tabular form. Tennant concluded that 10% of AAF is the minimum for short term fish survival, 30% of AAF is considered to be able to sustain fair survival conditions and 60% of AAF is excellent to outstanding habitat (Tennant, 1975). The details are given in Table-9.1.

TABLE-9.1
Instream flow for fish, wildlife & recreation. Source: Tennant 1975

Description of Survival conditions	**Recommended base flow regimes**	
	October- March	**April –September**
Flushing or Maximum	200% of AAF	
Optimum range	60% - 100% of AAF	
Outstanding	40%	60%
Excellent	30%	50%
Good	20%	40%
Fair or Degrading	10%	30%
Poor or Minimum	10%	10%
Severe degradation	10% of AAF to zero flow	

(ii) Hughes & Münster Method

Under this method, the Environmental Water Requirement (EWR) values are based on the time series of monthly river flows. So, computation of the long-term mean annual runoff (MAR) is required. This methodology is based in the concept of aquatic ecology that the conservation of aquatic ecosystem should be considered in the context of the natural variability of flow regime (Smakhtin, 2004). In this methodology, the EWR is the summation of Low Flow Requirements (LFR) and High Flow Requirements (HFR). Mathematically, it is written as

EWR = LFR + HFR

LFR is believed to approximate the minimum requirement of water of the fish and other aquatic species throughout the year. HFR is important for river channel maintenance, as a stimulus for processes such as migration and spawning, for wetland flooding and recruitment of riparian vegetation (Smakhtin, 2004). LFR is assumed to be equal to the monthly flow which is exceeded 90% of the time (Q_{90}) and HFR is taken from Table-9.2 which it is approximate by a set of thresholds linked to the different LFR levels (Smakhtin, 2004).

TABLE-9.2
Estimation of environmental high-flow requirement (HFR)

Low Flow Req. (Q_{90})	HFR	Comment
If Q_{90} < 10% AAF	Then HFR = 20% AAF	Basins with very variable flow regimes. Most of the flow occurs as flood events during short wet season
If 10% MAR ≤ Q_{90} < 20% AAF	Then HFR = 15% AAF	
If 20% MAR ≤ Q_{90} < 30% AAF	Then HFR = 7% AAF	
If Q_{90} ≥ 30% AAF	Then HFR = 0	Very stable flow regimes. Flow is consistent throughout the year. Low-flow requirement is the primary component.

Source: Smakhtin, 2004

In reliable flowing rivers with high baseflow contribution (and consequently high LFR), HFR is low. In the other hand, in highly variable rivers, baseflow contributions are normally low (and consequently LFR is low) and the total environmental requirement is dominated by high HFR (Smakhtin, 2004).

(iii) Index Method

This method defined the value of the Minimum Instream Flow (MIF) that must be maintained downstream water diversion in order to maintain vital conditions of ecosystem functionality and quality (Maran, 2007). Based on Q_{355} (the flow not exceeded more than 355 days per year) this means that, on average, the natural flow is less than Q_{355} value only for 10 days in a year (Maran, 2007).

MIF = Ka*Kb*Kc* Q_{355}

where:

- Ka is corrective coefficient for different environmental sensitive of the interested river stretch [0.7 to 1.0]
- Kb = implementation factor [0.25 to 1.0]
- Kc is corrective coefficient to account for different level of protection due to the naturalistic value of the interested area [1.0 to 1.5].

The concept of "environmental sensitive" is linked with Flow Duration Curve (FDC). When the slope of the FDC is flat, for example when $Q_{90} \geq 30\%$ AAF, the flow in the river is very stable thought the year, and the ecosystem is getting used to have a constant rate of flow in the river most of the time. This type of ecosystem is more sensitive to any change in river flow regime and the value of K_a will be taken as 1 (one). On other hand, when the FDC slope is steep, say $Q_{90} < 10\%$ AAF, the river flow is very unstable and present high extreme values (floods and droughts). Under this condition, ecosystem is getting used to water scarcity during some periods of the year, therefore this ecosystem is less sensitive to changes in flow regime, because the river naturally present a wide variability in flow regime. In this case, the value of K_a can be taken as 0.7.

The implementation factor refers to upgrade a degraded river condition, in which the quantity of water in the river is very low, due the abstractions made for different purposes (domestic, industrial, agriculture, etc.). The recovery of natural conditions of the river flow must to be done gradually, because another uses of water will be affected. In this case, the value of K_b could be 0.25. In the case of no significant abstractions, the value of K_b will be 1.

The K_c factor increases the value of MIF, for protection of special conditions in the river ecosystem like naturalistic and tourism values, fisheries development and medicinal or religious issues.

(iv) Building Block Method

The Building Block Method (BBM) is essentially a prescriptive approach, designed to construct a flow regime for maintaining a river in a predetermined condition. The objective of BBM is to determine ecologically acceptable, modified flow regimes for impounded rivers and other situations where flows are regulated (Arthington, 1998). An environmental flow regime is then constructed (month by month basis) through separate consideration of different components of the flow regime. Each component of flow being specified in terms of magnitude, time of year, duration and rate of rise and fall of flood flows. Each flow component is intended to achieve a particular ecological, geo-morphological or water-quality objective (Brown, 2006).

The BBM is holistic, but issues such as water quality and the flow requirements of water-dependent wildlife require more development and stronger linkages into the methodology. The BBM has advanced the field of environmental flow assessment in an entirely new direction, being an holistic methodology that addresses the health (structure and functioning) of all components of the riverine ecosystem, rather than focusing on selected species as do many similarly resource-intensive international methodologies.

2. Hydraulic Rating Method

Hydraulic Rating Method (HRM) is combined desktop-field methods requiring limited hydrological, hydraulic modeling and ecological data and expertise. Like previous method, HRM also use the hydrological record and link this data to simple cross-section data in the river of interest. This method uses the relationship between the flow of the river (discharge) and simple hydraulic characteristic such as water depth, velocity or wetted perimeter to calculate an acceptable flow.

These methods are an improvement on hydrological index methods, since they require measurement of the river channel and so are more sensitive than the desktop approaches to differences between rivers. The number of measurements taken and field visits made will depend on the level of confidence required for the study. Cross-sections are placed at a river site where maintenance of flow is most critical or where instream hydraulic habitat is most responsive to flow reduction, and thus potentially most limiting to the aquatic biota.

9.4 ENVIRONMENTAL WATER REQUIREMENTS IN LOHIT BASIN

(i) Tennant Method

Assume that fair and degrading conditions are prevailing in the basin. Hence EF is 10% of Annual Average Flow (AAF) for the period Oct. to March and 30 % for the period April to September for the year 2003-04 which represents the 90% dependable year. Table-9.3 summarizes the results for each proposed site in Lohit River basin.

TABLE-9.3
Environmental Water Requirements using Tennant Method

Project	AAF 2003-04 (cumec)	EWR (cumec) (October-March) (0.1 * col. 2)	EWR (cumec) (April-September) (0.3 * col. 2)
Kalai hydroelectric project, stage-1	557	56	167
Kalai hydroelectric project, stage-2	598	60	179
Hutong hydroelectric project, stage-1	602	60	181
Hutong hydroelectric project, stage-2	618	62	185
Demwe Upper hydroelectric project	689	69	207
Demwe Lower hydroelectric project	723	72	217

(ii) Hughes & Münster Method (H&M)

The EWR = LFR + HFR
LFR = $Q_{90\%}$ dependable flow of year 2003-04 (see Annexure D, table D7).

HFR are taken from Table 9.4, since all $Q_{90\%}$ > 30% of AAF the components of high flows are negligible. That means the flow in the river is very stable; the flow is consistent throughout the year and low-flow requirement is the primary component. This also means the river ecology is very sensitive to any change in river flow regimes.

TABLE-9.4
Environmental Water Requirements using Hughes & Münster method

Project	AAF 2003-04 (cumecs)	$Q_{90\%}$ 2003-04 (cumecs)	% Q90/AAF	HFR (cumecs)	EWR (cumecs)
Kalai hydroelectric project, stage-1	557	258	46.32	0	258
Kalai hydroelectric project, stage-2	598	278	46.49	0	278
Hutong hydroelectric project, stage-1	602	279	46.35	0	279
Hutong hydroelectric project, stage-2	618	287	46.44	0	287
Demwe Upper hydroelectric project	689	320	46.44	0	320
Demwe Lower hydroelectric project	723	336	46.47	0	336

(iii) Index Method

Assumptions taken in computations:

Ka = 0.7 River ecology is very sensitive.

Kb = 0.25 River flows are in natural state, therefore any implementation factor is required.

Kc = 1.0 considering high naturalistic values in Lohit river basin.

Q_{355} correspond to Q equaled or exceeded 98% of the time. This value is taken from flow duration curve for the year 2003-04 (refer Figures- 4.3 to 4.8 in Chapter-4 of this report)

MIF = Q_{355}*Ka*Kb*Kc

Table-9.5 summarizes the results of EWR using Index Method.

TABLE-9.5
Environmental Water Requirements using Index method

SITE	Q_{355} for 2003-04 (cumecs)	EWR (cumecs)
Kalai hydroelectric project, stage-1	254	45
Kalai hydroelectric project, stage-2	272	48
Hutong hydroelectric project, stage-1	274	48
Hutong hydroelectric project, stage-2	282	49
Demwe Upper hydroelectric project	314	55
Demwe Lower hydroelectric project	330	58

(iv) Building Block Method

The BBM methodology used in this study constructs a synthetic hydrograph which must satisfy the water requirements in the river for maintaining a desired condition. The hydrograph simulates the natural conditions in the river to fulfill the different flow regimes present through out the year. The identification and incorporation of these important flow characteristics will help to maintain the river's channel structure, diversity of the physical biotopes and processes. Four main seasons are identified along the year:

Season I: This season is considered as high flow season influenced by monsoon. It covers the months from May to September. The minimum flow during this period is assumed as 30% of average flow (10 daily or monthly).

Season II: This season is considered as average flow period. It covers the month of October in which the proposed minimum flow is taken as 25% of average flow. This period is a transitional period between the wet and dry period.

Season III: This season is considered as low or lean or dry flow season. It covers the months from November to March. The proposed minimum flow is taken as 20% of average flow during this period.

Season IV: This season is considered as average flow period and is same as that of season II. It covers the month of April in which the proposed minimum flow is taken as 25% of average flow. This period is a transitional period between the dry and wet period.

The proposed minimum flows have been estimated for 90% dependable year (2003-04) and are listed in Table-9.6.

TABLE-9.6

Building Block Methodology for monthly average flow for 90% dependable year (2003-04)

Month	Kalai HEP Stage-1	Kalai HEP Stage-2	Hutong HEP Stage-1	Hutong HEP Stage-2	Demwe Upper HEP	Demwe Lower HEP
June	221.9	385.6	388.2	398.6	438.7	460.7
July	280.7	566.8	570.6	585.9	433.7	455.4
August	225.2	329.3	331.5	340.4	215.9	226.8
September	199.4	203.3	204.7	214.0	202.5	212.7
October	116.3	114.4	115.2	118.3	131.3	137.8
November	63.1	63.5	63.9	65.6	83.7	87.8
December	51.0	79.9	80.6	82.6	73.2	76.8
January	43.1	51.3	51.7	53.1	68.1	71.5
February	44.8	49.7	50.0	51.3	63.0	66.1
March	48.2	39.3	39.6	40.6	84.7	89.0
April	109.6	137.4	138.3	142.0	197.5	207.3
May	208.3	232.6	234.2	241.5	237.2	249.2

9.5 ESTIMATION OF STAGE-DISCHARGE RELATIONSHIP

In Lohit River only cross section data was available at different locations downstream of three projects (Kalai I, Hutong II and Demwe Lower), and no stage discharge relationship was available. Therefore the first step was to generate a synthetic form of normal depth discharge relationship. Since, only cross section area (A) and corresponding wetted perimeter (P) is available at different stages; the discharges were obtained using Manning's equation. The water depths were taken in the intervals of 0.5 m, ranging between 0.5 m to 3.0 meters. Therefore, a relation between normal depth and discharge is obtained at three different project sites, where the cross section of the river is available at different length along the river channel. Assumptions taken in Manning's equation are :

- *Steady uniform flow condition.*

  The critical period of analysis in this project occurs during dry season, when rainfall is not expected and runoff can be taken as zero, therefore, additional discharge from lateral inflow for a selected reach is zero, seepage is negligible, and discharge is assumed to be steady, and uniform.

- *One-dimensional analysis.*

  In one-dimensional analysis, the mean velocity is used as a representative velocity for the entire cross section and is defined on the basis of the longitudinal component. Hence, the velocities in the other than the main direction of flow are not considered.

Manning's equation can be written in terms of discharge as:

$$Q = \frac{1}{n} A R^{2/3} S^{1/2}$$

where:

Q is the discharge (m3/s).
n is the roughness coefficient (dimensionless).
A is the area of the cross section perpendicular to flow (m2).
R is the hydraulic radius in meters (R=A/P).
S is the slope of the river bed.

The selection of *n* value was done by tables using a description of the river conditions "in situ". According with Chow, the roughness coefficient for a natural minor stream (top width at flood stage < 100 ft), mountain river stream, no vegetation in channel, banks usually steep, trees and brush along banks submerged at high stages. River bed conforms of boulders, cobbles and few boulders range from [0.03-0.05]. Therefore, the analysis has been carried out for Manning's n as 0.03, 0.04, and 0.05. Three different curves of Water Depth vs. Discharge were obtained for each dam site analyzed.

The river bed slope is taken as average value between two adjacent site projects, where the bed elevation and the distance is known. Hence, the slope is S = ΔH/ΔL, where ΔH is difference in bed elevation between two sites and ΔL is the distance between project sites. The details are given in Table-9.7.

TABLE-9.7
Average Slope Calculation

	Coordinates		Distance		Slope calculation		
Dam site	**Latitude**	**Longitude**	**Length (Km)**	**Length (km)**	**Bed Level, L (msl)**	**Diff. In level, H (m)**	**H/ L**
KL-1	27’64.55”N	96”67.30”E	0		915.25	-	-
				19.5		135.34	00.007
KL-II	27’54.20”N	96’47.57”E	19.6	-	779.8	-	-
				5.5	-	24	0.004
HTG-I	27’57.38”N	96’43.40”E	25		766.8		
				16.5		166.3	0.010
HTG-II	28’00.38”N	96’37.38”E	41.5		589.5		
				27		159.5	0.006
D.U.	28’02.58”N	26”27.06”E	68.5		430		
				26.6		125	0.006
D.L.	27’52.48”N	96”22.39”E	94.1		305		

The normal depth relationship w.r.t. to discharge was available for the following projects only:

- Kalai HEP Stage-1
- Hutong HEP Stage-2
- Demwe Lower HEP

The normal depth relationship for Kalai HEP Stage-1, Hutong HEP Stage-2 and Demwe Lower HEP are given in Tables 9.8 to 9.10 respectively.

TABLE – 9.8
Normal Depth – Discharge Relationship for Kalai Hydroelectric Proejct, Stage-1

100 m D/S (n=0.04; S= 0.007)						
Depth (m)	**Area (m2)**	**Perimeter (m)**	**H.Radius (m)**	**Discharge (m3/s)**	**Velocity (m/s)**	**Froude No.**
0.50	1.83	13.26	0.138	1.00	0.55	0.26
1.00	13.33	31.6	0.422	16.68	1.18	0.38
1.50	33.02	46.06	0.717	55.32	1.68	0.44
2.00	58.95	67.05	1.033	126.00	2.14	0.48
2.50	88.96	62.75	1.418	234.80	2.64	0.63
3.00	121.32	66.94	1.813	377.26	3.11	0.67

200 m D/S (n=0.04; S= 0.007)						
Depth (m)	**Area (m2)**	**Perimeter (m)**	**H.Radius (m)**	**Discharge (m3/s)**	**Velocity (m/s)**	**Froude No.**
0.50	4.56	17.8	0.266	3.84	0.84	0.38
1.00	18.78	36.67	0.514	25.20	1.34	0.43
1.50	40.07	50.92	0.787	71.46	1.78	0.46
2.00	69.29	64.42	1.076	152.15	2.20	0.50
2.50	103.12	70.52	1.462	277.85	2.69	0.54
3.00	139.4	75.23	1.863	439.85	3.16	0.58
300 m D/S (n=0.04; S= 0.007)						
Depth (m)	**Area (m2)**	**Perimeter (m)**	**H.Radius (m)**	**Discharge (m3/s)**	**Velocity (m/s)**	**Froude No.**
0.50	2.76	12.75	0.216	2.10	0.76	0.34
1.00	11.88	24.70	0.481	16.25	1.28	0.41
1.50	27.97	38.62	0.724	47.20	1.69	0.44
2.00	49.84	47.32	1.063	107.92	2.17	0.49
2.50	74.35	50.68	1.467	200.80	2.7	0.55
3.00	100.12	53.39	1.875	318.45	3.18	0.69

TABLE – 9.9

Normal Depth – Discharge Relationship for Hutong HEP, Stage-2

50 m D/S (n=0.04; S= 0.006)						
Depth (m)	**Area (m2)**	**Perimeter (m)**	**H.Radius (m)**	**Discharge (m3/s)**	**Velocity (m/s)**	**Froude No.**
0.50	1.81	21.37	0.225	3.44	0.71	0.32
1.00	21.15	42.84	0.494	24.48	1.21	0.39
1.50	47.33	60.09	0.788	78.16	1.65	0.43
2.00	79.63	68.35	1.165	170.74	2.14	0.48
2.50	116.66	85.85	1.359	277.16	2.38	0.48
3.00	160.66	90.76	1.770	455.26	2.83	0.62
100 m D/s (n-0.04; S= 0.006)						
Depth (m)	**Area (m2)**	**Perimeter (m)**	**H.Radius (m)**	**Discharge (m3/s)**	**Velocity (m/s)**	**Froude No.**
0.50	2.70	11.27	0.240	2.02	0.75	0.34
1.00	10.95	24.55	0.446	12.38	1.13	0.36
1.50	31.58	59.28	0.533	40.18	1.27	0.33
2.00	65.42	72.53	0.902	118.26	1.81	0.41
2.50	102.39	75.90	1.349	242.08	2.36	0.48
3.00	140.92	79.01	1.784	401.32	2.85	0.52
300 m D/s (n-0.04; S= 0.006)						
Depth (m)	**Area (m2)**	**Perimeter (m)**	**H.Radius (m)**	**Discharge (m3/s)**	**Velocity (m/s)**	**Froude No.**

0.50	10.84	46.75	0.232	7.92	0.73	0.33
1.00	41.65	70.96	0.587	56.62	1.36	0.43
1.50	81.09	85.46	0.949	151.62	1.87	0.49
2.00	176.88	96.07	1.321	295.75	2.33	0.53
2.50	176.06	101.96	1.727	490.73	1.79	0.56
3.00	228.00	106.28	2.145	734.44	3.22	0.69
500 m D/s (n-0.04; S= 0.006)						
Depth (m)	**Area (m2)**	**Perimeter (m)**	**H.Radius (m)**	**Discharge (m3/s)**	**Velocity (m/s)**	**Froud e No.**
0.50	18.67	60.37	0.309	16.52	0.89	0.4
1.00	52.69	75.25	0.700	80.44	1.53	0.49
1.50	93.14	85.21	1.093	191.37	2.05	0.64
2.00	136.87	89.42	1.531	362.06	2.67	0.68
2.50	182.07	91.92	1.981	556.08	3.06	0.62
3.00	186.97	93.88	1.992	573.15	3.07	0.57
733 m D/s (n-0.04; S= 0.006)						
Depth (m)	**Area (m2)**	**Perimeter (m)**	**H.Radius (m)**	**Discharge (m3/s)**	**Velocity (m/s)**	**Froud e No.**
0.50	2.88	24.82	0.116	1.32	0.46	0.21
1.00	10.60	36.91	0.287	8.94	0.84	0.27
1.50	35.11	53.62	0.666	51.28	1.46	0.38
2.00	62.89	57.82	1.088	128.80	2.05	0.46
2.50	92.67	61.85	1.498	234.98	2.54	0.51
3.00	124.31	65.39	1.901	369.42	2.976	0.55

TABLE 9.10
Normal depth – Discharge Relation for Demwe Lower Hydroelectric Project

100 m D/s (n-0.04; S= 0.004)						
Depth (m)	**Area (m2)**	**Perimeter (m)**	**H.Radius (m)**	**Discharge (m3/s)**	**Velocity (m/s)**	**Froud e No.**
0.50	14.94	23.83	0.442	13.70	0.92	0.41
1.00	32.92	28.50	0.655	46.90	1.42	0.45
1.50	53.14	43.16	1.231	98.52	1.46	1.62
2.00	75.57	47.59	1.588	162.63	2.15	0.49
2.50	100.10	52.02	1.924	244.86	2.45	0.49
3.00	126.09	56.20	2.240	241.20	2.71	0.5
200 m D/s (n-0.04; S= 0.004)						
Depth (m)	**Area (m2)**	**Perimeter (m)**	**H.Radius (m)**	**Discharge (m3/s)**	**Velocity (m/s)**	**Froud e No.**
0.50	5.79	7.28	7.98	7.87	1.36	0.81
1.00	11.56	15.70	0.726	14.90	1.29	0.41
1.50	23.54	16.70	1.410	46.79	1.99	0.52

2.00	29.35	21.62	1.258	56.89	1.94	0.44
2.50	41.29	26.14	1.680	86.55	2.14	0.42
3.00	53.25	29.49	1.806	124.85	2.34	0.42
500 m D/s (n-0.04; S= 0.004)						
Depth (m)	**Area (m2)**	**Perimeter (m)**	**H.Radius (m)**	**Discharge (m3/s)**	**Velocity (m/s)**	**Froude No.**
0.50	15.20	26.97	0.411	13.28	0.87	0.39
1.00	25.81	47.72	0.750	46.75	1.21	0.42
1.50	85.68	71.65	0.902	95.52	1.48	0.28
2.00	108.64	97.15	1.908	179.41	1.68	0.38
2.50	158.69	112.72	1.408	215.17	1.99	0.40
3.00	217.54	125.33	1.735	496.78	2.28	0.42
1000 m D/s (n-0.04; S= 0.004)						
Depth (m)	**Area (m2)**	**Perimeter (m)**	**H.Radius (m)**	**Discharge (m3/s)**	**Velocity (m/s)**	**Froude No.**
0.50	0.44	2.86	0.166	0.20	0.45	0.21
1.00	2.60	8.45	0.403	2.25	0.87	0.28
1.50	6.55	10.22	0.640	7.70	1.18	0.21
2.00	12.37	15.60	0.793	16.76	1.35	0.21
2.50	22.63	27.29	0.626	21.52	1.39	0.28
3.00	28.95	29.07	0.997	61.46	1.56	0.29
1500 m D/s (n-0.04; S= 0.004)						
Depth (m)	**Area (m2)**	**Perimeter (m)**	**H.Radius (m)**	**Discharge (m3/s)**	**Velocity (m/s)**	**Froude No.**
0.50	5.48	12.17	0.450	5.08	0.93	0.42
1.00	11.92	14.35	0.621	16.66	1.4	0.45
1.50	19.33	16.52	1.170	22.92	1.76	0.48
2.00	27.69	16.70	1.481	66.89	2.05	0.48
2.50	27.02	20.67	1.774	85.76	2.32	0.47
3.00	47.30	23.04	2.053	120.82	2.55	0.47
2000 m D/s (n-0.04; S= 0.004)						
Depth (m)	**Area (m2)**	**Perimeter (m)**	**H.Radius (m)**	**Discharge (m3/s)**	**Velocity (m/s)**	**Froude No.**
0.50	5.74	26.01	0.221	3.32	0.66	0.26
1.00	25.10	50.42	0.498	24.94	0.99	0.32
Depth (m)	**Area (m2)**	**Perimeter (m)**	**H.Radius (m)**	**Discharge (m3/s)**	**Velocity (m/s)**	**Froude No.**
1.50	54.88	67.90	0.808	75.20	1.27	0.26
2.00	92.64	83.58	1.108	158.88	1.69	0.36
2.50	138.48	100.21	1.381	271.46	1.96	0.40
3.00	192.34	114.21	1.884	430.50	2.24	0.41
2500 m D/s (n-0.04; S= 0.004)						

Depth (m)	Area (m2)	Perimeter (m)	H.Radius (m)	Discharge (m3/s)	Velocity (m/s)	Froude No.
0.50	22.43	58.53	0.400	20.11	0.86	0.39
1.00	57.01	75.95	0.751	74.45	1.31	0.42
1.50	100.87	101.75	0.991	158.55	1.57	0.41
2.00	158.61	128.20	1.237	289.00	1.62	0.41
2.50	226.92	142.82	1.578	488.26	2.14	0.43
3.00	302.12	157.26	1.921	728.24	2.44	0.45

Since Froude number is less than one in all cases, the flow is sub-critical. Normal depth vs. discharge relationship are prepared at a particular site considering the maximum discharge corresponding to a particular depth among various sections at a particular project site. That means, the maximum discharge which is capable of maintaining the required water depth (say 0.5, 1, 1.5, etc) in all the cross-sections in the respective reach is selected. These curves were prepared for n=0.03, 0.04 and 0.05. The relation between Normal depth and discharges at Kalai HEP Stage-1, Hutong HEP Stage-2 and Demwe Lower HEP are given in Tables 9.11 to 9.13 respectively. The relation between Normal depth and discharges at Kalai HEP Stage-1, Hutong HEP Stage-2 and Demwe Lower HEP is also shown in Figures-9.3 to 9.5 respectively.

TABLE-9.11
Relation between Normal depth and discharges at Kalai HEP,Stage-1

Depth (m)	Discharge (cumec)		
	n=0.03	n=0.04	n=0.05
0	0	0	0
0.5	5.14	3.84	3.1
1	33.57	25.2	20.14
1.5	95.27	71.45	57.16
2	202.85	152.15	121.71
2.5	370.5	277.85	222.3
3	586.48	439.85	351.88

TABLE-9.12
Relation between Normal depth and discharges at Hutong HEP,Stage-2

Depth (m)	Discharge (cumec)		
	n=0.03	n=0.04	n=0.05
0	0	0	0
0.5	22.02	16.52	13.21
1	107.26	80.44	64.36
1.5	255.16	191.37	153.09
2	469.4	352.06	281.64
2.5	741.44	556.06	444.86
3	979.24	734.44	587.55

TABLE-9.13
Relation between Normal depth and discharges at Demwe Lower HEP

Depth (m)	Discharge (cumec)		
	n=0.03	N=0.04	n=0.05
0	0	0	0
0.5	26.82	20.11	16.09
1	99.28	74.45	59.56
1.5	211.4	158.55	126.84
2	385.35	289	231.21
2.5	648.35	486.26	389
3	984.32	738.24	590.59

Figure-9.3 Normal depth vs. discharge at Kalai HEP, Stage-1 for different values of n

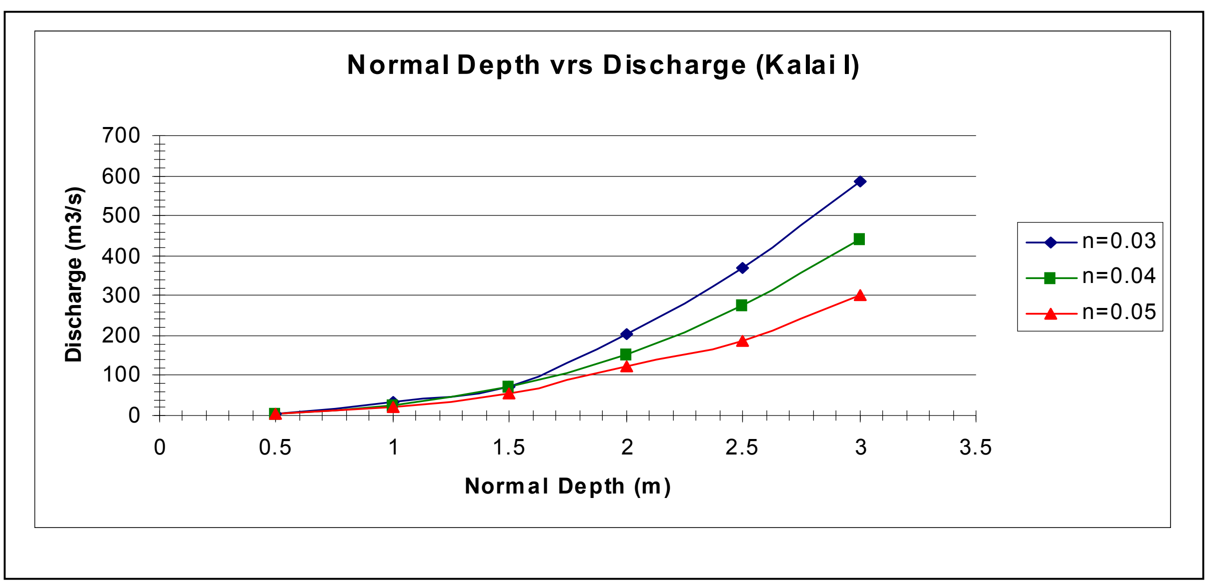


Figure-9.4 Normal depth vs. discharge at Hutong HEP, Stage-2 for different values of n

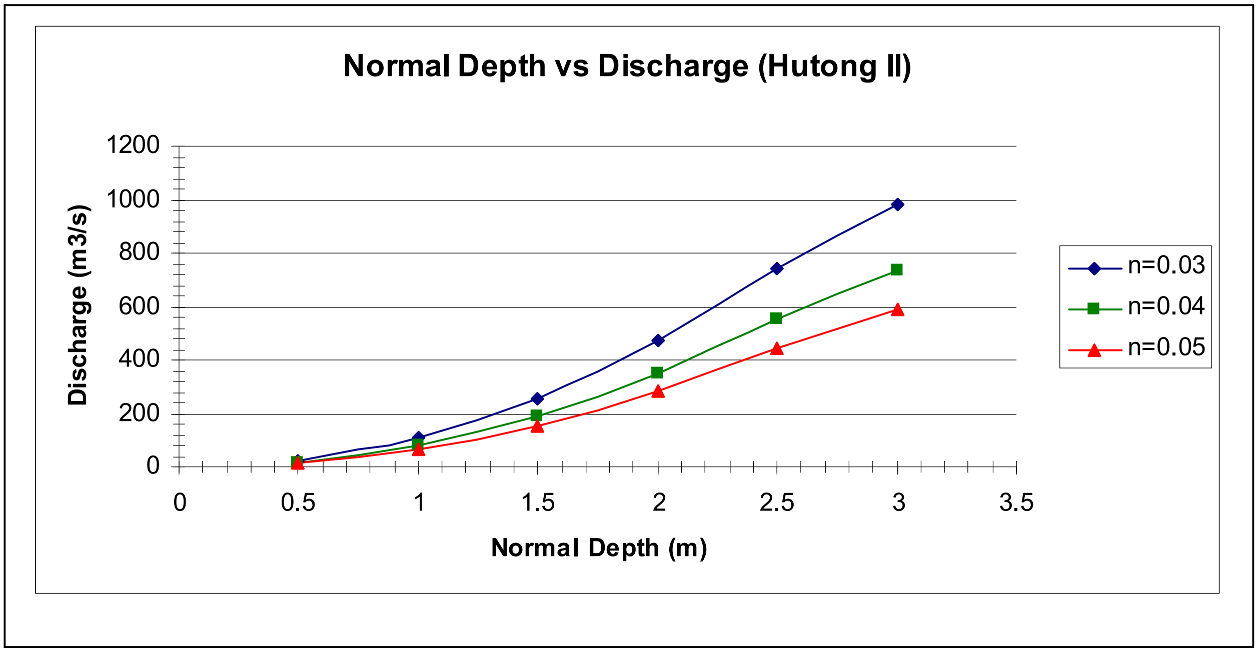
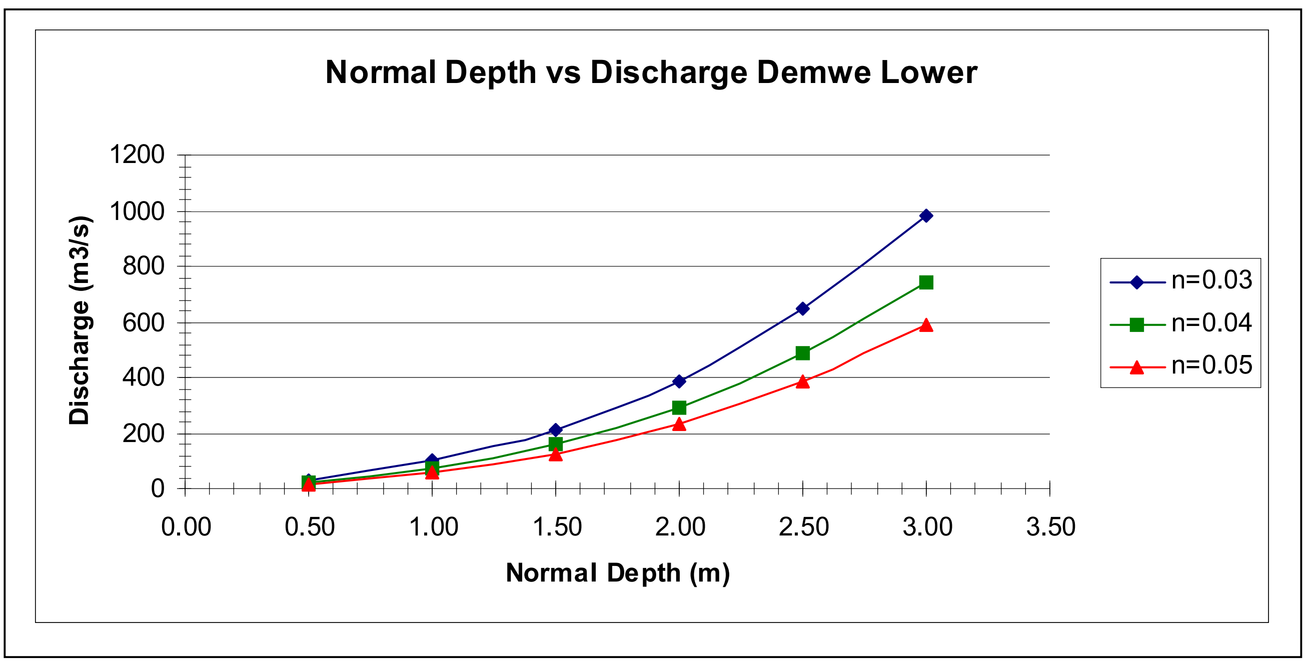


Figure-9.5 Normal Depth vs. discharge at Demwe Lower HEP for different values of n



Alternatively, numerical relationship can be derived between Normal depth and discharge corresponding to different values of n as shown in Table 9.14.

TABLE-9.14

Numerical relations for Normal depth-discharge relationship

N value	***n* = 0.03**		***n* = 0.04**		***n* = 0.05**	
SITE	**Equation**	**R^2**	**Equation**	**R^2**	**Equation**	**R^2**
Kalai HEP, Stage-1	$Q=32.64Y^{2.6424}$	0.9999	$Q=24.45Y^{2.6442}$	0.9999	$Q=19.621Y^{2.6398}$	0.9999
Hutong HEP,Stage-2	$Q=102.52Y^{2.1384}$	0.9982	$Q=76.896Y^{2.1382}$	0.9982	$Q=61.508Y^{2.1384}$	0.9982
Demwe Lower HEP	$Q=101.58Y^{1.9982}$	0.9979	$Q=76.175Y^{1.9983}$	0.9979	$Q=60.943Y^{1.9983}$	0.9979

9.6 SUMMARY OF ENVIRONMENTAL FLOWS

The environmental flow for Lohit basin has been estimated using the hydrologic and hydraulic rating methods. The various methods tried in hydrologic methods are : Tenant method, Hughes & Munster method, Index method, and the building block methods. The results are summarized in Table-9.15.

TABLE-9.15
Summary of Environmental Water Requirements for different techniques (2003-04)

Unit: cumec

Project	**Tennant Method**		**Hughes & Münster Method**	**Index Method**
	Oct.-Mar.	**April-Sept.**		
Kalai HEP, Stage-1	56	167	258	45
Kalai HEP, Stage-2	60	179	278	48
Hutong HEP, Stage-1	60	181	279	48
Hutong HEP, Stage-2	62	185	287	49
Demwe Upper HEP	69	207	320	55
Demwe Lower HEP	72	217	336	58

The proposed Minimum Flow on the basis of flow during the 90 % dependable year is given in Table-9.16. Using the hydraulic rating method, flow required for maintaining the various normal depths at various sites is given in Table-9.17.

TABLE-9.16
Proposed Minimum Flow on the basis of flow during 90 % dependable year for various hydroelectric projects (Unit : cumec)

Season	Month	Kalai HEP Stage-1	Kalai HEP Stage-2	Hutong HEP Stage-1	Hutong HEP Stage-2	Demwe Upper HEP	Demwe Lower HEP
I	May	208.3	232.6	234.2	241.5	237.2	249.2
	June	221.9	385.6	388.2	398.6	438.7	460.7
	July	280.7	566.8	570.6	585.9	433.7	455.4
	August	225.2	329.3	331.5	340.4	215.9	226.8
	September	199.4	203.3	204.7	214.0	202.5	212.7
II	October	116.3	114.4	115.2	118.3	131.3	137.8
III	November	63.1	63.5	63.9	65.6	83.7	87.8
	December	51.0	79.9	80.6	82.6	73.2	76.8
	January	43.1	51.3	51.7	53.1	68.1	71.5
	February	44.8	49.7	50.0	51.3	63.0	66.1
	March	48.2	39.3	39.6	40.6	84.7	89.0
II	April	109.6	137.4	138.3	142.0	197.5	207.3

TABLE-9.17
Flow required for maintaining the various normal depths at various sites

Project	Discharge-Normal Depth Relationship		
	n = 0.03	n = 0.04	n = 0.05
Kalai HEP, Stage-1	$Q=32.64Y^{2.6424}$	$Q=24.45Y^{2.6442}$	$Q=19.621Y^{2.6398}$
Hutong HEP, Stage-2	$Q=102.52Y^{2.1384}$	$Q=76.896Y^{2.1382}$	$Q=61.508Y^{2.1384}$
Demwe Lower HEP	$Q=101.58Y^{1.9982}$	$Q=76.175Y^{1.9983}$	$Q=60.943Y^{1.9983}$

9.7 PEAKING POWER AVAILABILITY CONSIDERING ENVIRONMENTAL FLOWS

The number of hours for which peaking is available after the release of Environmental Flows is given in Tables-9.18 to 9.23. The comparison of number of peaking hours available with and without Environmental Flows is given in Tabls-9.24 to 9.29.

TABLE-9.18
Number of hours of peaking available in 90% dependable year for Kalai HEP, stage-1

Month	Discharge in 90% Dependable year (cumec)	Environmental Flows for 90% Dependable year (cumec)	Balance discharge available in 90% Dependable year (cumec)	Rated discharge (cumec)	Time available for peaking power (hrs.)
June	739.5	221.9	517.7	1033.05	12.0
July	935.8	280.7	655.1	1033.05	15.2
August	750.8	225.2	525.6	1033.05	12.2
September	664.6	199.4	465.2	1033.05	10.8
October	465.1	116.3	348.8	1033.05	8.1
November	315.6	63.1	252.5	1033.05	5.9
December	255.2	51.0	204.2	1033.05	4.7
January	215.3	43.1	172.2	1033.05	4.0
February	224.2	44.8	179.4	1033.05	4.2
March	240.8	48.2	192.6	1033.05	4.5
April	438.3	109.6	328.7	1033.05	7.6
May	694.46	208.3	486.1	1033.05	11.3

TABLE-9.19
Number of hours of peaking available in 90% dependable year for Kalai HEP, stage-2

Month	Discharge in 90% Dependable year (cumec)	Environmental Flows for 90% Dependable year (cumec)	Balance discharge available in 90% Dependable year (cumec)	Rated discharge (cumec)	Time available for peaking power (hrs.)
June	1285.4	385.6	899.8	1112.27	19.4
July	1889.2	566.8	1322.4	1112.27	24.0
August	1097.6	329.3	768.3	1112.27	16.6
September	677.7	203.3	474.4	1112.27	10.2
October	457.6	114.4	343.2	1112.27	7.4
November	317.3	63.5	253.9	1112.27	5.5

Month	Discharge in 90% Dependable year (cumec)	Environmental Flows for 90% Dependable year (cumec)	Balance discharge available in 90% Dependable year (cumec)	Rated discharge (cumec)	Time available for peaking power (hrs.)
December	399.5	79.9	319.6	1112.27	6.9
January	256.7	51.3	205.4	1112.27	4.4
February	248.3	49.7	198.7	1112.27	4.3
March	196.5	39.3	157.2	1112.27	3.4
April	549.6	137.4	412.2	1112.27	8.9
May	775.3	232.6	542.7	1112.27	11.7

TABLE-9.20
Number of hours of peaking available in 90% dependable year for Hutong HEP, stage-1

Month	Discharge in 90% Dependable year (cumec)	Environmental Flows for 90% Dependable year (cumec)	Balance discharge available in 90% Dependable year (cumec)	Rated discharge (cumec)	Time available for peaking power (hrs.)
June	1294.1	388.2	905.9	1423.02	15.3
July	1902.1	570.6	1331.5	1423.02	22.5
August	1105.1	331.5	773.6	1423.02	13.0
September	682.3	204.7	477.6	1423.02	8.1
October	460.7	115.2	345.5	1423.02	5.8
November	319.5	63.9	255.6	1423.02	4.3
December	403.2	80.6	322.5	1423.02	5.4
January	258.4	51.7	206.8	1423.02	3.5
February	250.0	50.0	200.0	1423.02	3.4
March	197.8	39.6	158.3	1423.02	2.7
April	553.3	138.3	415.0	1423.02	7.0
May	780.6	234.2	546.4	1423.02	9.2

TABLE-9.21
Number of hours of peaking available in 90% dependable year for Hutong HEP, stage-2

Month	Discharge in 90% Dependable year (cumec)	Environmental Flows for 90% Dependable year (cumec)	Balance discharge available in 90% Dependable year (cumec)	Rated discharge (cumec)	Time available for peaking power (hrs.)
June	1328.8	398.6	930.2	1423.02	15.7
July	1953.1	585.9	1367.2	1423.02	23.1
August	1134.7	340.4	794.3	1423.02	13.4
September	713.5	214.0	499.4	1423.02	8.4
October	473.0	118.3	354.8	1423.02	6.0
November	328.1	65.6	262.4	1423.02	4.4
December	413.0	82.6	330.4	1423.02	5.6
January	265.4	53.1	212.3	1423.02	3.6
February	256.7	51.3	205.4	1423.02	3.5
March	203.1	40.6	162.5	1423.02	2.7
April	568.2	142.0	426.1	1423.02	7.2
May	804.9	241.5	563.4	1423.02	9.5

TABLE-9.22
Number of hours of peaking available in 90% dependable year for Demwe Upper HEP

Month	Discharge in 90% Dependable year (cumec)	Environmental Flows for 90% Dependable year (cumec)	Balance discharge available in 90% Dependable year (cumec)	Rated discharge (cumec)	Time available for peaking power (hrs.)
June	1462.3	438.7	1023.6	1513	16.2
July	1445.7	433.7	1012.0	1513	16.1
August	719.7	215.9	503.8	1513	8.0
September	675.0	202.5	472.5	1513	7.5
October	525.3	131.3	394.0	1513	6.2
November	418.3	83.7	334.7	1513	5.3
December	366.0	73.2	292.8	1513	4.6
January	340.7	68.1	272.5	1513	4.3
February	315.0	63.0	252.0	1513	4.0
March	423.3	84.7	338.7	1513	5.4
April	790.0	197.5	592.5	1513	9.4
May	790.7	237.2	553.5	1513	8.8

TABLE-9.23
Number of hours of peaking available in 90% dependable year for Demwe Lower HEP

Month	Discharge in 90% Dependable year (cumec)	Environmental Flows for 90% Dependable year (cumec)	Balance discharge available in 90% Dependable year (cumec)	Rated discharge (cumec)	Time available for peaking power (hrs.)
June	1535.7	460.7	1075.0	2085	12.4
July	1518.0	455.4	1062.6	2085	12.2
August	756.0	226.8	529.2	2085	6.1
September	709.0	212.7	496.3	2085	5.7
October	551.3	137.8	413.5	1729	5.7
November	439.0	87.8	351.2	1729	4.9
December	384.0	76.8	307.2	1729	4.3
January	357.7	71.5	286.1	1729	4.0
February	330.3	66.1	264.3	1729	3.7
March	445.0	89.0	356.0	1729	4.9
April	829.3	207.3	622.0	1729	8.6
May	830.7	249.2	581.5	1729	8.1

Note: As directed by CEA, Demwe Lower HEP will operate on MDDL during monsoon season (June to September) and for other season the project will operate at FRL i.e. during monsoon season project will operate at rated discharge of 2085 cumec whereas for other season it will operate at design discharge of 1729 cumec.

TABLE-9.24
Comparison of number of hours of peaking available in 90% dependable year for Kalai HEP, stage-1 for scenarios with and without Environmental Flows

Month	Time available for peaking power (hrs.)	
	Without EF release	With EF release
June	17.2	12.0
July	21.8	15.2
August	17.4	12.2
September	15.4	10.8
October	15.4	8.1
November	10.8	5.9
December	7.3	4.7
January	5.9	4.0
February	5.0	4.2
March	5.2	4.5
April	10.2	7.6
May	16.1	11.3

TABLE-9.25
Comparison of number of hours of peaking available in 90% dependable year for Kalai HEP, stage-2 for scenarios with and without Environmental Flows

Month	Time available for peaking power (hrs.)	
	Without EF release	With EF release
June	25.4	19.4
July	24.0	24.0
August	23.3	16.6
September	14.6	10.2
October	14.6	7.4
November	9.9	5.5
December	6.9	6.9
January	8.6	4.4
February	5.6	4.3
March	5.3	3.4
April	11.9	8.9
May	16.7	11.7

TABLE-9.26
Comparison of number of hours of peaking available in 90% dependable year for Hutong HEP, stage-1 for scenarios with and without Environmental Flows

Month	Time available for peaking power (hrs.)	
	Without EF release	With EF release
June	21.8	15.3
July	24.0	22.5
August	18.6	13.0
September	11.5	8.1
October	11.5	5.8
November	7.8	4.3
December	5.4	5.4
January	6.8	3.5
February	4.3	3.4
March	4.2	2.7
April	10.7	7.0
May	13.2	9.2

TABLE-9.27
Comparison of number of hours of peaking available in 90% dependable year for Hutong HEP, stage-2 for scenarios with and without Environmental Flows

Month	Time available for peaking power (hrs.)	
	Without EF release	With EF release
June	22.4	15.7
July	24.0	23.1
August	19.2	13.4
September	11.8	8.4
October	11.8	6.0
November	8.0	4.4
December	5.5	5.6
January	6.9	3.6
February	4.5	3.5
March	4.3	2.7
April	11.0	7.2
May	13.6	9.5

TABLE-9.28
Comparison of number of hours of peaking available in 90% dependable year for Demwe Upper HEP for scenarios with and without Environmental Flows

Month	Time available for peaking power (hrs.)	
	Without EF release	With EF release
June	21.7	16.2
July	19.6	16.1
August	11.4	8.0
September	10.7	7.5
October	10.7	6.2
November	8.3	5.3
December	6.6	4.6
January	5.8	4.3
February	5.4	4.0
March	6.7	5.4
April	12.5	9.4
May	12.5	8.8

TABLE-9.29
Comparison of number of hours of peaking available in 90% dependable year for Demwe Lower HEP for scenarios with and without Environmental Flows

Month	Time available for peaking power (hrs.)	
	Without EF release	**With EF release**
June	17.7	12.4
July	16.8	12.2
August	8.7	6.1
September	8.2	5.7
October	7.7	5.7
November	6.1	4.9
December	5.3	4.3
January	5.0	4.0
February	4.6	3.7
March	6.2	4.9
April	11.5	8.6
May	11.5	8.1

Kalai Hydroelectric project, stage-1

The number of hours for which peaking power shall be available in 90% dependable year for the scenario considering no release of Environmental Flows shall range from 5.0 to 10.8 hours in lean season of November to March.

It can be observed from Table-9.24, in 90%dependable year, even after release of Environmental Flow, peaking power for 4.0 to 5.9 hours will be available in lean season. This means that in lean season, there will be environmental flow of 43.1 to 63.1 cumec for a period of 18 to 20 hours. Tis will be followed by a rated discharge of 1033.05 cumec for a period of 4.0 to 5.9 hours in a 90% dependable year. As a result of release of Environmental flows the number of peaking hours shall reduce by 1 to 5 hours in 90% dependable year.

Kalai hydroelectric project, Stage-2

The number of hours for which peaking power shall be available in 90% dependable year for the scenario considering no release of Environmental Flows shall range from 5.3 to 9.9 hours in lean season of November to March. It can be observed from Table-9.25, that in 90% dependable year, even after release of Environmental Flows, peaking power will be available for a period of 3.4 to 6.9 hours. This means in lean season, there will be environmental flow of 39.3 to 79.9 cumec for a period of 17 to 19.5 hours, followed by a continuous flow of rated discharge (1112.27

cumec) for a period of 3.4 to 6.9 hours. As a result of release of Environmental flows the number of peaking hours shall reduce by 2 to 3 hours in 90% dependable year.

Hutong Hydroelectric project, stage-1

The number of hours for which peaking power shall be available in 90% dependable year for the scenario considering no release of Environmental Flows shall range from 4.2 to 7.8 hours in lean season of November to March. The number of hours of peaking power available in lean season after the release of Environmental Flows shall range from 2.7 to 5.4 hours. In lean season, there will be Environmental Flow of the order of 39.6 to 80.6 cumec for a period of 18 to 21 hours, followed by a continuous discharge of 1423.02 cumec (rated discharge). Thus, as a result of release of Environmental flows the number of peaking hours shall reduce by 1.5 to 2.4 hours in 90% dependable year. The details are given in Table-9.26.

Hutong hydroelectric project, Stage-2

The number of hours for which peaking power shall be available in 90% dependable year for the scenario considering no release of Environmental Flows shall range from 4.3 to 8 hours. The number of hours of peaking power available in lean season after considering the Environmental flows shall be of the order of 2.7 to 5.6 hours. As a result of release of Environmental flows the number of peaking hours shall reduce by 1.6 to 2.4 hours in 90% dependable year. Thus, the release of Environmental Flows will reduce the overall generation of energy.

In lean season, there will be Environmental flows for a period of 18 to 21 hours followed by a rated discharge of 1423.02 cumec for a period of 2.7 to 5.6 hours.

Demwe Upper Hydroelectric Project

As a result of release of Environmental flows, there will be reduction in peaking hours. The number of hours for which peaking power shall be available in 90% dependable year for the scenario considering no release of Environmental Flows shall range from 5.4 to 8.3 hours. On the other hand, if environmental flows of 20% are released in lean season, then number of hours for which peaking power will be available shall be of the order of 4.3 to 5.4 hours. Thus, the release of Environmental Flows will reduce the overall generation of energy. In lean season, there will be Environmental flows for a period of about 19 to 20 hours followed by a rated discharge of 1513 cumec for a period of 4.3 to 5.4 hours.

Demwe Lower Hydroelectric Project

As a result of release of Environmental flows, there will be reduction in peaking hours. The number of hours for which peaking power shall be available in 90% dependable year for the scenario considering no release of Environmental Flows shall range from 4.6 to 11.5 hours. The number of hours for which peaking power will be available considering Environmental flows range from 3.7 to 8.6 hours in lean season for 90% dependable year. This means that there will be Environmental Flow for a period of 15 to 21 hours. This will be followed by flow equivalent to rated discharge of 1729 cumec.

CHAPTER-10

ENVIRONMENTAL MANAGEMENT PLAN

10.1 INTRODUCTION

The aim of the Environmental Management Plan (EMP) is to ensure that the impacts due to stress/load on the ecosystem are ameliorated to the extent possible. The most reliable way to achieve the above objective is to incorporate the management plan into the overall planning and implementation of the proposed hydroelectric projects in the study area.

10.2 MANAGEMENT PLAN FOR FISHERIES

Various measures outlined for sustenance of riverine fisheries are described in the following paragraphs.

10.2.1 Release of minimum flow

The Building Block Methodology has been used in the present study to formulate a synthetic hydrograph which must satisfy the water requirements in the river for maintaining a desired condition. The hydrograph simulates the natural conditions in the river to fulfill the different flow regimes present through out the year. The identification and incorporation of these important flow characteristics will help to maintain the river's channel structure, diversity of the physical biotopes and processes. As outlined in Chapter-9, four main seasons have been identified in a calendar. These are listed as below:

Season I: This season is considered as high flow season influenced by monsoon. It covers the months from May to September. The minimum flow during this period is assumed as 30% of average flow (10 daily or monthly).

Season II: This season is considered as average flow period. It covers the month of October in which the proposed minimum flow is taken as 25% of average flow. This period is a transitional period between the wet and dry period.

Season III: This season is considered as low or lean or dry flow season. It covers the months from November to March. The proposed minimum flow is taken as 20% of average flow during this period.

Season IV: This season is considered as average flow period and is same as that of season II. It covers the month of April in which the proposed minimum flow is taken as 25% of average flow. This period is a transitional period between the dry and wet period.

The release of minimum flows on the basis of hydrology of each project has been estimated in Chapter-9 of this report. The proposed Minimum Flow is given in Table-10.1. The depth of flow for proposed minimum release is given in Table-10.2.

TABLE-10.1

Proposed Minimum Flow for various hydroelectric projects

Month	Kalai HEP Stage-1	Kalai HEP Stage-2	Hutong HEP Stage-1	Hutong HEP Stage-2	Demwe Upper HEP	Demwe Lower HEP
June	221.9	385.6	388.2	398.6	438.7	460.7
July	280.7	566.8	570.6	585.9	433.7	455.4
August	225.2	329.3	331.5	340.4	215.9	226.8
September	199.4	203.3	204.7	214.0	202.5	212.7
October	116.3	114.4	115.2	118.3	131.3	137.8
November	63.1	63.5	63.9	65.6	83.7	87.8
December	51.0	79.9	80.6	82.6	73.2	76.8
January	43.1	51.3	51.7	53.1	68.1	71.5
February	44.8	49.7	50.0	51.3	63.0	66.1
March	48.2	39.3	39.6	40.6	84.7	89.0
April	109.6	137.4	138.3	142.0	197.5	207.3
May	208.3	232.6	234.2	241.5	237.2	249.2

TABLE-10.2

Depth of flow for the proposed Minimum Flow for various hydroelectric projects

Season	Month	Kalai HEP-Stage-1		Hutong HEP, stage-2		Demwe Lower HEP	
		Discharge (m^3/s)	Depth (m)	Discharge (m^3/s)	Depth (m)	Discharge (m^3/s)	Depth (m)
I	May	221.9	2.17	398.6	2.16	460.7	2.46
	June	280.7	2.3	585.9	2.58	455.4	2.45
	July	225.2	2.1	340.4	2.01	226.8	1.73
	August	199.4	2.0	214.0	1.61	212.7	1.67
	September	116.3	1.6	118.3	1.22	137.8	1.35
II	October	63.1	1.3	65.6	0.93	87.8	1.07
III	November	51.0	1.2	82.6	1.03	76.8	1.00
	December	43.1	1.1	53.1	0.84	71.5	0.97
	January	44.8	1.1	51.3	0.83	66.1	0.93
	February	48.2	1.2	40.6	0.74	89.0	1.08
	March	109.6	1.6	142.0	1.33	207.3	1.65
IV	April	208.3	2.0	241.5	1.71	249.2	1.81

The minimum depth required for fish sustenance of fish species observed in the study area is 0.5 to 0.7 m. The depth available for minimum flows recommended is higher the depth required for sustenance of riverine fisheries.

10.2.2 Length of River with minimum flow

The construction of the hydroelectric projects would lead to conversion of free flowing river into a series of reservoirs interested with dams/diversion structure of various hydroelectric projects. As present, free flow stretch will be available for a stretch of 42.4 km out of a total stretch of 144.2 km from international boundary to Demwe Lower HEP. It is recommended to drop Hutong hydroelectric project, stage 1, so that free flowing river stretch increases to about 50 km i.e. about 35 % of total length of river stretch from international boundary to Demwe Lower HEP. The details are given in Table-10.3.

TABLE-10.3

Details of length of free flow of river in the study area with exclusion of Hutong HEP stage-1

S. No.	Projects	Length of free flow of river (km)
1.	International boundary to submergence of Kalai Stage 1	32.0
2.	Between Kalai HEP Stage-1 and Kalai HEP Stage-2	1.0
3.	Between Kalai HEP Stage-2 and Hutong HEP Stage-2	9.5
4.	Between Hutong Stage - 2 and Anjaw HEP	1.8
5.	Between Anjaw HEP and Demwe Upper HEP	3.8
6.	Between Demwe Upper HEP and Demwe Lower HEP	1.8
	Total	**49.9**

10.2.3 Provision of separate turbine for Environmental Flow-

Since Hutong hydroelectric project stage-I has been recommended to be dropped; all the remaining hydroelectric projects are dam/barrage toe power projects. For these projects, using Building Block Methodology, Environmental Flows have been recommended. It is suggested that for optimal utilization of lean season environmental flow a separate turbine of appropriate capacity be installed in each of the remaining hydroelectric projects. Continuous running of this turbine will ensure optimal utilization of Environmental Flows. The capacity of this turbine can be estimated as a part of DPR preparation of individual hydroelectric projects.

10.2.4 Management plan for sustenance of fish species

Based on the field studies, the following migratory fish species are observed in the study area:

- *Schizothorax richardsonii*
- *Acrossocheilus hexagonolepsis*
- *Tor putitora*
- *Tor tor*
- *Labeo pangusia*
- *Chagunius chagunio*
- *Garra gotyla*

The species *Schizothorax richardsonii* and *Acrossocheilus hexagonolepis* migrate from lower elevation to higher elevation in summer months and return to lower elevation in winter months. These species were observed at various sampling locations of all the proposed hydroelectric projects.

The fish species such as *Tor putitora*, *Tor tor* and *Labeo pangusia* migrate to lower elevation in summer months and undertake the return journey in winter months. These species were observed only in the vicinity of the following projects:

- Hutong hydroelectric project, stage-1
- Hutong hydroelectric project, stage-2
- Demwe Upper hydroelectric project
- Demwe Lower hydroelectric project

It is proposed to construct separate hatcheries for snow trout and mahseer in the study area. These hatcheries can be developed by the Department of Fisheries, State Government of Arunachal Pradesh. The stocking program shall comprise of the following:

- Acclimatization stocking (a new fish species is introduced in a water course)
- Supplementary stocking (a species already living in a water body)
- Transfer stocking (transportation of mature fish from one water body to another)
- Repetitive stocking (species which do not propagate in natural conditions).

Hatchery Units

A fish hatchery is the centre of ova production. It helps in propagating the ova of required species and stocking of fish fingerlings to different water bodies. A hatchery can play an important role in the conservation of threatened species and sustenance fishery.

It is proposed to stock the reservoirs of all the projects with fingerlings of *Schizothorax richardsonii* and *Acrossocheilus hexagonolepis.* The rate of stocking shall be 50 per ha.

It is proposed to stock the reservoirs of the following projects with fingerlings of *Tor putitora, Tor tor and Labeo pangusia:*

- Hutong hydroelectric project, stage-1
- Hutong hydroelectric project, stage-2
- Demwe Upper hydroelectric project
- Demwe Lower hydroelectric project

The rate of stocking shall be 50 per ha.

The number of fingerlings of *Schizothorax richardsonii* and *Acrossocheilus hexagonolepis* required for reservoir stocking are about 0.199 million. The details are given in Table-10.4.

TABLE-10.4
Details of fingerlings of *Schizothorax richardsonii* and *Acrossocheilus hexagonolepis* required for reservoir stocking

S. No.	Name of the project	Submergence Area (ha)	Stocking rate (no./ha)	Total fingerlings required
1.	Kalai Hydroelectric Project, Stage-1	745	50	37250
2.	Kalai Hydroelectric Project, Stage-2	660	50	33000
3.	Hutong Hydroelectric Project, Stage-1	51	50	2550
4.	Hutong Hydroelectric Project, Stage-2	651	50	32550
5.	Demwe Upper Hydroelectric Project	749	50	37450
6.	Demwe Lower hydroelectric Project	1131	50	56550
	Total	**3987**		**199350**

The number of fingerlings of *Tor putitora, Tor tor and Labeo pangusia* required for reservoir stocking are about 0.129 million. The details are given in Table-10.5.

TABLE-10.5
Details of fingerlings of *Tor putitora, Tor tor and Labeo pangusia* required for reservoir stocking

S. No	Name of the project	Submergence Area	Stocking rate	Total fingerlings
1.	Hutong Hydroelectric Project Stage 1	51	50	2550
2.	Hutong Hydroelectric Project Stage 2	651	50	32550
3.	Demwe Upper Hydroelectric Project	749	50	37450
4.	Demwe Lower hydroelectric Project	1131	50	56550
	Total	**2582**		**129100**

The dimension of the hatcheries, nurseries and rearing units for *Schizothorax richardsonii* and *Acrossocheilus hexagonolepis* is given in Table-10.6. The dimension of the hatcheries, nurseries and rearing units for *Tor putitora, Tor tor and Labeo pangusia* are given in Table-10.7.

TABLE-10.6
Dimensions of units required for development of hatcheries for *Schizothorax richardsonii* and *Acrossocheilus hexagonolepis*

Farm Component	Area (m)	Number	Rate of flow (lpm)
Hatchery building	25x 10 x 4	1	-
Hatching trough each with 4 trays each	5.0x1.0x 0.5	18	3.0-5.0
Nursery ponds (Cement lined)	9.0 x 1.5 x 0.5	8	25-50
Rearing tanks (cement lined)	10.0x 1.5 x 1.0	26	75-100
Stock raceways (cement lined)	30.0 x 6.0x 1.5	7	150-200
Storage – cum – Silting tank	6.0 x 4.0	1	-
Office store & laboratory room	8.0 x 6.0	3	-
Watchmen hut	4.0 x 4.0	1	-

TABLE-10.7

Dimensions of units required for development of hatcheries for *Tor putitora, Tor tor and Labeo pangusia*

Farm Component	Area (m)	Number	Rate of flow (lpm)
Hatchery building	25x 10 x 4	1	-
Hatching trough each with 4 trays each	4.0x1.0x 0.5	16	3.0-5.0
Nursery ponds (Cement lined)	9.0 x 1.5 x 0.5	5	25-50
Rearing tanks (cement lined)	9.0x 1.5 x 1.0	16	75-100
Stock raceways (cement lined)	30.0 x 6.0x 1.5	5	150-200
Storage – cum – Silting tank	6.0 x 4.0	1	-
Office store & laboratory room	8.0 x 6.0	3	-
Watchmen hut	4.0 x 4.0	1	-

The cost for fisheries development shall be shared amongst all the various hydro-electric projects proposed to be developed in the study area.

In case of Demwe Lower hydroelectric project, trapping and transportation coupled with hatcheries has been reccomended by EAC, MoEF as a part of Environment clearance of Project, as it is flexible and more convenient to operate irrespective of height difference between upstream and downstream water levels, fluctuations in water levels or quantity of migrating fish to be transported.

A Steering Committee of the project would be constituted for the monitoring of the project as listed in Table-10.8.

TABLE-10.8

Steering Committee constituted for the monitoring of fisheries development

S. No.	Officer	Position
1	Secretary (Fisheries) to the Government of Arunachal Pradesh	Chairman
2	Representative of District Collector	Member
3	Representative of Department of Power, state government of Arunachal Pradesh	Member
4	Nominated representative of local public	Member
5	Nominated representative of proponents of various hydroelectric projects	Member
6	Assistant Director of Fisheries, state government of Arunachal Pradesh	Member Secretary

The main task of the Committee shall be:

- Review of the progress and adequacy of various measures being implemented for sustenance of riverine fisheries.
- Consideration of the need for any mid-course change in the project component.

10.3 CONSERVATION OF THREATENED FLORA

During the course of survey, only one species i.e., *Lagerstroemia minuticarpa* classified as endangered plant species as per IUCN Red list was found in the submergence area of Hutong hydroelectric project, stage-2 and Demwe Upper hydroelectric project. The density of *Lagerstroemia minuticarpa* in Hutong hydroelectric project, stage-2 and Demwe Upper hydroelectric project is about 5 to 10 trees/ha respectively.

It can be concluded tha the density of *Lagerstroemia minuticarpa found in the submergene of* in Hutong hydroelectric project, stage-2 and Demwe Upper hydroelectric project is quite low, i.e. 5 to 10 trees/ha. However, a detailed study is reccomended as a part of the CEIA study of individual projects specially Hutong

Stage-2 and Demwe Upper hydroelectric project, to ascertain the impacts on *Lagerstroemia minuticarpa* and suggest appropriate conservation and management measures on this account.

10.4 RECOMMENDATIONS

10.4.1 Maintenance of free flow of river

The one of the major impact on hydrologic regime is on account of change in the free flowing condition of the river. With the construction of the proposed hydroelectric projects, the free flowing river shall be available on an intermittent basis only for a length of 42.4 km in a stretch of 144.2 km of the study area comprising of Lohit river upto Brahmakund in the Indian portion. It is recommended to drop Hutong HEP Stage-1 as it will make about 9.5 km of river stretch in the complete free flow stretch.

This will increase the length of free flow of river from 42.4 km to about 50 km i.e. about 35 % of total length of river stretch from international boundary to Demwe Lower HEP. The details are given in Tables-10.9 and 10.10.

TABLE-10.9

Details of length of free flow of river in the study area considering all the proposed projects

S. No.	Projects	Length of free flow of river (km)
1.	International boundary to submergence of Kalai Stage I	32.0
2.	Between Kalai HEP Stage-1 and Kalai HEP Stage-2	1.0
3.	Between Kalai HEP Stage-2 and Hutong HEP Stage-1	2.0
4.	Between Hutong HEP Stage-2 and Anjaw HEP	1.8
5.	Between Anjaw HEP and Demwe Upper HEP	3.8
6.	Between Demwe Upper HEP and Demwe Lower HEP	1.8
	Total	**42.4**

TABLE-10.10

Details of length of free flow of river in the study area with exclusion of Hutong HEP stage-1

S. No.	Projects	Length of free flow of river (km)
1.	International boundary to submergence of Kalai Stage 1	32.0
1.	Between Kalai HEP Stage-1 and Kalai HEP Stage-2	1.0
2.	Between Kalai HEP Stage-2 and Hutong HEP Stage-2	9.5
3.	Between Hutong Stage - 2 and Anjaw HEP	1.8
4.	Between Anjaw HEP and Demwe Upper HEP	3.8
5.	Between Demwe Upper HEP and Demwe Lower HEP	1.8
	Total	**49.9**

The length of river stretch from international boundary to the dam site of Demwe lower HEP is 144.2 km, which will be affected after construction of all proposed HEP. The free flow stretch with all proposed projects will be 42.4 km which will be 29.40% of the river stretch from international boundary to Demwe lower HEP. After dropping Hutong Stage 1 HEP the free flow stretch will be increased by 7.5 km (i.e. 3 km of submergence stretch, 4.5 km stretch of HRT) and will become about 50 km which is around 35 % of the river stretch from international boundary to Demwe lower HEP.

10.4.2 Minimum Environmental Flow

The Terms of reference for the following projects has been cleared:

- Kalai hydroelectric project stage-1
- Kalai hydroelectric project stage-2
- Hutong hydroelectric project stage-2
- Demwe Upper hydroelectric project
- Demwe Lower hydroelectric project

It is recommended that the minimum environmental flow as suggested in table 10.1 for various hydroelectric projects shall be maintained for sustenance of aquatic ecology and downstream user requirements.

10.4.3 Conservation of Flora of under threatened category

During the course of survey, only one species i.e., *Lagerstroemia minuticarpa* classified as endangered plant species as per IUCN Red list was found in the submergence area of Hutong hydroelectric project, stage-2 and Demwe Upper hydroelectric project. The density of *Lagerstroemia minuticarpa* in Hutong hydroelectric project, stage-2 and Demwe Upper hydroelectric project is about 5 to 10 trees/ha respectively. It can be concluded that the density of *Lagerstroemia minuticarpa* found in the submergene of in Hutong hydroelectric project, stage-2 and Demwe Upper hydroelectric project is quite low, i.e. 5 to 10 trees/ha. However, a detailed study is recommended as a part of the CEIA study of individual projects specially Hutong Stage-2 and Demwe Upper hydroelectric project, to ascertain the impacts on *Lagerstroemia minuticarpa* and suggest appropriate conservation and management measures on this account.

The lower elevations of the basin study area are presently degraded due to high human pressure, large scale lopping and removal of fodder and timber species, grazing, construction of road, etc. Nayar and Sastry (1987-1990) have reported 35 species of rare and endangered plant species from Arunachal Pradesh. Of these threatened species *Acer oblongum* var. *microcarpum, Begonia burkillii, Calanthe manii, Dioscorea deltoidea, Paphiopedilum wardii* and *Phoenix rupicola* have been reported from low hills in the altitudinal range of 300-1200 m. The details are given in Table-10.12. There is a possibility that some of these species may be present in the project area though the present surveys were not able to record these in the field.

It is thus recommended that a study should be conducted as a part of the CEIA study for proposed projects on these aspects. If these species are observed, then an appropriate conservation plan shall be prepared.

TABLE-10.12

Rare, vulnerable and endangered plants reported in the Study Area

S. No.	Species	Family	Altitude (m)	Habit	Status
1.	*Acer oblongum* var. *microcarpum*	Acerceae	500-1200	Tree	Endangered
2.	*Begonia burkillii*	Begoniaceae	300-1000	Herb	Rare
3.	*Calanthe manii*	Orchidaceae	Up to 1000	Herb	Rare
4.	*Dioscorea deltoidea*	Dioscoreaceae	300-3000	Climber	Endangered
5.	*Paphiopedilum wardii*	Orchidaceae	Up to 1000	Herb	Rare
6.	*Phoenix rupicola*	Arecaceae	Up to 450	Tree	Rare

Source: CEIA Report, Demwe Lower hydroelectric project

10.4.4 Conservation of economically important plant species

The density of various economically important plant species in the submergence area of various hydroelectric projects is given in Table-7.13 of Chapter 7 of this report.

In Kalai Hydroelectric Project, Stage-1, seven economically important plant species were recorded. They were namely, *Ficus cunia*, *Macaranga denticuiata*, *Nephrolepis cordifolia*, *Alnus nepalensis*, *Rubus* spp., *Thysanolaena maxima* and *Saurauria nepalensis*.

At various sampling sites, Kalai Hydroelectric Project, Stage-2, various plants of economic importance such as timber, medicinal, edible fruits were commonly observed. *Canarium strictum* is a very good incense yielding tree and *Pandanus odoratissima* is a fiber yielding tree species. These are seen commonly here and there at the project sites.

Five economically important plants were recorded from Hutong Hydroelectric Project, Stage-1 viz., *Ficus cunia*, *Macaranga denticulata*, *Nephrolepis cordifolia*, *Rubus* spp. and *Thysanolaena maxima.*

About 9 economically important plant species were recorded from the study area in

Hutong Hydroelectric Project, Stage-2. These include *Clerodendron colebrookianum*, *Ficus cunia*, *Macaranga denticulata*, *Nephrolepis cordifolia*, *Rubus* spp., *Terminalia myriocarpa*, *Thysanolaena maxima*, *Saurauria nepalensis* and *Spondias pinnata*.

About 12 economically important plant species were recorded from the study area in Demwe Upper Hydroelectric Project. These species include *Clerodendron colebrookianum, Ficus cunia, Ficus roxburghii, Macaranga sp., Nephrolepis cordifolia, Pandanus odoratissima, Rubus spp., Terminalia myriocarpa, Thysanolaena maxima, Saurauria nepalensis, Sapium baccatum and Spondias axillaries.*

Ten economically important plant species were recorded from the study area in Demwe Lower Hydroelectric Project. Plant of economical importance such as timber (*Terminalia myriocarpa*, *Dalbergia sissoo,),* medicinal *(Nephrolepis cordifolia, Spondias pinnata*), edible fruits (*Ficus roxburhghii, Rubus* sp.*)* and *Macaranga spp*. known for fuel wood value were commonly seen here and there at the project site.

It is recommended that the economically important plant species be grown as a part of Compensatory Afforestation Programme, which is to be implemented as a part of Environmental Management Plan for each hydroelectric project proposed to the developed in the basin area.

10.4.5 Afforestation

The total forest area to be diverted for various project appurtenances needs to be ascertained as a part of the project related studies. The Indian Forest Conservation Act (1980) stipulates:

- If non-forest land is not available, compensatory afforestation are to be established on degraded forest lands, which must be twice the forest area affected or lost, and
- If non- forest land is available, compensatory forest are to be raised over an area equivalent to the forest area affected or lost.

The quantum of forest land to be diverted except for Demwe Lower hydroelectric project cannot be ascertained at this stage, as DPRs are yet to be finalized. Compensatory afforestation, NPV and cost of trees need to be included as a part of the Environmental Management Plan to be prepared as a part of the CEIA study of individual hydroelectric projects in the study area.

10.4.6 Measures to prevent degradation due to increased labour population

Keeping in view the sudden influx of labour population in the areas, the following actions are suggested for the conservation of flora and fauna in the region.

- The project authorities need to ensure that strict vigil is kept especially during the breeding season of animals.
- Care should be taken during blasting operations and prevailing norms for the same should be followed.
- Penalties should be imposed for violation of this conduct by contractors/labour, etc. during this period.
- These aspects can be included in the Tender Document for the Contractor involved in construction works.
- Information dissemination emphasizing the need of conservation and legal consequences on violation of Forest and Wildlife (Protection) Acts be prioritised and publicised.
- Awareness needs to be imparted to the labour engaged in construction activities for exerting great restraint especially during critical months of breeding and nesting of animals and birds.
- Signboards/Notice boards highlighting penalties for violation of rules, need to be put nearby habitation areas of labour population.
- Strict monitoring of labour and associated workers for any activity related to endangering the life or habitat of wild animals and birds.
- Strict restrictions need to be imposed on the workers at project sites to ensure that they do not harvest any produce from the natural forests and cause any danger or harm to the animals and birds.
- Where the project site is in the close vicinity of natural animal/bird habitats, minimum level of noise during construction activities need to be maintained, and care should be taken up during night.
- Fuel wood to the labour and technical staff involved in construction phase be provided from plantations meant for the purpose and/or the provision should be made for the supply of the free subsidized

kerosene/LPG from the depots being set up for this purpose to avoid forest degradation and animal habitats.

- Interference of human population need to be kept to the minimum and it should be ensured that the contractors do not set up labour colonies in the vicinity of forests and wilderness areas.

10.4.7 Anti-Poaching Measures

During construction phase of each hydroelectric project, in and around the main construction areas where construction workers congregate, some disturbance to the wildlife population may occur. Therefore, adverse impacts are anticipated on wildlife due to various construction activities. In view of this it is recommended that adequate number of check posts be developed in the major construction area and in vicinity labour camps for each project during construction phase to prevent anti-poaching activities in the area. Each check post shall have 4 guards to ensure that poaching does not take place in the area. The guards will be supervised by a range officer.

It is also recommended that the staff manning these check posts have adequate communication equipment and other facilities. Apart from inter-linking of check posts, communication link needs to be extended to Divisional Forest Office and the local police station also.