Environmental Assessment Report

Full Environmental Impact Assessment Report
Project Number: 41627-04
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IND: Himachal Pradesh Clean Energy Development Investment Program – Sainj Subproject (Tranche 3)

Prepared by WAPCOS Limited

ENVIRONMENTAL IMPACT ASSESSMENT
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ABBREVIATIONS AND ACRONYMS

AAQM	-	Ambient Air Quality Monitoring
CAT	-	Catchment Area Treatment
CEIA	-	Comprehensive Environmental Impact Assessment
CHC	-	Community Health Centre
DEM	-	Digital Elevation Model
DPR	-	Detailed Project Report
EC	-	Electrical conductivity
EIA	-	Environmental Impact Assessment
EIMU	-	Environmental Impact Management Unit
EMP	-	Environmental Management Plan
FCC	-	False Color Composite
FRL	-	Full Reservoir Level
PFR	-	Pre-Feasibility Report
GIS	-	Geological Information System
GHNP	-	Great Himalayan National Park
GOI	-	Government of India
GPP	-	Gross Primary Productivity
HEP	-	Hydroelectric Project
HRT	-	Head Race Tunnel
HPSEB	-	Himanchal Pradesh State Electricity Board
IDC	-	Interest During Construction
IMD	-	India Meteorological Department
MDDL	-	Minimum Draw Down Level
MOEF	-	Ministry of Environment and Forests
MOWR	-	Ministry of Water Resources
MOU	-	Memorandum of Understanding
MU	-	Million Units
MW	-	Mega Watt
NOC	-	No Objection Certificate
NOx	-	Nitrogen Oxides

NPRR	-	National Policy for Resettlement & Rehabilitation
PAP	-	Project Affected People
PAF	-	Project Affected Families
NRSA	-	National Remote Sensing Agency
PHC	-	Primary Health Centre
ROR	-	Record of Rights
R&R	-	Resettlement & Rehabilitation
RPM	-	Respirable Particulate Matter
SAV	-	Study Area Village
SPCB	-	State Pollution Control Board
SPL	-	Sound Pressure Level
SPM	-	Suspended Particulate Matter
SPSS	-	Statistical Package for Social Sciences
SO_2	-	Sulphur dioxide
STP	-	Sewage Treatment Plant
SYI	-	Silt Yield Index
TRT	-	Tail Race Tunnel
TDS	-	Total Dissolved Solids
WAPCOS	-	Water and Power Consultancy Services (I) Limited

CHAPTER-1

INTRODUCTION

1.1 GENERAL

The Himachal Pradesh State Electricity Board (HPSEB) proposes to develop the Sainj hydro-electric project with a total installed capacity of 100 MW in the state of Himachal Pradesh. The project has been handed over to Himachal Power Corporation Limited (HPCL) under the control of Government of Himachal Pradesh. The project is located up-stream of the Parbati stage –III (520 MW) project, which at present is under construction. The proposed Sainj Hydro Electric project is located in Sainj Sub Tehsil of district Kullu at a distance of about 35 km from NH-21. The project is a runoff river scheme over river Sainj, a tributary of river Beas. The barrage site is proposed to be located near village Niharani of Godapur Panchayat. Likewise, power house is proposed near village Suind of Rohilla panchayat in Sainj sub-tehsil and Banjar main tehsil of Kullu district. The power house of the Sainj Hydro-electric project is located about 300 m upstream of proposed power house of the Parbati Stage-II. The barrage and power house sites are located at a distance of 58 km and 46 km from Kullu, (district headquarters) respectively. The project location has been shown in Figure-1.1.

The Pre-Feasibility Report (PFR) of Sainj hydro-electric project (100 MW) was prepared by HPSEB during 1998-99. The state government of Himachal Pradesh Govt. signed a memorandum of understanding (MOU) with M/s. Jindal Hydro electric Company Ltd. on June 14, 2002. The Jindal Hydro Electric Company Ltd. had submitted DPR of the project, however, the state government of Himachal Pradesh cancelled the MOU with Jindal Hydro Electric Company Ltd., during June 2004 and the project was handed for to HPSEB for commissioning.

1.2 NEED FOR THE PROJECT

In the present developing state of country's economy, there is a great requirement of electrical power for both industrial and agricultural use. As per power position, requirement during March-April'03 in the Northern Region was 156,610 MU against the availability of 144,218 MU. Thus, there was a deficit of and 7.9%, for Northern Region. This deficit will continue to increase even after commissioning of various power projects in the Northern Region as indicated in the anticipated power supply position in 2006-07 (X^{th} plan). As per this report, in the year 2006-07, total energy and peak energy demands in the Northern Region were 220,820 MU and 355,540 MU against availability of 181,468 MU and 229,667 MU, respectively. Thus, there was a deficit of 17.80% and 16.5% for total energy and peak energy respectively in the Northern Region. The corresponding deficit figures on all India basis were 12.9% and 12.3% respectively. Thus, energy crisis in Northern Region is quite severe.

With the limited coal resources and difficult oil position all over the world, it is necessary that electricity generation be aimed to achieve the economic balance of 40:60 between the hydro and thermal generation of power, as against the existing 25:75 ratio. Thus it is of utmost importance to commission hydroelectric projects.

1.3 POLICY, LEGAL AND ADMINISTRATIVE FRAMEWORK

A Comprehensive Environmental Impact Assessment (CEIA) report is prerequisite for obtaining Environmental Clearance. HPSEB has awarded the work for Comprehensive Environmental Impact Assessment Study for the Sainj hydroelectric project to Water and Power Consultancy Services (India) Limited, a Government of India Undertaking under the Ministry of Water Resources vide letter No.HPSEB/LCC/DB-SAINJ/06-6974-77 dated 8.12.06. The Agreement for the implementation of the study was signed on 14.02.2007.

The principal Environmental Regulatory Agency in India is the Ministry of Environment and Forests (MOEF), Government of India. MOEF formulates environmental policies and accords environmental clearance for the projects. The State Pollution Control Board (SPCB) accords No Objection Certificate (NOC) Consent for Establishment and consent for Operation for the projects.

As per the guidelines pertaining to Environmental clearance issued by Ministry of Environment and Forests (MoEF) dated September 14, 2006, the Terms of Reference (TOR) for the EIA study is to be approved by MoEF. In this connection Form-I alongwith TOR in the prescribed format was submitted to MoEF. The same was received by the Environmental Appraisal Committee of River Valley Projects of MoEF. The TOR was approved by MoEF vide their letter no. J-12011/33/07-IA.I dated 12.07.2007. A copy of the TOR approved by MoEF is enclosed as Annexure-I.

1.4 SCOPE OF THE EIA STUDY

The brief scope of EIA study includes:

- Assessment of the existing status of physico-chemical, ecological and socio-economic aspects of environment
- Identification of potential impacts on various environmental components due to activities envisaged during construction and operational phases of the proposed hydro-electric project.
- Prediction of significant impacts on major environmental components using appropriate mathematical/simulation models.
- Delineation of Environmental Management Plan (EMP) outlining measures to minimize adverse impacts during construction and operational phases of the proposed project.
- Formulation of Resettlement and Rehabilitation Plan.
- Formulation of Catchment Area Treatment (CAT) Plan.
- Formulation of environmental quality monitoring programmes for construction and operation phases.

- Estimation of Cost for implementation of Environmental Management Plan, Resettlement & Rehabilitation Plan, Catchment Area Treatment Plan and Environmental Monitoring Programme.

1.5 STAGES IN AN EIA STUDY

The purpose of this section is to enumerate the steps involved in an Environmental Impact Assessment (EIA) study, which are described in the following paragraphs.

Scoping : An exhaustive list of all likely impacts drawing information from as many sources as possible was prepared. The next step was to select a manageable number of attributes which were likely to be affected as a result of the proposed project. The various criteria applied for selection of the important impacts were follows :

- magnitude
- extent
- significance

Description of Environment : Before the start of the project, it is essential to ascertain the baseline levels of appropriate environmental parameters which could be significantly affected by the implementation of the project. The baseline status assessed as a part of CEIA study involved both field work and review of data collected from secondary sources.

Prediction of Impacts: is essentially a process to forecast the future environmental conditions of the project area that might be expected to occur as a result of the construction and operation of the proposed hydroelectric project. An attempt was generally made to forecast future environmental conditions quantitatively to the extent possible. But for certain parameters which cannot be quantified, general approach was to discuss such intangible impacts in quantitative terms so that planners and decision-makers were aware of their existence as well as their possible implications.

Environmental Management Plan: the approach for formulation of an Environmental Management Plan (EMP) is to maximize the positive environmental impacts and minimize the negative ones. The steps suggested included modifications of plans, engineering designs, construction schedules and techniques, as well as operational and management practices. After selection of suitable environmental mitigation measures, cost required for implementation of various management measures was also estimated.

Environmental Monitoring Programme: An Environmental Monitoring Programme for implementation during project construction and operation phases has been estimated to oversee the environmental safeguards, to ascertain the agreement between prediction and reality and to suggest remedial measures not foreseen during the planning stage but arising during operation and to generate data for further use.

1.6 OUTLINE OF THE REPORT

The document for the Comprehensive EIA study for the proposed Sainj hydroelectric project has been presented in two volumes. Volume-I presents the Environmental Impact Assessment (EIA) study and Volume-II delineates the Environmental Management Plan. The present document (Volume 1) outlines the findings of the EIA study for the proposed Sainj hydroelectric project. The contents of the document are organized as follows:

Chapter-1 The Chapter gives an overview of the need for the project. The policy, legal and administrative framework for environmental clearance has been summarized. The objectives and need for EIA study too have been covered.

Chapter-2 gives a brief description of the proposed Sainj hydroelectric project.

Chapter-3 outlines the methodology adopted for conducting the Comprehensive EIA study for the Sainj hydroelectric project.

Chapter-4 covers the environmental baseline conditions covering physical aspects of environment. The baseline study involved both field work and review of existing documents, which is necessary for identification of data which may already have been collected for other purposes.

Chapter-5 presents the biological aspects of environment. The study is based on collection of data from various secondary data sources. As a part of the Comprehensive EIA study detailed ecological survey for was conducted for various seasons. The findings of the study were analysed and ecological characteristics of the study area have been described in this Chapter.

Chapter-6 covers Pre-project environmental baseline conditions covering socio-economic aspects of environment. The baseline study involved data collection using primary as well as secondary sources of data and public consultation.

Chapter-7 describes the anticipated positive and negative impacts as a result of the construction and operation of the proposed hydro-power project. It is essentially a process to forecast the future environmental conditions of the project area that might be expected to occur as a result of the construction and operation of the proposed project. An attempt was generally made to forecast future environmental conditions quantitatively to the extent possible. But for certain parameters, which cannot be quantified, general approach has been to discuss such intangible impacts in qualitative terms so that planners and decision-makers are aware of their existence as well as their possible implications.

CHAPTER-2

PROJECT DESCRIPTION

2.1 GENERAL

The Sainj hydroelectric project has been contemplated as run off the river scheme which envisages construction of barrage across river Sainj near village Niharani, located on the right bank of the river. The power house is proposed with two units of 50 MW each to be located near confluence of Jiwa Nallah and river Sainj, which is about 300 m upstream of the proposed power house of the Parbati Stage-II Hydro-electric Project. The energy generation of 399.57 GWh at 90% dependable year and 436.90 GWh at 50% mean year is envisaged as a result of commissioning of the project.

2.2 ALTERNATIVES CONSIDERED

Proposal – I

The proposal envisaged diversion of inflow of Sainj river with diversion barrage ±24.50 m high near Niharni at El ± 1730m, 3.76 dia, 6.30 km long HRT with 2 Nos. adits, i.e. one adit ±320 m long meeting HRT at RD 930 m on left bank of Kartaul nallah and ±430 m long meeting HRT at RD 4750 m, u/s of the Surge Shaft, a Surge Shaft, a ±560 m long Pressure Shaft and an underground Power House at EL ± 1347.80 m on the right bank of river Sainj near village Suind, for generating 100 MW of power utilizing a gross head of 409.60 m, 2 No. units each of 50 MW with vertical axis Pelton turbines shall generate 399.57 GWH of energy in 90% dependable year. The feasibility of all the proposed components were checked at site alongwith Geological Survey of India (GSI) team. The proposal was found to be most suitable,

as it is facilitated with two nos. construction adits to the Head Race Tunnel, which will reduce the construction time of tunnel excavation.

Proposal – II

The alignment of water conductor of this proposal is about 400 m towards the uphill side of the proposal-I. The features of this proposal are similar to proposal-I, except that the HRT length increases from 630 km to 645 km and only one No. adit of length ±600 m in reverse grade at Kartaul nallah has been available. During the site visit alongwith GSI team, no rock face was encountered on left bank of Kartaul nallah for adit portal and also adit to the tunnel alignment was available to reduce the construction time of tunnel. The tunnel alignment also passes under a maximum cover of ±1180 m, resulting into development of maximum stresses on HRT.

In addition, all approaches to the tunnel face shall be longer lengths, which will also increase the construction time, considering the above factors, the alternative was ruled out.

Proposal – III

The alignment of water conductor system of this proposal is about ±450 m towards valley side of the Proposal-I. The proposal envisages construction of a rock fill dam ±30 m high at El. 1728 m, near village Niharni, 3.50 m dia, 625m long HRT to carry a design discharge of 27.60 cumecs, with one No. adit about 1.5 km u/s of Surge Shaft. In this proposal the HRT opens on the banks of Kartaul nallah and crosses it by an pipe aqueduct ±120 m long, supported on RCC pillars, a Surge Shaft, ±545 m long Pressure Shaft, and underground Power House at El. 1336 m, generating 100 MW of Power with a gross head a 415.10 m by 2 Nos. vertical shaft Francis type Turbine each of 50 MW and shall generate about 409 GWhr of energy in 90% dependable year.

The proposal was not adopted due to the following considerations:

- Aqueduct over Kartaul nallah will always remain under threat of washing away due to occurrences of flash floods in the nallah as a result of heavy rains and cloud bursts in the catchment area.

- The hill slops along the bank of Kartaul nallah at aqueduct crossing require heavy slope protection works, resulting into significant expenditure. The structure will also be under threat due to falling boulders on the pipe aqueduct.

- The aqueduct pipe requires to be supported on ±25 m high RCC pillars. A water conductor system of such a nature in a high seismic prone area will always remain under threat at the time of earthquake.

All the above three proposals were studied and the proposal No.-1 was found to be most favourable and attractive on techno-economical grounds and was finally adopted. The various alternative considered as a part of the study area.

2.3 PROJECT FEATURES

The salient features of project are briefly described as below:

- 24.5 m high Diversion gated barrage at an elevation of ±1733m, downstream of village Niharni on river Sainj. The FRL and MDDL is proposed at an elevation of ±1752 m and ±1738.50 m respectively, to attain a live storage of ± 38.41 ham to meet up diurnal peaking requirement during lean months.

- Two underground disilting tanks (145mx15mx7.5m) to exclude all silt particles down to 0.2 mm Size.

- A Head Race Tunnel (HRT) on the right bank of river Sainj, of about ±6.3 km long with 3.76 m diameter designed to carry a discharge of 28.70 cumec.

- Two intermediate adits 320 m and 430 m long and 4 m D-shaped proposed at RD 930 m and 4750 m respectely to facilitate construction of HRT.

- An underground restricted orifice surge shaft at the end of HRT - adit to top elevation ±1766.5 m and another adit at Bottom Elevation +1672.37m is proposed to facilitate the construction of surge shaft

- An underground pressure shaft of ±2.75 m diameter, 550 in long to carry discharge into power house.

- An underground power house to be located on right bank of river Sainj near confluence of Jiwa Nallah and Sainj river, which will have two units of 50 MW each to provided total installed capacity of 100MW.

- A tail race tunnel (TRT) of 400 m long and 4.8 m D-shaped, will constructed for discharging the water back into river Sainj.

The salient features of the project are given in Table-2.1. The layout plan has been shown in Figure-2.2

TABLE–2.1
Salient features of Sainj hydroelectric project

Location	
State	Himachal Pradesh
District	Kullu
River	Sainj, a tributary of river Beas
Barrage site	Near village Niharni
Power house site	Near village Suind
Hydrology	
Catchment area at diversion site	408 sq.km.
Snow catchment	176 sq.km. above El. 4250 m
Mean annual rainfall	1047.72 mm
Probable Maximum flood }	1800 cumec
Standard project flood }	
Observed maximum flood	437.04 cumec at Talara
Reservoir	
Full reservoir level (FRL)	1752.00 m
Maximum reservoir level (MRL)	1753.00 m
Minimum draw down level (MDDL)	1738.50 m
Gross storage upto FRL 1752 m	42.31 ha.m.
Live storage	38.41 ha.m.
Peaking available	4 hrs.
Diversion Structure	
Type	Gated Barrage
Max. height from river bed	24.50 m
Elevation of top of barrage	El. 1754.50 m
Average bed level	El. 1730.00 m
Spillway	
Design flood	1800 cumec
Type	Gated spillways with radial gates
Nos. of spillways, Crest elevation	3 Nos. El. 1733.00 m
Clear waterway of spillways	8 m each
Energy dissipation	Depressed stilling basin
	El. 1726.00 m
Length	45 m
Downstream bed level	El. 1729 m

Intake structure

Type	Surface
Sill level	El. 1735.00 m
No. & size of opening	4 No., 4.0 m x 19.50 m
Total drawdown discharge	35.88 cumec

Approach Tunnel

No.	1
Velocity	2.85 m/sec
Length	100 m
Design discharge from intake	35.88 cumec

Desilting Arrangement

Type	Underground, central gutter type
No. of basins	2 nos.
Length of each basin	145 m
Size of each basin	Width 15.00 m, Depth 7.50 m
Minimum particle size to be removed	0.2 mm
Flushing tunnel, size	4.00 m, D-Shaped, length-670 m
Adits to hoisting chambers	2 Nos., 230 m, length-320 m

Head Race Tunnel

No.	1
Size & Shape	3.76 m diameter, modified horse shoe shaped, concrete lined
Length	6300 m
Design discharge	28.70 cumec
Adit-I (left bank of Kartaul Nalllah and meeting HRT at RD 930 m)	4 m D-shaped, 320 m length

Surge Shaft

Type	Underground, restricted orifice type
Size	9 m dia, 87.00 m high
Orifice	1.25 m dia

Pressure Shaft

Type	Underground
Size	1 No., 2.75 m dia, $\pm$550 m long
Velocity	4.83 m/sec

Power House

Type	Underground
Installed capacity	100 MW
No. and capacity of unit	2 Nos. 50 MW each
Size of machine Hall	59.40 m x 18.90 m x 29.70 m
Type of turbine	Pelton, Vertical Axis
Maximum net head	400.70 m
Minimum net head	387.20 m

Tail Race Tunnel

Size and shape	4.80 m diameter, D-shaped concrete lined
Length	±400 m

Power Generation

Installed capacity	2 x 50 MW
Annual energy generation:	
- 90% dep. Year	399.57 GWhr
- 50% mean year	436.90 GWhr

Cost Estimate

Capital cost of the project
(At June, 2005 price level)

Civil works	Rs.304.13 crore
Electrical works (P-Production)	Rs.213.82 crore.
Cost of generation	Rs.517.95 crore
Transmission	Rs.27.21 crore
Total cost including generation	Rs.545.16 crore
Generation cost (including Escalation Rs.52.04 Cr. & IDC Rs.60.09 Cr.)	Rs.630.08 crore
Loan 70%	Rs.441.06 crore
Equity 30%	Rs.189.02 crore

The power generated will be fed into the northern region grid through a 220 KV transmission system. The project is proposed to be operated as a peaking station for power absorption in the grid. The project has a distinct advantage of very easy accessibility and as such requires minimum infrastructure work.

The project is located in the vicinity of the Great Himalayan National Park (GHNP) and Sainj Wildlife sanctuary. The boundary of the GHNP is at a distance of about 1.5 km from the barrage site. Likewise, boundary of the Sainj Wildlife Sanctuary is at a distance of about 2 km from the proposed barrage site.

2.4 LAYOUT PLAN

The proposed Sainj hydroelectric project shall comprise of the following components:

- Barrage
- Reservoir
- Intake structure
- Desanding arrangement
- Head race tunnel
- Surge shaft
- Pressure shaft
- Power house
- Tail race tunnel

Barrage

A 35 m long and 24.5m high barrage including abutments and piers with crest level of barrage bays at El 1733 m has been proposed to pass the estimated design flood at FRL El 1752.00m. The proposed barrage comprises 3 bays of 8.00 m each with 3.00 m thick piers.

Reservoir

The reservoir spreads over an area of 4.06 ha and is about 500 m long. The full reservoir level (FRL) is fixed at El 1752.00m. The minimum draw down level (MDDL) has been fixed at El 1738.50 m. The reservoir is so formed has a gross storage capacity of 42.31 ha-m at FRL and 3.90 ha-m at MDDL. Available diurnal storage of 38.41 ha-m is sufficient for running the power station as a peaking station at full installed capacity for 4.00 hours per day during the period of lean flows.

Intake Structure

The intake structure comprising single intake 4 no. openings, has been proposed on the right bank of river, to handle a discharge of 35.88 cumec. A semi-circular trash rack structure with reinforced concrete columns has been proposed for intake. Crest elevation of intake is proposed as 1735m. Intake gate has been proposed for controlling flow through intake bays 4 nos. (4.00m x19.50m).

Desanding arrangement

An underground desanding arrangement to exclude all silt particles down to 0.2 mm has been proposed ± 100m d/s of barrage on the right bank of river sainj. Two nos desanding chambers each (145m x 15m x 7.5m), flushing gallery and other auxiliary structures has been proposed. Two adits to inlet and outlet ventilation cum hoisting gallery have been proposed for their operation if required for the cleaning of the chambers. Deflushing tunnel of 670 m length, 4.00m D- shaped has been proposed to flush out the silt as accommodated in the hoppers of desanding chambers. A gate has also been proposed at its tail end to prevent the entry of water/debris during flood season as safety measures.

The Head Race Tunnel

The head race tunnel 3.76 m dia, 6300m modified horse shoe type has been proposed to carry a design discharge of 28.70 cumec from the junction point of feeder tunnels of desilting chamber to the surge shaft. The tunnel is located along right bank of river Sainj. Two intermediate adits have been proposed for the construction of tunnel. One intermediate adit of 4 m D-shaped, 320m length has been proposed along the left bank of Kartaul nallah, meeting the HRT at RD 930m. Another intermediate adit of 4 m D-shaped , 430 m length has been proposed meeting HRT at RD 4750m.

Surge Shaft

The underground restricted orifice type surge shaft of 9m dia and 87.00 m height has been proposed at the outlet end of Head Race Tunnel at RD 6300m top level of surge shaft is proposed at El 1767.50m. Two adits each 4m x 6m D-shaped, one approaching the top at El 1767.00m and other at the bottom at El 1672.87 m has been proposed.

Pressure Shaft

A 2.75m-dia-pressure shaft with centerline at El 1674.75 m will take off from surge shaft for leading the water in to turbines. In the initial 50 m horizontal reach, a valve gallery has been proposed to accommodate butterfly valve. After top horizontal reach pressure shaft of 1.95m dia, 30 m each length, takes off from the main pressure shaft to feed two units in the powerhouse.

Power House

The proposed underground powerhouse is located on the right bank of Sainj river near Suind. The erection bay and transformer hall floor levels are proposed at El 1347.8m. The approach to power house and transformer hall cavern is through 7m D-shaped main excess tunnel.

Tail Race Tunnel

The outflow from the bottom of turbine will be to tail race tunnel 4.80 m D-shaped, 400 m length. A vertical lift gate has been proposed at the tail end to prevent entry of silt during flood season.

2.5 OTHER ACTIVITIES

The following components are proposed to be constructed as a part of the proposed Sainj hydroelectric project.

Project roads

Approach roads 5/7 m wide of total length 19.50 km will be constructed to connect different sites of the project. The existing road from Suind to Neuli (8 Km long) has also been proposed to be widened.

Bridges

Five number of RCC bridges have been proposed on Sainj river and other nallahs crossing to connect the existing road and project road.

Colony at Sundarnagar

A permanent residential / non-residential complex for planning and design organization will be constructed at Sundarnagar Mandi. The same can be used for monitoring/ planning liaison purpose after the completion of the project.

Colony at Ropa

A permanent residential / non-residential colony for the construction of the project is proposed to be constructed at village Ropa, which is on the mid-way to proposed barrage and power house sites. Labour huts, stores and field offices will be constructed near Barrage, Adit, Kartaul, Suind near surge shaft.

Office complex for outlet side works

Office complex for the construction of barrage, power house complex, penstock, surge shaft and tunnel is proposed at Ropa village.

Schools and Hospitals

Adequate provision of building for Hospital, school etc. has been made in the project estimate under Sub-Head K-buildings to cater for construction force. First aid posts shall be provided at all project sites.

2.6 LAND REQUIREMENT

The total land required for the project is 56.763 ha. The category wise detail of land required is given in Table -2.2.

TABLE-2.2

Component wise area requirement for Sainj H.E.P

Name of the component	**Ownership wise break-up**		
	Forest Land/Govt. land (ha)	**Private Land (ha)**	**Grand Total (ha)**
Barrage and submergence	4.8	0.844	5.1664
Dumping cum job facility	7.012	3.717	10.729
Road and bridge	26.747	1.683	28.43
Colony and Labour colony	1.663	0.664	2.327
Site store and other job facility	1.718	1.862	3.58
Sub-Total	**41.94**	**8.77**	**50.71**
Under ground	6.053	-	6.053
Grand Total	**47.993**	**8.77**	**56.763**

2.7 CONSTRUCTION EQUIPMENT

The lists of major equipment to be used during construction phase are listed as below:

- Crushers
- Batching plant
- Aggregate processing plant
- Dumpers
- Concrete Mixer
- Excavator
- Loader
- DG Sets
- Compactor
- Compressor
- Concrete pump
- Ventilation Blower
- Boomer

2.8 CONSTRUCTION PERIOD

The project is proposed to be completed within a time frame of about 4.5 years.

CHAPTER-3

METHODOLOGY ADOPTED FOR THE EIA STUDY

3.1 INTRODCUTION

Standard methodologies of Environment Impact Assessment were followed for conducting the CEIA study for the proposed Sainj hydroelectric project. A brief account of the methodologies and matrices followed in the present study is given below under different headings. All the methods were structured for the identification, collection and organization of environmental impact data. The information thus gathered has been analysed and presented in the form of a number of visual formats for easy interpretation and decision-making.

3.2 STUDY AREA

The study area covered as a part of the EIA study is as below (Refer Figure 3.1).

1.	Upstream of the dam site	10 km on either side from the periphery of reservoir submergence
2.	Downstream of the dam site	10 km on either side of the river.
3.	Catchment Area	Catchment area intercepted at barrage site

3.3 SCOPING MATRIX

Scoping is a tool which gives direction for selection of impacts due to the project activities on the environment. As a part of the study, scoping exercise was conducted selecting various type of impacts which can accrue due to hydroelectric project. Based on the project features, site conditions, various parameters to be covered as a part of the EIA study were selected. The results of scoping analysis are presented in Table-3.1.

TABLE-3.1

Scoping Matrix for EIA study for the proposed Sainj hydroelectric Project

Aspects of Environment	**Likely Impacts**
A. Land Environment	
Construction phase	- Increase in soil erosion - Pollution by construction spoils - Acquisition of land for labour colonies - Solid waste from labour camps/ colonies.
Operation phase	- Acquisition of land for various project appurtenances - Loss of agricultural and forest land due to submergence
B. Water resources & water quality	
Construction phase	- Increase in turbidity of nearby receiving water bodies - Degradation of water quality due to disposal of wastes from labour, colony and construction sites
Operation phase	- Modification of hydrologic regime
C. Aquatic Ecology	
Construction phase	- Increased pressure on riverine fisheries as a result of indiscriminate fishing by the labour population. - Reduced productivity due to increase in turbidity levels as a result of disposed off effluents from construction sites.
Operation phase	- Impacts on spawning & breeding grounds - Degradation of riverine ecology - Impacts on migratory fish species - Impact on aquatic ecology due to The drying of the river stretch
D. Terrestrial Ecology	
Construction phase	- Increased pressure from labour to meet their fuel wood requirements - Adverse impacts on flora and fauna due to increased accessibility in the area and increased influx of human population - Loss of forest due to construction of road and other project appurtenances

Aspects of Environment	**Likely Impacts**
Operation phase	- Loss of forests in the submergence area - Impacts on wildlife movement - Impacts on wildlife habitats
E. Socio-Economic Aspects	
Construction phase	- Increased employment potential during the project construction phase - Development of allied sectors leading to greater employment - Pressure on existing infrastructure facilities. - Cultural conflicts and law and order issues due to migration of labour population
Operation phase	- Loss of lands - Loss of private properties - Impacts on archaeological and cultural monuments, if any - Impacts on mineral reserves, if any
F. Air Pollution	
Construction Phase	- Impacts due to fuel combustion in various construction equipment - Impacts due to increased vehicular movement - Fugitive envisions from various sources - Impacts due to emissions of DG sets
G. Noise Pollution	
Construction Phase	- Noise due to operation of various construction equipment - Noise due to increased vehicular movement - Impacts due to blasting - Increased noise levels due to operation of DG sets
H. Public Health	
Construction Phase	- Increased incidence of water related diseases - Transmission of diseases by immigrant labour population
Operation phase	- Increased incidence of vector borne diseases

Based on the Scoping matrix, the environmental baseline data has been collected. The project details have been superimposed on environmental baseline conditions to understand the beneficial and deleterious impacts due to the construction and operation of the proposed project.

3.4 DATA COLLECTION

Primary surveys were started in April 2007 and conducted in different seasons of the year to collect data on flora, fauna, forest types and ecological parameters, geological and soil features. During these surveys data and information was collected on physico-chemical, biological and socio-economic aspects of the study area. In addition, detailed surveys and studies were also conducted for understanding bio-diversity in the study area.

3.4.1 Physico-chemical aspects

Physiography

Spatial database on physiographic features were taken from various sources including Survey of India (SOI) topographic sheets, satellite data and analysed with Geographic Information System (GIS) tools. These data were collected, arranged and presented according to the EIA methods used in the study. These data were organized and presented in the form of general drainage map of the catchment and its sub-watersheds. In addition, a gradient profile indicating river profile was calculated from the origin of the river up to the barrage site. A slope model for the catchment area of intercepted at the dam site of the proposed Sainj hydroelectric project was digitized from the contours of Survey of India topographical sheets at 1:50,000 scale, following a 40 m contour interval. The contours were traced from the toposheets, scanned and digitized. From the digital data, a digital elevation model

(DEM) for the project area as well as its sub-watersheds of the free draining catchment of the project was generated.

The area for each slope category was calculated for entire catchment. Percent area under various slope categories namely gently sloping, moderately sloping, strongly sloping, moderately steep to steep, steep, very steep and escarpments were calculated for the entire catchment.

Geology

The regional geology around the project area highlighting geology, stratigraphy and structural features were based on the existing information on these aspects contained in Detailed Project Report (DPR) of the project.

Hydrology

Hydrological data for river Sainj as available in the Detailed Project Report was collected and suitably incorporated in the Comprehensive EIA study.

Landuse pattern

Landuse pattern of the study area as well as the catchment area was carried out by standard methods of analysis of remotely sensed data and followed by ground truth collection and interpretation of satellite data. For this purpose digital satellite data was procured from National Remote Sensing Agency, Hyderabad, IRS-P6 LISS-IV. The data was processed through ERDAS software package available with WAPCOS.

Soil

The soil quality was monitored at various locations in the catchment area. The monitoring was conducted for three namely summer (April 2007), post-monsoon (October 2007) and Winter (December 2007). The parameters monitored were:

- pH
- Electrical Conductivity

- Organic Matter
- Sodium
- Phosphates
- Potassium
- Nitrates
- Cation Exchange Capacity
- Sulphates
- Chlorides
- Amoniacal Nitrogen
- Particle Size Distribution

Water Quality

The existing data on water quality has been collected to evaluate river water quality on upstream and downstream of the project site. The water quality was monitored for three seasons namely. The details of time of sampling are given as below:

- Summer season - April 2007
- Post-monsoon - October 2007
- Winter season - December 2007

The water samples were collected from the study area and analyzed for physico-chemical parameters which are listed in Table-3.2.

TABLE-3.2
Water quality parameters analysed as a part of the field studies

pH	Zinc
Electrical Conductivity	Cadmium
TDS	Magnesium
Sulphates	Lead
Chlorides	Manganese
Nitrates	Fluorides
Phosphates	Hardness
Sodium	DO
Potassium	BOD
Calcium	COD
Copper	Oil & grease
Iron	Total Coliform

Ambient air quality

The ambient air quality was monitored at three locations in the study area. Monitoring was conducted for three seasons namely summer (April-May 2007) and

post-monsoon season (October 2007) and winter (November-December 2007). The frequency of monitoring in each season was twice a week for four consecutive weeks. The parameters monitored were SPM, RPM, SO_2, and NOx.

Ambient Noise level

As a part of the EIA study noise level was monitored at various locations in the study area. Monitoring was conducted for three seasons namely summer (April 2007), post-monsoon (October 2007) and winter (December 2007). At each station, hourly noise level was monitored.

3.4.2 Ecological Aspects

Terrestrial Ecology

Flora

Data on forest type legal status and their extent in the catchment and study area has been collected from forest department. The other relevant data on bio-diversity economically important species medicinal plant. Rare and endangered species in the study area and its surroundings have been collected from secondary sources like research institute forest and wild life department. In addition field studies were conducted to collect data on various aspects in the study area. The sampling sites were selected based on topography and floristic composition. The various aspects studied were floral density frequency and abundance of species of trees, shrubs, herbs and grasses. Plant of economical species and meditional use and endangered species were also identified as a part of the study.

The monitoring was conducted for the following three seasons:

- Summer season : April 2007
- Post-monsoon season : October 2007
- Winter season : January 2008

Fauna

The assessment fauna have been done on the bases secondary data collected from different government offices like forest department, wildlife department, fisheries department etc. The presence of wildlife was also confirmed from the local inhabitants depending on the animal sightings and the frequency of their visits in the catchment area. In addition review of secondary data was another source of information for studying the fauna of the area. In addition, sightings of faunal population during ecological survey and then field studies was also recorded as a part of the data collection exercise.

Aquatic Ecology and fisheries

Water samples from river Sainj were also collected as a part of field studies. The density and diversity of periphyton and phytoplanktons, species diversity index and primary productivity etc. were also studied. The field studies were conducted for three seasons, namely summer (April 2007) and post-monsoon (October 2007) and winter season (January 2008).

The data on the prevailing fish species in the river Sainj was collected from Fisheries Department and through literature review as well. Fishing was done at various sites in the project area and river stretches both upstream and downstream of the barrage site to ascertain the dispersal pattern of fish species. Identification and measurements of all the fish catch was done and an inventory of the fish species was also prepared. Various migratory species and the species to be affected due to conversion of lentic to lotic conditions as a result of commissioning of the proposed project were also identified.

3.4.3 Socio-economic Aspects

Demography

The demographic and socio-economic characteristics of the submergence area as well as the study area have been studied through primary as well secondary sources. Detailed socio-economic census survey was conducted in all the affected villages due to the proposed project. Collection of data was completed at two levels - at village/ block and individual household level. The socio-economic survey at the village/ block level was aimed at finding out the status and extent of amenities and resources at the disposal of villages/ blocks. The household surveys were conducted with the main aim of evolving and preparing compensatory and rehabilitation packages for families who would be rendered houseless, landless and whose part of land would be acquired for various project activities. Based on the assessment of demographic profile of Project Affected Families (PAFs), Resettlement and Rehabilitation Plan using guidelines and norms as per Policy laid down for Parbati Stage-II and National Policy on Resettlement and Rehabilitation (2007) was formulated.

Public consultation

A Public Consultation meeting was conducted on 07/12/2007. The public consultation was conducted by the officials of Himachal Power Corporation Limited (HPCL) and attended by the local villagers. The local attendance included about 26 villagers from the affected villages. The public consultation delved in many issues relating to environment, socio-economic conditions, etc. One of the issues that came to the light was to disposal of muck, which would be extracted during construction phase of the project. The participants suggested to the officials of HPCL to ensure proper disposal of muck at designated sites and to ensure to protect the environment

and the natural water sources. The participants were also of the view that the forests in the vicinity of the project area should be protected, as many of their needs are catered to by the forests. The participants also mentioned and suggested to the officials of HPCL that atleast 15% of stored water should be released (as per Government norms) to facilitate survival of fish. They also suggested that fish ladders to be constructed for up-stream and down-stream movement of fish in the river. Another issue that came to light was regarding the poor health care facilities in the project area. In addition, the participants communicated that at present the employment rate is about 10% while the remaining are un-employed. The economy of the locals is primarily agrarian, where wheat, maize, paddy, pulses, etc are cultivated. Some farmers also cultivate apples. During discussions, it was observed that the participants perceived benefits in terms of rising opportunities for employment, better education and health care facilities would result from the construction of the proposed project. Last but not the least, the participants communicated that they welcome the project and extended their whole hearted support to HPCL for construction of the project. They reiterated that taking people (affected families/ population) into confidence would ensure success of the project. They suggested that local panchayat bodies and self help groups may be involved in the implementation of the project.

3.5 SUMMARY OF DATA COLLECTION

The summary of the data collected from various sources is outlined in Table-3.3.

TABLE-3.3

Summary of data collected from various sources

Aspect	Mode of Data collection	Parameters monitored	Frequency	Source
Meteorology	Secondary	Temperature, humidity, rainfall	-	India Meteorological Department (IMD)
Water Resources	Secondary	Flow, Design hydrograph and design flood hydrograph	-	Detailed Project Report (DPR)
Water Quality	Primary	Physico-chemical and biological parameters	Three seasons	Field studies for summer, Post-monsoon and winter seasons
Ambient air quality	Primary	RPM, SPM, SO_2, NOx	Three seasons	Field studies for summer, Post-monsoon and winter seasons
Noise	Primary	Hourly noise and equivalent noise level	Three seasons	Field studies summer, Post-monsoon and winter seasons
Landuse	Primary and secondary	Landuse pattern	-	NRSA and Ground truth Studies
Geology	Secondary	Geological characteristics of study area	-	Detailed Project Report (DPR)
Soils		Physico-chemical parameters	Three seasons	Field studies for summer, post-monsoon and winter seasons
Terrestrial Ecology	Primary and secondary	Floral and faunal diversity	Three seasons	Field studies for summer, post-monsoon and winter seasons. Secondary data

Aspect	Mode of Data collection	Parameters monitored	Frequency	Source
				as available with the Forest and Wild life Department
Aquatic Ecology	Primary and Secondary	Presence and abundance of various species	Three seasons	Field studies for summer, post-monsoon and winter seasons. Secondary data as available with the Fisheries Department
Socio-economic aspects	Primary and secondary	Demographic and socio-economic, Public health cultural aspects	-	Field studies for PAFs, secondary data collection from Revenue Department and literature review.

3.6 IMPACT PREDICTION

Prediction is essentially a process to forecast the future environmental conditions of the project 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. The environmental impacts predicted are as follows:

- Loss of land.
- Displacement of population due to acquisition of private and community properties.
- Impacts on hydrologic regime.
- Impacts on water quality.

- Increase in incidence of water-related diseases including water borne and vector-borne diseases.
- Effect on riverine fisheries including migratory fish species.
- Increase in air pollution and noise level during project construction phase
- Impacts due to sewage generation from labour camps
- Impacts due to acquisition of forest land
- Impacts due to increase in terrestrial and aquatic ecology due to increased human interferences during project construction and operation phases.

3.7 ENVIRONMENTAL MANAGEMENT PLAN AND COST ESTIMATES

Based on the environmental baseline conditions and project inputs, the adverse impacts were identified and a set of measures have been suggested as a part of Environmental Management Plan (EMP) for their amelioration.

The management measures have been suggested for the following aspects:

- Compensatory afforestation and bio-diversity conservation plan
- Catchment Area Treatment
- Fisheries Management Plan
- Public health delivery system
- Environmental management in labour camp
- Muck Management Plan
- Restoration of quarry sites and landscaping of construction sites
- Management of Impact due to construction of road
- Greenbelt development plan
- Control of Air Pollution
- Measure for noise control
- Water pollution control
- Resettlement and Rehabilitation Plan

The expenditure required for implementation of these management measures has also been estimated as a part of the EMP study.

3.8 RESETTLEMENT AND REHABILITATION PLAN

As a part of the CEIA study, a socio-economic survey of project affected families was conducted. As a part of the survey, information on family profile, occupational profile, income, land holding, crop grown, assets owned, etc. was collected. Based on the findings of the survey and the norms of outlined in National Policy for Resettlement and Rehabilitation (NPRR) 2007, a Resettlement and Rehabilitation Plan has been formulated.

3.9 CATCHMENT AREA TREATMENT PLAN

As a part of the CEIA study, a catchment area treatment plan for the catchment area intercepted at the project site has been formulation. Various sub-watersheds have been categorized into different erosion categories, as per Silt Yield Index (SYI) method. For high and very high erosion categories a catchment area treatment plan comprising of engineering and biological measures has been formulated.

3.10 ENVIRONMENTAL MONITORING PROGRAMME

It is necessary to continue monitoring of certain parameters to verify the adequacy of various measures outlined in the Environmental Management Plan (EMP) and to assess the implementation of mitigative measures. An environmental monitoring programme for critical parameters has been suggested for implementation during project construction and operation phases. The staff, necessary equipment and agencies to be involved for implementation of the Environmental Monitoring Programme and costs have also been indicated.

CHAPTER-4

BASELINE SETTING FOR PHYSICO-CHEMICAL ASPECTS

4.1 GENERAL

Before start of any Environmental Impact Assessment study, it is necessary to identify the baseline levels of relevant environmental parameters which are likely to be affected as a result of the construction and operation of the proposed project. A similar approach has been adopted for conducting the EIA study for the proposed Sainj hydroelectric Project. A Scoping Matrix as outlined in Chapter-3 was formulated to identify various issues likely to be affected as a result of the proposed project. Based on the specific inputs likely to accrue in the proposed project, aspects to be covered in the EIA study were identified. The other issues as outlined in the Scoping Matrix were then discarded. Thus, planning of baseline survey commenced with the shortlisting of impacts and identification of parameters for which the data needs to be collected.

The baseline status has been divided into following three categories:

- Physico-chemical aspects
- Ecologcal aspects
- Socio-Economic aspects.

The baseline setting for physico-chemical aspects have been covered in this Chapter.

4.2 METEOROLOGY

The climate of the project area is characterised by cool and dry climate. Meteorologically, the year can be divided into three distinct seasons. Winter season sets in from the month of October and continues upto February, followed by summer season from March to June. The area receives rainfall under the influence of south-west monsoons over a period of three months from July to September.

Temperature

The temperature in and around the project area varies significantly with elevation. The period from March to June is the period of continuous rise in temperature. June is the hottest month of the year, with mean maximum and minimum monthly temperatures of the order of 32.9°C and 26.6°C respectively. With the onset of monsoons in early July, there is an appreciable drop in the temperature. After the withdrawal of monsoons by about middle of September, both day and night temperatures decrease. January is the coldest month of the year. During winter months, temperature goes even below the freezing point for some days, especially at night. The monthwise temperature variations is given in Figure-4.1.

Rainfall

The monsoon rainfall occurs mainly during July to September. Maximum rainfall is received in the month of July and August. The annual average rainfall in the project area is 1459.2 mm. Majority of the annual rainfall is received under the influence of south-west monsoons. During the period from January to April, winter precipitation occurs in association with the passage of western disturbances. The winter precipitation accounts for nearly 40% of the annual rainfall. The rainfall as received in various months of the year is given in Figure-4.2.

Snowfall

The upper reaches of Sainj catchment receives, heavy snow falls in the month of December and January. The catchment area intercepted at barrage site is 408 sq. km. of which about 176 sq. km is under snow. The runoff proposed to be diverted at barrage site, is mostly due to snowmelt caused by the diurnal temperature changes in

the upper reaches. The snowmelt starts from February and continues up to October. In the remaining three months, i.e. from November to January, the runoff reduces drastically.

Humidity

Relative humidity is maximum (91%) during the monsoon months, while it is minimum (50%) in the summer months of April-May. Humidity is normally higher in the morning hours than during the afternoon hours.

Cloud Cover

Heavily clouded to overcast sky conditions prevail during the monsoon months from July to September. During winter months too, overcast conditions are observed for few days as a result of passage of western disturbances. Skies are mostly clear to lightly clouded during rest of the year.

Special Weather Phenomenon

During winter season, western disturbances affect the weather over the district. Thunderstorms occur between March to October, with maximum incidence during April to June. Fog appears occasionally in the valleys during the winter months.

The average meteorological conditions in the project area district are summarized in Table-4.1.

TABLE-4.1

Average meteorological conditions in the project area

Month	Temperature (^oC)		Rainfall (mm)	Humidity (%)	
	Maximum	Minimum		8.30 A.M.	5.30 P.M.
January	10.0	-1.8	145.0	76	68
February	11.1	-1.0	145.6	72	65
March	15.9	2.8	187.3	60	55
April	21.6	6.1	111.3	50	48
May	24.9	8.6	69.1	57	50
June	26.6	12.4	94.5	71	58
July	25.5	14.8	235.0	86	75
August	25.0	14.6	243.6	91	81
September	24.7	10.4	108.4	86	73
October	22.5	5.4	33.1	73	65
November	18.4	1.3	39.8	62	58
December	14.0	-0.3	46.5	60	54
Average	20.0	6.1		71	63
Total			**1459.2**		

4.3 Geology

Regional Geology

Geologically the area falls in the Lesser Himalayan segment of the North-West Himalayas. The project area falls in the geological domain of Larji-Rampur tectonic window zone. The Larji-Rampur Window Zone exposes, two Granitoid Complex bodies namely (i) the Bandal Granitoid Gneisses in the north west and (ii) the Jeori-Wangtu Granitoid Gneiss in the south-west. The Bandal Granaitoid Gneiss is considered equivalent to the Jeori-Wangtu Gneissic Complex on the basis of similarity in tectonic position, lithology and chronology of the rocks. The Bandal Gneisic Complex, spread over 500 km^2 is exposed in Garash valley (in the north west) to the Sainj valley (in the south east), where it has been reportedly enveloped by the Manikaran Quartzite. The Bandal Granitoid Gneiss with litho-trend long NNW-SSE

and comprising porphyroclastic as well as medium to coarse-grained gneiss and mylonitic gneiss.

The Rampur Group presents an association of metabasalts and metasediments. The Rampur Group is divisible into the three formations:

- Bhallan Formation
- The Banjar Volcanics
- The Manikaran Formation.

The general lithostratigraphy of the area is given below :

Mesoproterozoic	Larji Group	Aut Formation	Stromatolitic dolomite and limestone
		Hurla Formation	White, Pink and Purple quartzite with shale partings
		Naraul Formation	Quartzarenite, calcarenit, shale, slate and coglomerate
	Rampur Group	Manikaran Formation	Grey and white massive quartzarenite with interbands of metabasalt
		Banjar Volcanics	Mainly metabasalts as dark green phyllite with interbands of quartzite and gray phyllite
		Bhallan Formation	Slates, greenish phyllite schists and white flaggy quartzarnite
	Palaeo	Baqndal-Jeori	Gneissic Complex-pegmatite, aplite quartz veins
	Proterozoic	Wangtu	Banded streaky and augen Gneiss Quartz-biotite schist, garnet-mica schist chlorite schist, etc.

Geology of the Project Area

The project area falling within the Bandal Gneissic Complex of the Larji Rampur tectonic window is banded by latitudes 31^{o}45’ and 31^{o}50’ and longitudes 77^{o}19’ and

77°25' falling in Survey of India toposheet no. 53E/5. The various project components are proposed to be located along the right bank of the Sainj river valley. The inaccessibility and limited outcrop has restricted the geological data collection mostly in the lower reaches as such a highly tentative geology of the project area has been evolved. The upstream of the project area is occupied by gneissic rocks of Bandal Gneissic Complex comprising granitoid gneiss with zones of younger intrusive granitoids and amphibolites. The litho-sequence thrust over the massive quartzite of Manikaran Formation, which in turn overlie the green phyllites of Banjar Volcanics-belonging to Rampur Group of rocks.

The Bandal gneisses are represented mainly by prophyroclastic granite gneiss. This gneiss predominates the gneissic complex and has been further intruded by younger granitoid (gneiss) of fine to medium graintoid of granular character in a lit pear lit fashion and defines major zones in between intake site and Kartaul nala area. The amphibolites represent basic intrusive within the gneises occurring frequently in the area in varying dimensions defining thick zones around Neuli where the recede of the right valley wall may be attributed to the collapse of the amphibolite zones. Further downstream of zone with frequent interbands of chlorite and mica schist within the porphyroclastic gneiss has also been delineated. The prophyrclastic gneiss gradually passes into a streaky and strongly foliated type in the near vicinity of the underlying massive quartzite defining characters of mylonite and hence attests the presence of a thrust in between gneissic sequence and the underlying Manikaran Quartzite.

The rocks of Rampur Group are exposed in the downstream part of the project area. The Manikaran Quartzite first spears at Ropa village and continues in the downstream

area with a gradual decrease in thickness. The rock is represented by massive thickly bedded quartzite with occasional and minor interbands of green phyllite. The litho-unit overlies the green phyllite disoformably, however shows sheared contacts at places. The Banjar metabasic volcanics is represented by green phyllite (quartz-chlorite schist). The lithounit in upper part exhibits stretched amygdules.

Barrage Site

The proposed axis of diversion barrage marked at site is located about 120 m u/s of wooden bridge across Sainj khad near Niharni village. At this site, no exposed rock was observed on left bank while on right bank, the exposed rock was about 50 m away of river bank involving huge excavation and protection works.

The gneises rock is exposed on both the banks which is fresh and hard and trend in N20^{o}W-S20^{o}E whose dip varies between 50^{o}-55^{o} in North Easterly direction i.e. in upstream direction. Within the gneises, thin bands of porphyritic and augen gneisses occur. On both the abutments the slopes in general are stable.

Head Race Tunnel

The head race tunnel of the project is proposed on the right bank and will be about 6.3 km long. The reconnaissance geological studies have revealed that the H.R.T. will be excavated through thick bands of porphyritric and augen gneisses, ganitods, pale to greenish quartzites. The H.R.T. will cut these rocks oblique to the foliation. One construction adit is proposed in HRT in Kartaul khad which will meet the HRT at $\pm$2.5 km from inlet. The bed of Kartaul khad is not very steep and the length of adit is about 65 m.

Surge Shaft

At the end of head race tunnel, an underground surge shaft ±9m dia, 87 m height with the bottom elevation ±1672.37 m and top level ±1767.5 m is expected to lie in quartzite in the lower part of gneisses. As the litho boundary of the overlain gneisses and quartzite present a tectonic contact, the rocks in this zone are expected to be highly shear and fractured. As the thrust zone is prone to develop battle and open fractured in the rock and lies well within the surge level. The surge shaft will require to be suitably designed so that there should not be any eepage into the surrounding rock mass. The detailed surveys for surge shaft, penstock and powerhouse are in 1:1000

Pressure Shaft

The underground pressure shaft, ±2.70 m dia, ±550 m long is proposed on ridge between surge shaft and power house location. Rocks exposed along proposed pressure shaft alignment may be phyllites, phylitic quartzites and bands of quartzites of Banjar formation. The slope of the hill appears to be stable.

Power House

The proposed underground powerhouse is located on right bank of Sainj about 150 m u/s of confluence of Sainj river with Jiwa nallah. The bed rock around power house will be phyllites, phyllitic quartzites and quartzites of Banjar formation, whose trend of foliation varies between N50^{o}W-S50^{o}E to N60^{o}W-S60^{o}E direction and the dip varies between 40^{o}-50^{o} in North-East direction. At the proposed site of power house a comparatively flatter terrace is available.

4.4 SEISMOLOGY

The project area falls in under seismic zone-V, as per IS: 1894: 2002 i.e highest seismic zone in Western Himalayas. In the past, the region has been affected with a number of strong earthquakes. Since year 1720, 17 nos. of earthquakes of intensity greater than 5 on Richter scale have been reported in the area. The most devastating earthquake recorded in the region, is the Kangra earthquake of 1905, which caused considerable damage to life and property in Kullu district. Other major quakes are Chamba-1945, 1947, 1950 (M=6.5, 6.6, & 5.5); Dharamshala 1978, 1986 (M= 5&5.7) and Kathua-1980 (M=5.3).

The major earthquake causing considerable damage in last 100 year sin the region are given in Table- 4.2.

TABLE-4.2

List of major earthquakes in the region in last 100 years

Year	Earthquake	Magnitude
1905	Kangra	7.8
1906	Kullu	6.4
1930	Sultanpur	6.0
1945	Chamba	6.0
1947	Chamba	6.0
1950	Chamba	6.0
1951	Chamba-Udhampur	6.0
1955	Lahual-Spiti	6.0
1962	Chamba-Udhampur	6.0
1975	Kinnaur	6.8
1978	Dharamshala	5.0
1980	Kathua	5.3
1986	Dharamshala	5.7
1986	Uttarkashi	6.6
1995	Chamba	-
2004	Kangra	5.1

Source: Amateur Seismic Centre, Pune, 2007

The project area falls in iso-seismals of 4.0-4.0 of the Kangra earthquake. The major earthquakes enumerated above were generated along the MBT. Appropriate seismic co-efficient from this zone is proposed to be taken up for the design of barrage and other appurtenant structures. The other major dislocation in and around the area are as follows.

4.5 LAND USE PATTERN

Landuse describes how a patch of land is used (e.g. for agriculture, settlement, forest), whereas land cover describes the materials (such as vegetation, rocks or buildings) that are present on the surface. Accurate land use and land cover identification is the key to most of the planning processes.

The land use pattern of the study area has been studied through digital satellite imagery data. Digital IRS-P6, LISS-III satellite imagery (Path: 095, Row: 048) dated 9th May,2007 was procured from National Remote Sensing Agency (NRSA), Hyderabad. The data was processed through ERDAS software package available with WAPCOS.

Multi-variate statistics have been used for the analysis of multi-spectral data. As a first step, clustering algorithms was established to a set of multi-variate class statistics against which each pixel measurement vector in the scene was compared. Then a classification decision rule, such as the probability of maximum likelihood that the pixel belongs to a particular class amongst the statistics set was calculated and the pixel was assigned to the particular class. The information classes most often considered include both cover type or community type descriptors as well as limited structural categories, such as crown cover and size class: of the trees.

Although two different approaches to the development of the multi-variate statistics

are used, unsupervised and supervised, their combination gives better results. In the unsupervised classification, the radiance values of the image data set were submitted to clustering algorithms that generate statistics until the stopping rule i.e. minimum number of points per cluster, was reached and the minimum distance between clusters and separability measure was established. Another approach is to 'seed' spectral space with starting points to establish candidate mean value for clusters, and then iterate the clustering procedure until minimization criteria is achieved. In the supervised method, training sites with known properties were used to extract spectral statistics from the image data by interactively identifying the sites in the imagery. Ground truthing was done for site identification. In the unsupervised method, identification of the cluster was done after completing the classification by comparing the spatial distribution of the mapped classes with ground reference data.

The wide geographic distribution and the range of sites and climates occupied by forests complicates the understanding of the interaction of forests with solar radiation. Many forests grow in uneven mountainous terrain. The terrain relief produces large variations in how solar radiation reaches the forests and produces land form shadows. Terrain relief also generates large micro-climate variations in temperature, precipitation, and soil properties that produces large differences in forest composition and activity over elatively small geographic areas. Vegetation indices are an aid for obtaining accurate results. The DN values of different bands can be combined mathematically to create output images that can be used extensively in forest analysis to bring out small differences between vegetation classes. These mathematical combinations are called indices and if chosen judiciously, they highlight and enhance

differences, which cannot be observed in the display of original color bands. Indices also help in minimizing shadow effects in satellite multi-spectral images. Ground truth studies were conducted in the area to validate various signals in the satellite images and correlate them with different land use domains. The image obtained after the vegetation index, enhancement becomes a single band data Le. The grey set. The grey set was merged with the colored False Color Composite (FCC). This image was then classified using the prominent signatures extracted based on the past experience. However, this is only a preliminary classification which will be refined further. The FCC and the classified image of the project and its surroundings is given as Figures-4.3 and 4.4 respectively. The landuse pattern of the study area are given in Table-4.3.

TABLE-4.3

Land use pattern of the study area

Landuse Cover	**Area (ha)**	**Percentage of Study Area (%)**
Dense vegetation	19999	39.73
Open vegetation	21199	42.10
Forest area	41198	81.83
Agriculture land	1670	3.32
Barren land /pasture land	4854	9.64
Water body	1187	2.36
Snow covered area	1389	2.76
Built-up area/Exposed rock	54	0.11
Total	**50352**	**100.00**

It is evident from Table-4.3, that the major land use category in the study area is forest, which accounts for almost 81.83% of the study area. The other major category is barren land accounting for about 9.64% of the study area. The agriculture land accounts for about 3.32% of the study area. The area under snow and water body

account for about 2.76% and 2.36% of the study area. The area under settlement / exposed rock is about 0.60% of the study area.

4.6 SOILS

Soil is the product of geological, chemical and biological interactions. The soils in the region vary according to altitude and climate. The soil in the project area and study area are young like any other region of Himalayas. The vegetal cover is one of the most important influencing factors characterizing the soil types in a region. Soil on the slope above 30^{o}, due to erosion and mass wasting processing, are generally shallow and usually have very thin surface horizons. Such soils have medium to coarse texture. Residual soils are well developed on level summits of lesser Himalayas, Sub-soil are deep and heavily textured.

As a part of field studies, soil depth at various locations in the catchment area ranged from 20 to 50 cm. has been collected during summer, post-monsoon and winter seasons and were analyzed. The sampling stations are shown in Figure- 4.5. The results of the analysis of soil samples for the summer (April 2007), post-monsoon (October 2007) and winter (December 2007) seasons are given in Tables 4.4 to 4.6 respectively.

TABLE-4.4
Results of soil sampling analysis of study area (Summer season)

Parameter	Unit	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
pH	-	6.9	7.4	6.8	7.31	7.21	7.2	7.12	7.55	6.6	7.1
Electrical Conductivity	micro mhos/ cm	18.3	28.3	19.2	20.5	22.3	19.3	25.4	22.7	25.1	27.3
Organic Matter	%w/w	8.7	Nil	Nil	7.7	3.7	4.8	5.8	Nil	7,6	Nil
Sodium (as Na),	mg/kg	4555	3500	7800	6000	5011	6600	3890	4210	5100	5000
Phosphates (as P)	mg/kg	12.8	19.6	15.8	14.7	17.6	16.7	18.1	17.9	13.6	18.2
Potassium (as K)	mg/kg	137	500	360	280	140	400	500	250	260	380
Nitrates (as	%w/w	173	180	94	125	98	158	98	98	130	150

Parameter	Unit	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
NO_3)											
Cation Exchange Capacity	meq/ 100 gm	12.8	13.7	12.2	11.8	13.5	13.0	12.1	13.4	13.0	13.4
Sulphates (as SO_4)	mg/kg	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Chlorides (as cl)	mg/kg	230	380	320	255	293	260	328	365	217	260
Ammonical Nitrogen	mg/kg	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Particle Size Distribution,	%w/w										
>0.25mm	%w/w	19.6	4.2	10.9	12.5	13.6	14.5	11.3	10.8	13.8	8.5
0.25 to 0.149mm	%w/w	27.0	27.0	21.3	27.3	27.5	32.2	26.0	26.8	27.9	28.7
0.149 to0.088mm	%w/w	32.2	48.6	41.8	36.1	40.1	33.6	44.1	43.5	35.4	38.5
0.088 to 0.074mm	%w/w	10.6	11.8	19.6	9.9	14.7	13.8	14.3	11.8	13.4	11.6
0.074 to 0.0625mm	%w/w	2.6	1.7	2.1	2.3	1.8	1.6	2.4	1.5	2.0	2.6
0.0625 to 0.053mm	%w/w	1.7	0.9	1.8	1.6	1.7	1.6	1.1	1.3	1.7	1.2
<0.053mm	%w/w	4.4	0.6	1.5	3.7	1.5	1.5	0.9	3.6	2.8	1.9

TABLE-4.5
Results of soil sampling analysis of study area (Post-monsoon season)

Parameter	Unit	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
pH		7.19	7.56	7.78	7.66	7.89	7.46	7.12	7.65	6.54	7.26
Electrical Conductivity	micro mhos/ cm	16.3	26.3	16.2	18.5	20.3	17.3	23.4	21.7	24.1	25.3
Organic Matter	%	0.8	0.9	1.2	1.4	1.2	3.4	2.8	1.2	2.6	1.7
Sodium (as Na),	mg/kg	4455	3138	7190	5400	4511	4400	3390	3510	5400	4100
Phosphates (as P)	mg/kg	10.8	18.6	13.5	12.3	15.5	13.4	16.2	15.9	11.7	15.6
Potassium (as K)	mg/kg	127	480	333	250	110	370	450	220	230	340
Nitrates (as NO_3)	%w/w	163	176	84	115	90	150	88	97	120	145
Cation Exchange Capacity	meq/ 100gm	12.6	13.1	11.2	11.6	13.0	12.3	11.5	12.8	13,0	12.7
Sulphates (as SO_4)	mg/kg	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Chlorides (as cl)	mg/kg	222	374	302	250	289	250	320	350	210	250
Amoniacal Nitrogen	mg/kg	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1

Parameter	Unit	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
Particle Size Distribution,	%w/w										
>0.25mm	%w/w	19.7	5.2	11.9	11.4	14.4	15.3	10.3	11.8	11.5	7.5
0.25 to 0.149mm	%w/w	28.0	31.0	22.3	28.3	30.5	30.2	25.0	26.3	27.7	30.7
0.149 to0.088mm	%w/w	33.2	49.4	426	35.6	40.4	35.6	46.1	44.3	38.4	39.1
0.088 to 0.074mm	%w/w	10.2	11.5	17.6	12.3	15.7	13.2	15.3	10.8	11.2	12.6
0.074 to 0.0625mm	%w/w	2.8	1.5	2.0	2.5	1.8	1.5	2.3	1.7	2.0	2.5
0.0625 to 0.053mm	%w/w	1.9	0.9	1.9	1.5	1.8	1.7	1.3	1.5	1.7	1.4
<0.053mm	%w/w	4.2	0.5	1.7	3.5	1.4	1.7	0.8	3.5	2.5	1.8

TABLE-4.6
Results of soil sampling analysis of study area (Winter season)

Parameter	Unit	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
pH	-	7.1	7.2	6.9	7.3	7.2	7.4	6.9	7.2	6.8	7.0
Electrical Conductivity	micro mhos/ cm	17.4	25.6	18.7	19.6	21.8	18.8	24.8	21.9	24.9	25.4
Organic Matter	%w/w	0.9	0.9	1.2	1.4	1.2	3.2	2.6	1.4	2.5	1.9
Sodium (as Na),	mg/kg	4210	3540	7680	6020	5050	6510	3850	4100	4920	4980
Phosphates (as P)	mg/kg	12.2	18.5	14.9	14.2	16.5	16.4	17.4	17.1	13.2	18.0
Potassium (as K)	mg/kg	131	474	309	264	127	384	472	236	235	350
Nitrates (as NO_3)	%w/w	170	180	88	120	95	154	88	94	118	148
Cation Exchange Capacity	meq/ 100g m	12.5	13.2	11.6	11.6	13.0	12.8	11.8	12.9	13.0	12.8
Sulphates (as SO_4)	mg/kg	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Chlorides (as cl)	mg/kg	220	375	310	250	291	254	325	354	215	255
Ammonical Nitrogen	mg/kg	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Particle Size Distribution,	%w/w										
>0.25mm	%w/w	19.5	4.4	10.5	12.0	13.5	14.4	10.5	10.9	14.1	9.2
0.25 to 0.149mm	%w/w	26.5	29.6	21.5	29.8	27.6	32.0	25.0	26.9	28.4	31.9
0.149 to0.088mm	%w/w	33.4	49.5	41.0	39.4	39.3	33.8	44.8	43.1	36.1	39.4
0.088 to 0.074mm	%w/w	10.5	12.6	21.4	9.5	14.4	13.4	13.6	11.8	14.2	12.5
0.074 to 0.0625mm	%w/w	2.5	1.2	2.5	2.8	2.0	1.8	2.8	1.8	2.4	3.0

Parameter	Unit	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
0.0625 to 0.053mm	%w/w	1.8	1.9	1.9	2.1	1.8	2.0	1.5	4.2	1.9	1.4
<0.053mm	%w/w	5.8	1.9	1.3	3.7	1.4	2.6	1.8	4.2	2.9	2.8

The pH of soil at various sites lies within neutral range. The levels of NPK indicate moderate to high soil productivity. The sodium levels do not indicate any potential for soil salinization or adverse impacts on soil productivity.

In a hydroelectric project, no significant impact on soil quality is expected barring, soil pollution at local level due to disposal of construction waste. For amelioration of such impacts appropriate management measures are recommended.

4.7 WATER REOURCES

The proposed project is envisaged as a run off the river scheme on river Sainj. River Sainj is the major tributary of the river Beas, originating from west of Rakti Dhar at an elevation of ±5500 m. It traverses in westerly direction and is joined by river Tirtan before its confluence with river Beas near village Larji. A sub-tributary (Jiwa Nalla) joins river Sainj near village Suind. The total catchment 'area of river Sainj intercepted at the barrage site is 408 sq.km. of which 176 sq.km. is permanently under snow (above elevation of 4250 m). The river is perennial in nature as it is fed by snowmelt. Over one-third of the catchment area intercepted at diversion structure site is under snow.

As per the Detailed Project Report, the 10 daily flow 90% dependable year and 50% mean year flow at Sainj barrage site have been estimated based on average of 12 years data available from 1993 to 2004. The same is outlined in Table-4.7.

TABLE-4.7
10 daily flows at barrage site

Month	Period	90% dependable Year	50% mean year
June	I	26.79	26.18
	II	24.54	45.85
	III	26.99	55.71
July	I	28.09	33.70
	II	47.22	50.12
	III	56.51	54.18
August	I	43.40	49.33
	II	33.89	56.81
	III	25.30	51.98
September	I	22.38	32.98
	II	12.97	25.92
	III	6.53	19.09
October	I	5.90	15.57
	II	5.83	13.05
	III	5.58	11.75
November	I	4.82	10.72
	II	5.18	9.90
	III	8.16	9.36
December	I	7.92	8.36
	II	7.36	6.85
	III	6.95	6.01
January	I	6.65	5.44
	II	6.38	5.24
	III	6.28	5.20
February	I	6.08	4.98
	II	6.24	4.75
	III	6.48	5.04
March	I	6.02	5.40
	II	6.37	5.55
	III	7.38	5.85
April	I	8.42	6.79
	II	9.27	9.18
	III	11.54	11.58
May	I	16.92	14.98
	II	22.41	12.76
	III	19.00	16.43

Source: Detailed Project Report, 2005

The minimum flow for 90% dependable year is observed as 4.82 cumecs, and the same is observed in the month of November.

As per the Detailed Project Report 2005, the design flood has been estimated using various methods for flood frequency analysis and the results are summarized in Table-4.8.

TABLE-4.8
Design Flood estimated for the Sainj H.E. Project

Return period year	Maximum flood average (cumec)	Inst. Flood 1.15 time of maximum flood (cumec)
10	240.073	276.08
20	268.643	308.94
25	277.705	319.36
50	305.623	351.47
100	333.335	383.34
200	360.946	415.09
500	397.374	456.98
1000	424.904	488.64
5000	488.799	562.12
10000	516.312	593.76

Source: Detailed Project Report 2005

Sedimentation

The proposed project is run of the river scheme. Diversion of flow has been proposed through a gated barrages. No major storage has been proposed. Available gross storage is very small i.e. approximately 42.31 ha. Keeping in view of the likelihood of deposition of sediments on bank of river in reservoir area thereby causing erosion, the live storage capacity of 38.41 ha m has been consider. The provision of 13% of live storage is 4.49 ha m has been kept for effects due to sedimentation in the reservoir the balance storage capacity (33.92 ha m) will cater the peaking need for 4 hr only. The average silt load data from 1990 to 2004 of river Sainj at larji in downstream of diversion site has been has been given in Table-4.9.

TABLE-4.9

Average Silt Load in Sainj River at Larji from 1990 to 2004

Year	Jan	Feb	March	April	May	June	July	August	Sept	Oct	Nov	Dec
1990	-	-	-	-	-	-	-	6.7217	2.8169	1.6027	0.928	0.772
1991	0.717	0.8487	2.4049	2.2477	1.9936	4.5299	8.4384	8.9123	5.2521	-	1.6915	0.6654
1992	1.3714	1.1417	5.6661	-	-	4.3604	13.093	1.4652	-	-	0.6876	
1993	-	-	-	-	-	4.3024	66.385	5.2609	3.9363	1.1356	0.6339	0.5283
1994	0.5942	0.7954	1.0996	2.3878	4.2604	9.4829	28.418	21.911	4.3661	1.0406	0.7022	0.5991
1995	0.4468	0.4151	0.6461	0.8763	1.5064	2.8913	8.7539	6.7772	39.122	0.9593	0.5422	0.4735
1996	0.387	0.4065	0.9943	1.512	1.6173	11.341	14.398	11.318	3.113	0.5127	0.7636	0.4942
1997	0.468	0.7278	0.4991	1.1843	2.479	1.052	4.7535	20.451	6.0773	1.8877	1.3027	0.9512
1998	0.5649	0.8818	2.0925	1.841	3.519	10.264	13.647	24.137	12.216	6.2705	1.6285	1.1027
1999	0.4803	0.376	-	-	-	-	-	-	-	-	-	-
2000	-	-	-	-	-	-	-	-	-	-	-	-
2001	-	-	-	-	-	-	-	-	-	-	-	-
2002	-	-	-	-	-	-	-	-	-	-	-	-
2003	-	-	-		-	-	-	-	-	-	-	-
2004	0.9629	0.7029	0.6798	0.7196	5.788	3.1805	-	-	-	-	-	-
Monthly Average of Silt(g/l)	**0.66583**	**0.69954**	**1.7603**	**1.53839**	**3.02339**	**5.7116**	**19.7359**	**11.8838**	**9.61246**	**1.91559**	**0.98669**	**0.6983**

Source: *Detail Project Report (DPR), August 2005*
Note: --: Data not available

4.8 WATER QUALITY

There are no major sources of organic pollution loading in the basin. The Sainj river basin has low population density with low cropping intensity. The low cropping intensity coupled with low agro-chemical dosing also means that the pollution load due to agro-chemicals is quite low. The absence of industries implies that there is no pollution load from this source as well.

As a part of the field studies, water samples from river Sainj at various locations, i.e. one upstream barrage site, two downstream of barrage site. In addition, water sample from Kartaul khad and the drinking water in village Sainj was also collected. The sampling was conducted from three seasons namely summer (April 2007), Monsoon (July 2007) and Winter (December 2007). The water sampling results for three seasons namely summer (April 2007), post-monsoon (October 2007) and winter (December 2007) are given in Tables-4.10 to 4.12 respectively. The location of various sampling stations as shown in Figure-4.5. The drinking water quality standards are enclosed as Annexure-II.

TABLE-4.10

Water quality in the study area (Summer season)

Parameter	Unit	Sampling stations				
		W1	W2	W3	W4	W5
pH	-	7.8	7.98	8.1	7.4	7.9
TDS	mg/l	99	97	105	106	89
Sulphates	mg/l	<1.0	<1.0	<1.0	<1.0	<1.0
Nitrates	mg/l	2.3	2.2	3.0	2.4	2.7
Phosphates	mg/l	0.3	0.3	0.4	0.3	0.3
Chlorides	mg/l	6	7	11	7	7
Sodium	mg/l	14	11	13	12	12
Potassium	mg/l	3.6	3.0	4.9	3.8	4.8
Calcium	mg/l	18	22	24	16	18
Magnesium	mg/l	3.6	3.0	4.7	3.6	2.9

Parameter	Unit	Sampling stations				
		W1	W2	W3	W4	W5
Copper	mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Mercury	mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Lead	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001
Iron	mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Zinc	mg/l	0.15	<0.1	<0.1	0.14	<0.1
Cyanides	mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
Cadmium	mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Chromium	mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Manganese	mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
DO	mg/l	8.0	8.2	7.8	8.0	8.0
BOD	mg/l	1.4	1.3	1.6	1.2	1.2
COD	mg/l	2.2	2.1	2.5	2.3	2.3
Hardness	mg/l	55	61	65	60	62
Electrical Conductivity	μS/cm	135	133	144	145	124
Total Coliform	MPN/ 100 ml	Nil	Nil	Nil	Nil	Nil

Note:

W1 - 200 meter upstream of the proposed barrage site
W2 - 1 km downstream of the-proposed barrage site
W3 - Kartaul khad
W4 - 5 km downstream of the proposed barrage site
W5 - Drinking Water Sainj village.

TABLE-4.11

Water quality in the study area (Post-monsoon season)

Parameter	Unit	Sampling stations				
		W1	W2	W3	W4	W5
pH	-	7.7	7.9	8.1	7.3	7.8
TDS	mg/l	90	88	102	99	80
Sulphates	mg/l	<1.0	<1.0	<1.0	<1.0	<1.0
Nitrates	mg/l	2.0	2.0	2.5	2.2	2.4
Phosphates	mg/l	0.2	0.2	0.2	0.2	0.2
Chlorides	mg/l	6	6	8	6	6
Sodium	mg/l	12	10	12	10	10
Potassium	mg/l	3.2	2.9	4.5	3.1	4.0
Calcium	mg/l	16	18	18	13	15
Magnesium	mg/l	3.0	2.8	3.6	3.2	2.2
Copper	mg/l	<0.1	<0.1	<0.1	<0.1	<0.1

Parameter	Unit	Sampling stations				
		W1	W2	W3	W4	W5
Mercury	mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Lead	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001
Iron	mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Zinc	mg/l	0.15	<0.1	<0.1	0.14	<0.1
Cyanides	mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
Cadmium	mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Chromium	mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Manganese	mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
DO	mg/l	8.1	8.2	8.0	8.0	8.2
BOD	mg/l	1.2	1.2	1.4	1.2	1.2
COD	mg/l	2.0	2.1	2.3	2.2	2.4
Hardness	mg/l	53	57	60	36	47
Electrical Conductivity	μS/cm	122	120	139	135	109
Total Coliform	MPN/ 100 ml	Nil	Nil	Nil	Nil	Nil

Note:

W1 - 200 meter upstream of the proposed barrage site
W2 - 1 km downstream of the-proposed barrage site
W3 - Kartaul khad
W4 - 5 km downstream of the proposed barrage site
W5 - Drinking Water Sainj village.

TABLE-4.12

Water quality in the study area (Winter season)

Parameter	Unit	Sampling stations				
		W1	W2	W3	W4	W5
pH	-	7.8	7.9	8.1	7.4	7.9
TDS	mg/l	95	94	102	102	92
Sulphates	mg/l	<1.0	<1.0	<1.0	<1.0	<1.0
Nitrates	mg/l	2.1	2.1	2.3	2.2	2.2
Phosphates	mg/l	0.3	0.3	0.3	0.3	0.3
Chlorides	mg/l	7	7	10	8	8
Sodium	mg/l	13	12	14	12	13
Potassium	mg/l	3.7	3.4	5.0	3.2	4.4
Calcium	mg/l	19	23	23	15	19
Magnesium	mg/l	3.2	3.2	4.8	3.8	2.5
Copper	mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Mercury	mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Lead	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001

Parameter	Unit	Sampling stations				
		W1	W2	W3	W4	W5
Iron	mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Zinc	mg/l	0.24	<0.1	<0.1	0.12	<0.1
Cyanides	mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
Cadmium	mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Chromium	mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Manganese	mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
DO	mg/l	8.0	8.0	8.1	8.0	8.3
BOD	mg/l	1.4	1.3	1.5	1.3	1.4
COD	mg/l	2.2	2.2	2.7	2.5	2.6
Hardness	mg/l	60	70	77	53	58
Electrical Conductivity	μS/cm	130	130	139	140	126
Total Coliform	MPN/ 100 ml	Nil	Nil	Nil	Nil	Nil

Note:
W1 - 200 meter upstream of the proposed barrage site
W2 - 1 km downstream of the-proposed barrage site
W3 - Kartaul khad
W4 - 5 km downstream of the proposed barrage site
W5 - Drinking Water Sainj village.

The total hardness in water samples ranged from 55-65 mg/l in summer, 47-60 mg/l in post-monsoon and 53-77 in winter seasons respectively. The hardness level in the low calcium and magnesium levels are responsible for soft nature of water. The low EC and TDS values indicate the lower concentration of cations and anions. The concentration of TDS level ranged from 124 to 145 mg/l, 109 to 139 mg/l and 126 to 140 mg/l in summer, monsoon and winter seasons respectively, which is much lower than the permissible limit of 500 mg/l specified for domestic use (Refer Annexure-II). This is also reflected by the fact that the concentration of most of the cations and anions are well within the permissible limit.

The BOD 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 low COD values also indicate the absence of chemical

pollution loading in the area. The marginal quantity of pollution load, which enters river Sainj, gets diluted. In fact, even for the minimum flow, there is more than adequate water available for dilution. The heavy metal concentration in the study area is below the permissible limit used for drinking purposes. Total Coliform count is nil in the study area. It can be concluded that water quality was observed to be quite good. It is clear from Table-4.9 to 4.11 that levels of various cations and anions are well below the permissible limit. It is also reflected in the values of Electrical Conductivity (EC) and Total Dissolved Solids (TDS). The concentration of the heavy metals is quite low. Thus, it can be concluded that water quality of river Sainj can be considered as Class-A as per IS:2296 and can be used for meeting drinking water requirements after disinfection.

4.9 Ambient air quality

The ambient air quality with respect to the study area around the proposed site forms the baseline information. The study area represents rural environment. The sources of air pollution in the region are vehicular traffic, dust arising from unpaved village roads and domestic fuel burning. The prime objective of the baseline air quality study was to establish the existing ambient air quality of the area. This section describes the identification of sampling locations, methodology adopted for monitoring, frequency of sampling.

Selection of Sampling Locations

The baseline status of the ambient air quality has been established through a scientifically designed ambient air quality monitoring network and is based on the following considerations:

- Meteorological conditions on synoptic scale;
- Representatives of regional background air quality for obtaining baseline status
- Representation of likely affected area.

Three Ambient Air Quality Monitoring (AAQM) locations were selected taking care of above-mentioned points. The locations of Ambient Air Quality station are shown in Figure-4.5.

Frequency and Parameters for Sampling

Ambient air quality monitoring has been carried out with a frequency of two samples per week at three locations for three seasons. The monitoring was conducted for the following seasons:

- Summer : April - May 2007
- Post-monsoon : October 2007
- Winter : November - December 2007

The baseline data of ambient air environment has been generated for the mentioned parameters as given below:

- Suspended Particulate Matter (SPM)
- Respirable Particulate Matter (RSPM)
- Sulphur dioxide (SO_2)
- Oxides of Nitrogen (NOx).

Result of Ambient Air Quality Monitoring

The result of ambient air quality monitoring conducted for various seasons are given in Tables-4.13 to 4.15. The ambient air quality standards are given in Annexure-III.

TABLE-4.13
Results of ambient air quality monitoring in the study area (Summer season)
(Unit: μg/m^3)

Station	Date	SPM	RPM	SO_2	NO_x
Suind Village	01.05.07	100	44	BDL	9.1
	05.05.07	125	51	BDL	13.8
	08.05.07	129	54	BDL	6.3
	12.05.07	119	48	BDL	11.6
	15.05.07	101	40	BDL	8.0
	19.05.07	133	53	BDL	11.9
	22.05.07	136	55	BDL	8.9
	26.05.07	145	59	BDL	7.6
Neuli Village	01.05.07	130	51	BDL	13.5
	05.05.07	119	48	BDL	14.5
	08.05.07	129	50	BDL	16.7
	12.05.07	108	45	BDL	8.5
	15.05.07	101	40	BDL	6.3
	19.05.07	103	42	BDL	15.4
	22.05.07	107	43	BDL	8.5
	26.05.07	120	47	BDL	13.8
Niharni Village	01.05.07	135	56	BDL	7.5
	05.05.07	114	46	BDL	6.8
	08.05.07	116	46	BDL	7.5
	12.05.07	125	50	BDL	7.3
	15.05.07	131	52	BDL	8.3
	19.05.07	107	42	BDL	6.2
	22.05.07	121	49	BDL	9.6
	26.05.07	130	53	BDL	12.4

BDL: Below Detectable Limit(6μg/m^3)

TABLE-4.14

Results of ambient air quality monitoring in the study area
(Post- Monsoon season)

(Unit: μg/m^3)

Station		SPM	RPM	SO_2	NO_x
Suind Village	02.10.07	125	514	BDL	9.1
	06.10.07	121	48	BDL	13.8
	09.10.07	127	52	BDL	6.3
	13.10.07	111	45	BDL	11.6
	16.10.07	110	42	BDL	8.9

Station		SPM	RPM	SO_2	NO_x
	20.10.07	127	51	BDL	8.3
	23.10.07	128	51	BDL	8.9
	27.10.07	143	58	BDL	7.6
Neuli Village	02.10.07	131	52	BDL	13.5
	06.10.07	109	44	BDL	14.5
	09.10.07	127	50	BDL	16.7
	13.10.07	115	46	BDL	8.5
	16.10.07	124	51	BDL	6.3
	20.10.07	102	41	BDL	15.4
	23.10.07	113	45	BDL	8.5
	27.10.07	118	49	BDL	13.8
Niharni Village	02.10.07	124	51	BDL	7.5
	06.10.07	122	49	BDL	6.8
	09.10.07	105	42	BDL	9.0
	13.10.07	123	49	BDL	9.6
	16.10.07	128	51	BDL	8.3
	20.10.07	106	44	BDL	6.2
	23.10.07	130	54	BDL	8.4
	27.10.07	127	51	BDL	9.5

BDL: Below Detectable Limit(6μg/m^3)

TABLE-4.15

Results of ambient air quality monitoring in the study area (Winter season)

(Unit: μg/m^3)

Station		SPM	RPM	SO_2	NO_x
Suind Village	03.12.07	115	45	BDL	8.7
	06.12.07	121	49	BDL	11.6
	10.12.07	124	50	BDL	11.4
	13.12.07	131	53	BDL	13.2
	17.12.07	109	43	BDL	13.0
	20.12.07	125	50	BDL	11.8
	24.12.07	138	56	BDL	9.9
	27.12.07	116	48	BDL	10.6
Neuli Village	03.12.07	111	45	BDL	12.4
	06.12.07	140	58	BDL	13.1
	10.12.07	125	51	BDL	8.9
	13.12.07	116	48	BDL	10.2
	17.12.07	115	52	BDL	12.6
	20.12.07	112	45	BDL	13.2

Station		SPM	RPM	SO_2	NO_x
	24.12.07	123	50	BDL	11.6
	27.12.07	138	56	BDL	12.1
Niharni Village	03.12.07	121	49	BDL	8.4
	06.12.07	128	52	BDL	8.9
	10.12.07	116	47	BDL	11.7
	13.12.07	133	54	BDL	9.8
	17.12.07	128	51	BDL	10.3
	20.12.07	114	46	BDL	10.2
	24.12.07	130	54	BDL	8.9
	27.12.07	121	50	BDL	10.4

BDL: Below Detectable Limit(6μg/m^3)

Summary of ambient air quality monitoring

The summary of results of ambient air quality monitoring is given in Table-4.16.

TABLE-4.16

Summary of ambient air quality monitoring in the study area for summer season
Unit: μg/m^3

Station	Average	Maximum	Minimum
Summer season			
RPM			
Suind village	50.5	59	40
Neuli village	45.8	51	40
Niharni Village	49.3	56	42
SPM			
Suind village	123.5	145	100
Neuli village	114.6	130	101
Niharni Village	122.4	135	107
SO_2			
Suind village	BDL	BDL	BDL
Neuli village	BDL	BDL	BDL
Niharni Village	BDL	BDL	BDL
NOx			
Suind village	9.7	13.8	6.3
Neuli village	12.2	16.7	6.3
Niharni Village	8.2	12.4	6.2
Post-Monsoon season			
RPM			
Suind village	49.8	58	42

Station	Average	Maximum	Minimum
Summer season			
Neuli village	47.3	52	41
Niharni Village	48.9	54	42
SPM			
Suind village	124	143	110
Neuli village	117.4	131	102
Niharni Village	120.6	130	105
SO_2			
Suind village	BDL	BDL	BDL
Neuli village	BDL	BDL	BDL
Niharni Village	BDL	BDL	BDL
NOx			
Suind village	9.3	13.8	6.3
Neuli village	12.2	16.7	6.3
Niharni Village	8.2	9.6	6.2
Winter season			
RPM			
Suind village	49.3	56	43
Neuli village	50.6	58	45
Niharni Village	50.4	54	46
SPM			
Suind village	122.4	138	109
Neuli village	122.5	140	111
Niharni Village	123.9	133	114
SO_2			
Suind village	BDL	BDL	BDL
Neuli village	BDL	BDL	BDL
Niharni Village	BDL	BDL	BDL
NOx			
Suind village	11.3	13.2	8.7
Neuli village	11.8	13.2	8.9
Niharni Village	9.8	11.7	8.4

Source: Primary survey

Observations on NOx levels

The highest average NOx values of 12.2 $\mu g/m^3$ were observed at Neuli village in the summer and post-monsoon seasons respectively. Likewise, the highest average NOx value of 11.8 $\mu g/m^3$ in winter season was also observed at the same station. The highest value of 16.7 $\mu g/m^3$ too was also observed at the same station. The NOx level

observed at various sampling stations was much lower than the permissible limit of 80 μg/m^3 for residential and rural areas are given in Annexure-III.

Observation on ambient SO_2 levels

The SO_2 level was Below Detectable Limit BDL) of 6 μg/m^3 at all the stations covered in ambient air quality monitoring programme.

Observations on ambient SPM levels

The maximum SPM level observed in survey conducted during summer, post-monsoon and winter seasons was observed to be 145, 143 and 140 μg/m^3 respectively. The average SPM level at various monitoring stations ranged from 114.6 to 123.5 μg/m^3 in summer season, 117.4 to 124 μg/m^3 in post-monsoon seasons and 122.4 to 123.9 μg/m^3 in winter season. The SPM level at various stations covered during ambient air quality monitoring for three seasons were well below the permissible limit of 200 μg/m^3, specified for residential, rural and other areas (Refer Annexure-III). But in some station SPM level is quite high.

Observations on ambient RPM levels

The average RPM levels as observed at various stations in the study area ranged from 45.8 to 50.5 μg/m^3 47.3 to 49.8 μg/m^3 and summer 49.3 to 50.6 μg/m^3 post-monsoon, and winter seasons respectively. The highest RPM value was recorded as 59 μg/m^3 at Suind village in summer season. The RPM values monitored during the field survey were above the permissible limit of 100 μg/m^3 for residential and rural areas (Refer Annexure-III).

Conclusions

Based on the findings of the ambient air quality survey, conducted for the summer, post-monsoon and winter seasons, it can be concluded that the ambient air quality is quite good in the area. The values of these parameters were well below the permissible limits specified for residential, rural and other areas. The absence of industries, low vehicular traffic and low population density can be attributed for good ambient air quality in the project area.

4.10 NOISE ENVIRONMENT

Baseline noise data has been measured using a weighted sound pressure level meter. The survey was carried out in calm surrounding. Sound Pressure Level (SPL) measurement in the outside environment was made using sound pressure level meter. Hourly noise meter readings were taken at different sites. The survey for summer season was conducted in April 2007, and post-monsoon season, survey was conducted in October 2007. Likewise, survey for winter season was conducted in the month of December 2007. The location of various noise monitoring stations is shown in Figure-4.5. The noise levels were monitored continuously from 6 AM to 9 PM at each location and hourly equivalent noise level was measured. Sound Pressure Level (SPL) measurement in the ambient environment was made using sound pressure level meter. The hourly ambient noise levels monitored for summer, post-monsoon and winter seasons are given in Tables-4.17 to 4.19 respectively. The day time equivalent noise levels estimated are given in Table-4.20. The noise standards for various categories is given in Annexure-IV.

TABLE-4.17

Hourly equivalent noise levels in the study area (summer season)

(Unit: dB(A))

Time	Barrage site	Niharni village	Neuli	Suind	Sainj
6 -7 AM	32	32	33	34	33
7 -8 AM	33	33	35	35	34
8 -9 AM	34	35	37	37	35
9-10 AM	34	36	37	38	37
10-11 AM	40	44	40	45	44
11 AM - 12 Noon	41	42	45	41	43
12 Noon-1PM	41	41	43	40	42
1 –2 PM	43	44	41	43	43
2 – 3 PM	43	43	40	42	44
3 – 4 PM	42	43	44	44	43
4 – 5 PM	45	44	44	42	42
5 – 6 PM	45	45	45	44	44
6 – 7 PM	40	40	41	40	40
7 – 8 PM	38	38	38	38	37
8 – 9PM	36	36	36	37	35

TABLE-4.18

Hourly equivalent noise levels in the study area in Post-monsoon season

(Unit: dB(A))

Time	Barrage site	Niharni village	Neuli	Suind	Sainj
6 -7 AM	32	33	32	32	32
7 -8 AM	33	33	33	33	33
8 -9 AM	34	35	37	37	35
9-10 AM	34	35	37	38	36
10-11 AM	40	42	40	42	39
11 AM - 12 Noon	40	40	44	42	40
12 Noon–1 PM	40	40	41	41	41
1 –2 PM	40	42	40	41	41
2 – 3 PM	41	42	40	40	42
3 – 4 PM	41	42	42	42	42
4 – 5 PM	43	42	42	42	40
5 – 6 PM	44	43	41	42	38
6 – 7 PM	38	40	39	40	37

Time	Barrage site	Niharni village	Neuli	Suind	Sainj
7 – 8 PM	36	36	37	35	35
8 – 9PM	36	36	36	35	34

TABLE-4.19
Hourly equivalent noise levels in the study area (Winter season)
(Unit: dB(A))

Time	Barrage site	Niharni village	Neuli	Suind	Sainj
6 -7 AM	32	32	32	33	32
7 -8 AM	32	33	33	33	33
8 -9 AM	34	34	35	36	34
9-10 AM	34	34	36	37	35
10-11 AM	38	38	38	40	38
11 AM - 12 Noon	39	39	40	41	39
12 Noon–1 PM	40	40	42	42	40
1 –2 PM	41	41	44	42	42
2 – 3 PM	41	41	44	41	42
3 – 4 PM	42	42	43	41	41
4 – 5 PM	44	43	42	40	41
5 – 6 PM	42	42	41	39	39
6 – 7 PM	40	39	40	39	38
7 – 8 PM	38	38	38	38	36
8 – 9PM	38	36	35	35	35

TABLE-4.20

Average ambient noise levels

S. NO.	Location	Zone	L_{day} (dB(A))
Summer			
1.	Barrage site	Residential	38
2.	Niharni village	Residential	39
3.	Neuli	Residential	39
4.	Suind	Residential	39
5.	Sainj	Residential	38
Monsoon			
1.	Barrage site	Residential	40
2.	Niharni village	Residential	40
3.	Neuli	Residential	40
4.	Suind	Residential	40
5.	Sainj	Residential	39
Winter			

S. NO.	Location	Zone	L_{day} (dB(A))
1.	Barrage site	Residential	39.6
2.	Niharni village	Residential	39.3
3.	Neuli	Residential	37.5
4.	Suind	Residential	39.3
5.	Sainj	Residential	38.3

The day time equivalent noise level in summer and monsoon seasons at various sampling stations ranged from 32 to 45 dB(A), 34 to 46 dB(A). Likewise, day time equivalent noise level in winter season ranged from 37.5 to 39.6 at various sampling stations which were well within the permissible limit specified for residential area (Refer Annexure-IV).

CHAPTER-5

BASELINE SETTING FOR ECOLOGICAL ASPECTS

5.1 GENERAL

The baseline status has been divided into following three categories:

- Physico-chemical aspects
- Ecological aspects
- Socio-Economic aspects.

The baseline setting for ecological aspects are outlined in the present Chapter. The study area represents diverse biological assemblages unique in structure, composition, and spatial pattern. These have been under a long influence of local communities. The following section highlights floral and faunal diversity, based on a review of available information, professional judgment, and preliminary field assessments.

5.2 TERRESTRIAL ECOLOGY

5.2.1 Flora

5.2.1.1 Forest type

The proposed project lies in the Sainj valley. The study area comes under Sainj, Forest range and Jiwa Forest range under the Great Himalayan National Park Conservation Area (GHNPCA). The forest types observed in the study area are listed as below:

- Himalayan Chir Pine forest
- Broad leaf forest
- Conifer mixed with broad leaf forest
- Secondary scrubs
- Sub-tropical Riverine Forest.

Himalayan Chir Pine Forest

Chir pine (*Pinus roxburghii)* is the dominant species in this forest type. In Sainj valley good forest can be seen on both sides of slopes. At few places towards north from Sainj, these are mixed with other broadleaf species as well. The ground flora is degraded and is subjected to grazing and fire.

Broad leaf forest

Broad leaf forests in lower temperate and upper temperate regions of Sainj vary in composition. The dominant tree species in lower temperate forests include *Aesculus indica* and *Populus ciliate*. At top slopes tree species, e.g. *Rhododendron arborium* form the first storey. The temperate broad leaf forest has tree species such as *Acer* sp. *Betula alnoides*, *Juglens regia.* Scattered trees of *Taxus wallichiana* occur in the lower storey. Understorey comprises of plants like *Bercens, Impatients, Strobitanthes, Polygonatum, Hedea*, etc.

Conifers Mixed with Broadleaf Forest

In these forests conifer trees are more in proportion than the broadleaf trees. The coniferous trees namely *Taxus wallichiana, Quercus semicarpifolia* form the top storey inter-mixed with the species, such as *Acer acuminatum,* etc. The ground storey comprises of broadleaf forest mixed with conifer forest.

Secondary scrub

Secondary scrubs are found inter-mixed with agriculture shrubs, which have replaced the original vegetation. *Barberis* species forms the top storey. The ground floral elements include *Carex, Hypericum, Rubia, Indigofera*, etc. Occasionally scattered trees of *Pinus wallichiana* are also seen.

Sub-tropical Riverine Forest

Even though the Sainj valley is narrow, river beds at some locations are quite wide. The river beds and side slopes have different species composition. The dominant tree species in sub-tropical riverine forests is *Alnus nitida* and is found growing in narrow belts. These are commonly found in the river beds from Ghusainj to Bathad and up to Rolla. In Sainj valley, river beds at Nevil and towards Baha sub-tropical riverine forest is observed. Good forest of this type is also present along river Sainj, Dela khad. After Lappa, moderately less disturbed forests are observed. In this area, species such as *Alnus nitida, Felis tetrandra, Pyrus* sp. *Firardinia diversifolia, Diplazium esculentum*, etc. grow abundantly.

5.2.1.2 Floral Composition of the catchment area

Chir Pine (*Pinus roxburghii*) is the dominant forest category in the catchment area. In this forest category, coniferous tree species, e.g. *Cedrus deodara, Picea smithiana, Pinus wallichiana, Taxus wallichiana,* etc. form the top storey inter-mixed with species of *Acer, Prunus*, etc. In Sainj Valley, good forest can be seen on both sides of slopes. Sub-tropical forest of Chir Pine (*Pinus roxburghii)* can be seen in the lower reaches amidst orchards and agricultural lands as well.

Most of the Catchment area is under temperate conditions and therefore, temperate broad leaf and conifer forest are the dominant forest types observed in the project. Broadleaf forest in lower and upper temperates account for about 5% of the total area. Oaks are the predominant species of these forests found in association with *Acer* sp., *Juglens regia, Rhododendron* sp. etc. Dense forest area of this category is

observed on moderate slopes (northern aspects). The understorey is very rich in herbaceous plants and *Taxus wallichiana* is also found scattered in these forests.

The mixing of broad leaf and coniferous forests is predominant in complex terrain between sub-tropical and alpine areas. Narrow gorges and valleys have higher moisture availability and support broadleaf forest whereas coniferous forests are confined to drier regions on the ridges. The conifer forests form about 7% of the total forest area. The mixing of these patches could vary in proportions however broadleaf species are denser. Broadleaf species like *Aesculas indica, Quercus semi-carpifolia, Acer* sp*., Pinnus conuita, Anglens regia*, etc. and coniferous species like *Picea smithiana, Pinus wallichii, Cedrus deodara, Abies pindrow,* etc. are observed in the catchment area.

Coniferous forest covers maximum portion of the catchment area and forms about 10% of the total area. Conifer forest has intermixing of several species. Middle temperate zone is occupied by this type of forest. Pure patches of *Cedrus deodara* with scattered trees of *Picea smithiana* and *Pinus wallichiana* along with varying inter-mixing of broad leaf plants is observed in the middle temperate zone. Broad leaf trees like *Betula*, sp. *Quercus* sp. are observed in some forest patches.

Coniferous forest also have in some areas high mixture of deciduous or evergreen broadleaf trees. About 2.8% of the area has this type of mixed forests comprising of species like *Cedrus deodara, Picea smithiana, Abies pindrow*, *Taxus buccata, Acer susguinatum, Betula alnoides, Celtis* sp. Extensive bamboo patches can be seen from Shift to Rukhundi. The flora is quite rich in these forests.

Alpine scrub is found in the higher reaches throughout the catchment area and the vegetation in the area is of transition between temperate forest and alpine vegetation. The commonly observed species are *Betula afilis* and *Rhododendron comopanulatum*. Each of these species is seen growing gregariously in the area. *Betula utilis* occurs in pure patches near Basico pass and around Rukhundi top Gumtarao surroundings. The improved growth of *Rhododendron commanulatum* scrub is observed on on the eastern, north-eastern aspects.

Grasslands form the highest cover in the catchment area and cover about 8% of the total area, which is quite favourable from wildlife point of view. The grasslands known as `thatch' are mainly the resting sites used by shepherds or local grazers.

Riverine forest occurs in sub-tropical and temperate zones and occupy about 10.1% of the area and are around Ghusaini, Sainj, Neuli and river beds of Palachan streams and lower reaches of Dhela khad near Lappa and Rupa nala. Mapping of trees has been difficult firstly because of the shadow and secondly because these forests occur in very narrow belts along streams or on islands. Sub-tropical riverain forests have *Alnus nepalensis* and *Alnus nitida* as the dominant species along with *Prunus armeniaca, Pyrus communis* sp. and *Berberis* sp. These species grow gregariously on flat based riverbeds and along streams. The main species observed are *Hippophae salicifolia, Soroberia tomentosa* and *Rosa rabblena*.

5.2.1.3 Endemic and monotypic species

The vegetation in the catchment area represents dense stands of blue pine with Deodar and a few popular tree. A number of monotypic genera distributed along the altitudinal cline were also reported in the Sainj Valley. Some of these taxa are

*Asperugo procumbens (*Boraginaceae), *Boenmingausenia albiflora* (Rutaceae), *Hemiphragma heterophylum* (Scrophulariace), *Parochetus communis*, *Ougeinea oogeinensis* (Fabaceae) and *Oxyria digyna* (Chinopodiaceae).

Some of the endemic Himalayan taxa are also reported from the Sainj Valley. These include *Aconitum chasmanthum* (mohra), *Atropa acuminate* (Jharka), *Codonapsis ovata* (Seerdandi), *Dioscorea deltoidea* (singli mingli) *Gentiana kurroo* (kurroo) *Meconopsis aculeate* (Poppy), *Nardostachys Jatamansi* (Jata masi), *Picrorhiza kurrooa* (Kutki) *Podophyllum hexandrum* (bankakri), *Trillidium govanianum, Meconogsis aculeate* (Poppy), *Ougeinia oogeineusis, Hemiphragma hetrophyllum, Pierohiza kurroo* (Karu) *Veronica taxa* and *Phlogacanthus thyrsiflorus*.

5.2.1.4 Vegetation composition in study area

The proposed Sainj H. E. Project envisages the construction of 24.5 m high gated barrage on Sainj river near village Niharni of Sainj sub Tehsil in Kullu district. Forest area on the left bank of the river comes under Sainj Range while the area on the right bank is a part of Jiwa Range. The total land requirement for the various project appurtenances is 56.763 ha, which includes the submergence area of 5.17 ha. The project area lies in the vicinity of Great Himalayan National Park (GHNP) (Refer Figure-5.1). The tail end of the submergence is situated about 1.00 km from the boundary of GHNP and 1.5 km from the Sainj Wildlife sanctuary.

The proposed project lies in the Sainj Valley, and various project appurtenances lie within an altitude range varying from 1350 m to 1750 m. This area mainly represent Himalayan moist temperate deciduous forests. The top storey comprises of *Cedrus deodara* and *Pinus wallichiana* and the middle storey consists of *Quercus*

leucotrichophora, Alnus, nepalensis etc. The undergrowth is not well developed and consists of *Berberis Iycium, Desmodium* sp*., Girardenia diversifolia,* etc. Forests in the area and its surroundings comprise mainly of coniferous trees species, e.g. spruce--blue pine and deodar trees with a mixture of evergreen and deciduous broad leaved trees.

Silver fir and spruce are commonly observed in the area. At lower altitudes, spruce in association with deodar is quite dominant. *Pinus. wallichiana* is the other commonly observed species in the region. Kail is confined to southern slopes ridges on shallow soils. In the higher reaches silver fir is predominant. Broad leaved deciduous-trees species including *Aesculus indica, Juglans regia, Prunus armenica* etc. are found in depressions and nallahs.

Quercus leucotrichophora was observed on the ridges in .the project area in association with silver fir. *Pyrus comunii* and *Prunus armenica* are the other species found in this region.

Alnus forest were noticed along the river bank and along nallahs at several locations in this area. Other species observed with the *Alnus nitida* are *Populus ciliate, Pyrus comunii, Ficus* sp. etc. The undergrowth in these forests consists of *Polygonum recumbens* Alnus sp. with thorny undergrowth was also noticed during the field visits along the river.

5.2.1.5 Field Studies

As a part of the EIA study, a detailed Ecological survey was conducted for three seasons namely summer, post-monsoon and winter. The field studies for summer,

post monsoon and winter seasons was conducted in the months of April 2007, October 2007 and January 2008 respectively.

5.2.1.6 Sampling Sites and Methodology

As a part of the study, terrestrial ecological survey was conducted at the following locations:

- T_1 - identified near village Niharani on Sainj River (1,730 m above m.s.l.) just above the barrage site in the submergence area
- T_2 - near Kartah village (1,450m above m.s.l.) between power house and proposed barrage site.
- T_3 - near Suind village, (1,337 m above m.s.l.) in the proposed power house area.

The location of the above referred sampling sites is shown in Figure-5.1.

Considering the difficult terrain, quadrate method was used for sampling of the vegetation. Taking into consideration, the size of the vegetation patches, 10 random quadrates of 10m x 10m size were laid to study the trees and shrubs, and 10 random quadrates of 1m x 1m size were laid to study the herbaceous component at each sampling site. During the survey, numbers of plants of different species in each quadrate were counted and identified. The height of individual tree was estimated using Abney level/ Binocular and the DBH of all trees having height more than 8m was measured. Based on the quadrate data, frequency, density and cover (basal area) of each species were calculated. The importance value index (IVI) values for different trees species were determined based on the relative density, relative frequency and relative cover value. 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 hectare (ha).

Species diversity indices (Shannon Weiner Index) of general diversity ($\overline{H}$) was computed using the following formula:

Shannon Weiner Diversity Index ($\overline{H}$) = $-\sum_{l-1}^{s}\left(\frac{n_i}{N}\right)\log_2\left(\frac{n_i}{N}\right)$

where, $\overline{H}$ = Shannon Wiener index of diversity; n_i= total no. of individuals of a species; and

N= total no of individuals of all species.

During the vegetation survey, herbaria were prepared for those plants which had flowers. The Red Data Book of India and other available literature, floral herbaria pertaining to the rare/ endangered species were considered to identify the endemic, rare and other threatened categories of plants.

5.2.1.7 Floral diversity

The altitude in the project area ranges from 1,330 m to 1,750 m above m.s.l. The major forest type of the project area is conifer mixed with broad leaf forest. A total number of 115 plant species were recorded during the floristic survey in the project area. Plant diversity of the project area is given in Table 5.1.

TABLE -5.1

Plant diversity of the project area

Groups	No. of Species
Angiosperm & Gymnosperms	
• Trees • Shrubs • Herbs • Grasses	27 18 39 8
Pteridophytes	8
Bryophytes	6
Lichens	3
Fungi	6
Total	**115**

5.2.1.8 Economically Important Species

The economic dependence of local people is essentially on the plant resources growing in the valley include plants of medicinal value, fodder, fuelwood, timber fruit etc. People living in the Sainj Valley depend essentially on naturally occurring grasses, herb, shrub and trees for meeting the fodder requirements of their livestock. The oaks (*Auercus spp.)* are pre-dominantly topped for fodder. Some of the grass, herb, shrub and tree species are also used for this purpose. The list of major floral species observed in the project area, alongwith their economic importance are given in Table-5.2.

Major floral species observed in the study area, their local names, ecological status and economic values have been presented in Table 5.2.

TABLE - 5.2
Major floral species observed in the study area

S. No	Botanical Name	Vernacular Name	Status	Economic Importance
A. Angiosperms/ Gymnosperms				
Trees				
1.	*Aesculus indica*	Pangar	Common	Edible and Medicinal
2.	*Albizia julibrissin*	Siris	Common	Fodder, Wood
3.	*Alnus nepalensis*	Utees	Common	Timber, medicinal, soil binder
4.	*Betula alnoides*	Kath Bhuj	Rare	Furnitue wood, fodder, snake antidote
5.	*Boehmeria regulosa*	Genthi	Common	Edible, medicinal
6.	*Cedrella toona*	Tun	Common	Timber
7.	*Cedrus deodara*	Diar, Kialmang, Kelo	Common	Timber
8.	*Celtis australis* L.	Kharik	Common	Fruits edible, fodder, medicinal
9.	*Dioscorea bulbifera.*	Ratulu	Common	Medicinal
10.	*Ficus hispida*	Tutmila	Common	Fruits edible, fodder
11.	*Ficus oligodon*	Timla	Rare	Fodder
12.	*Juglans regia*	Khor, Akhrot	Common	Timber, dye and medicine
13.	*Kydia calycina*	Phuilau	Common	Bark yields fibre, medicinal
14.	*Morus australis*	Tut	Not common	Fruits edible, fodder
15.	*Neolitsea chinense*			Timber, dye, medicine
16.	*Phobe lanceolata*	Kaula	Common	Wood for cabinet work, fodder
17.	*Pinus roxburghii*	Chir	Common	Wood used for construction, resin for varnish and paint
18.	*P. wallichiana*	Kail	Common	Timber, medicinal ,fuel
19.	*Populus ciliata*	Syan	Common	Fodder, medicinal
20.	*Prunus armeniaca*	Chuli, Chul	Common	Edible and medicine
21.	*Pyrus communis*	Nashpati	Common	Fruits edible
22.	*P.malus*	Seb, Seo	Common	Fruits edible
23.	*P.pashia*	Melu	common	Fruits edible
24.	*Quercus leucotrichophora*	Banj	Common	Timber, Fuel, fodder, medicinal
25.	*Rhododendron arboreum*	Burans	Common	Flowers for refreshing drink, medicinal
26.	*Rhus suceedanea*L.	Tantri	Common	Fruits edible, wood as fuel
27.	*Salix*		Common	Fodder, eood for

S. No	Botanical Name	Vernacular Name	Status	Economic Importance
				agricultural implements
Shrubs				
1.	*Artemisia nilagerica*	Kunjaa	Common	Medicinal, Sacred plant
2.	*Berberis lyceum*	Kingor	Common	Fruits edible, medicinal
3.	*Cannabis sativa* Lam.	Bhang	Common	Fibre, fuel, medicinal
4.	*Chenopodium ambrosiodes*	Mexican tea	Common	
5.	*Clematis sp.*			
6.	*Desmodium gangeticum*	Safed Kathi	Rare	Medicinal
7.	*Hypericum petalaum*	Basanti		
8.	*Pyracantha crenulata*	Bakeel	Common	Soil binder
9.	*Rhamanus triqueter*			
10	*Rosa brunonii* Lindley	Kunja	Common	Medicinal
11.	*Sinarundinaria falcato*			
12.	*Sorbus acuparia*	Mohli	Rare	Fruits edible, medicinal
13.	*Solanum surattense*			
14.	*Spermadictyon sauveolens*	Padera	Common	Medicinal
15.	*Trichosanthes palmate*	Indrian	Common	Medicinal
17.	*Viburunum mullaha*	Moliya	Common	Medicinal
18.	*Zanthoxylum alatum*	Tirmira	Common	Medicinal
Herbs				
1.	*Anaphalis contorta*	Bugla	Common	
2.	*Achyranthes aspera* L.	Latjri	Common	Medicinal
3.	*Arundinella sp* Raddi			
4.	*Apium sp*			
5.	*Bistorta amplexculas*	Kutrya	Common	Medicinal
6.	*B. macrophylla*	Kukhri	Rare	
.	*Bupleurum hamiltonii*	Janglee jeera	Common	Medicina, Edible for cattle
7.	*Cassia occidentalis*	Chakunda	Common	Medicinal
8.	*Delphinium denudatum*	Nirbishi	Common	Medicinal
9.	*Eulalopis binnata*	Sabai grass	Common	Fodder
10.	*Fagopyrum esculentum*	Ougal	Common	Edible, flour of seeds as substitute of wheat
11.	*Fragaria nubicola*	Gandkaphal	Common	Edible, medicinal
12.	*Geranium*			
13.	*Gnaphalium hypoleucum*	Buglu, Bugla	Common	Plant extract used in cuts and wounds
14.	*Hedychium spicatum*	Jungali Haldi		
15.	*Impatiens bicolor*			

S. No	Botanical Name	Vernacular Name	Status	Economic Importance
16.	*Inula* spp.			
17.	*Ipomea nil*			
18.	*Mentha longifolia*	Paudina	Common	Leaves used as flavoring and refrigerant, medicinally used in vomiting and indigestion
19.	*Micromeria biflora*	Gorakhopan	Commoin	Medicinal
20.	*Nepeta* spp.	Uprya ghas	Common	Medicinal
21.	*Oenothera* spp.			
22.	*Oxalis corniculata*	Khatibuti	Common	Medicinal
23.	*Pilea scripta* Wedd.	Chailu	Common	Medicinal
24	*P. umbrosa* Wedd.	Chailu		Medicinal
25	*Polygonatum verticillatum* .	Salammisri	Rare	Medicinal
26	*Polygonum chinense*		Common	Medicinal
27	*Potentilla fulgens*	Bajardantu	Common	
28	*Plectranthus mollis*		Common	
29	*Polygonum recumbens*	Oglyajhar	Common	
30	*Ranunculus arvensis*	Chambul	Common	Medicinal
31	*Rumex nepalensis*	Khatura	common	Edible leaves, medicinal
32	*Sonchus arvensis*	Thistle	Common	
33	*Spergula arvensis*			
34	*Scutellaria linearis*			
35	*Tagetes erecta*	Genda	Common	Medicinal
36	*Thalactrum foliosum*	Mamiri	Common	Medicinal
37	*Viola canescens* Wal.	Vanfsa	Common	Medicinal
38	*Vicoa. Indica*		Common	Medicinal
39.	*Urtica dioica*	Kandali	Common	Stem yield fibre, fodder, vegetable, medicinal in sciatica, rheumatism etc.
Grasses				
1.	*Andropogon ischaemum*		Common	Fodder
2.	*Arundinaria falcata*	Ringal, Nirgal, Poo	Common	Widely used for mats and baskets, leaves as fodder
3.	*Arundinella setosa*	Ringal	Common	Used for brooms
4.	*Cymbopogon spp*		Common	Medicinal
5.	*Festuca gigantea*		Common	Ropes made from the leaves, also fodder
6.	*Poa pratensis*	-	Common	Fodder
7.	*Pogonatherum saccharoideum*	-	Common	Fodder

S. No	Botanical Name	Vernacular Name	Status	Economic Importance
8.	*Tripogon filiformis*	-	Common	Fodder
B. Pteridophytes				
1.	*Adiantum capillus-veneris*		Common	
2.	*Athyium foliolosum*		Common	
3.	*C. Caniogramma intermedia*		Common	
4.	C. candata		Commom	
5.	*Dryopteris wallichiana*		Common	
6.	*Lepisorus pseudonudus*		Common	
7.	*Onychium contiguum*		Common	
8.	*Pteris cretica*		Common	
C. Bryophytes				
1.	*Anthoceros sp.*		Common	
2.	*Marchantia paleacea*		Common	
3.	*Pellia sp*		Common	
4.	*Reboulia hemisphaerica* Raddi		Common	
5.	*Riccia pathankotensis*		Common	
6.	*Funaria sp.*		Common	
D. Lichens				
1.	*Graphis sp.*		Common	
2.	*Parmelia sp*		Common	
3.	*Usnea indica*		Common	
E. Fungi				
1.	*Erysiphe* spp		Common	
2.	*Uncinula* spp		Common	
3.	*Aecidium* spp		Common	
4.	*Rhizopus* spp		Common	
5.	*Agaricus* spp		Common	
6.	*Morchella esculenta*	Guchachii	Common	

5.2.1.9 Dominance of various floral species

The sampling site T_1 is the barrage site and submergence area (1,730m above m.s.l.). Both the banks of the Sainj River is dominated by the tree species of *Alnus nepalensis, Juglans regia* and *Aesculus indica*. However, a dense patch of the big

trees was present at the left bank of the Sainj river. Right bank of the river has scattered trees where few houses are observed.

The sampling site T_2 close to Kartah village between proposed barrage and power house site. Both the banks of the Sainj river at this site has only scattered vegetation. The left bank of the site has steep slope while the right bank has few tin sheds of human habitation.

The sampling site T_3 (the site of Power House) which is located near village Suind (1,337 m above m.s.l.) lies in an open wide valley. Left bank of the Sainj river has a steep slope with scattered vegetation dominated by shrubs. However, the left bank has human habitations with young scattered cultivated trees. This site is close to the project site of Parbati Stage III HEP.

The frequency, density, abundance, basal area and importance value index (IVI) of the trees, herbs and shrubs at barrage site and submergence area between proposed barrage and power house and in power house area during summer and post-monsoon seasons have been presented in Tables 5.3 to 5.8.

A perusal of the data on the ecological analysis revealed that near barrage site and submergence area the most dominant tree species were *Alnus nepalensis* (IVI: 57.543), *Juglans regia* (IVI 40.730)*, Aesculus indica* (IVI:38.189) and *Cedrella toona* (IVI: 37.385). The shrubs were dominantly represented by the species of *Vibrunum mullaha* (IVI:42.514) followed by *Sinarundinaria falcta* (IVI: 30.089) and *Desmodiun gangeticum* (IVI: 27.334) and *Girardinia diversifolia* (IVI: 27.069). The dominant herbs were the species of *Impatiens bicolor* (IVI: 36.502), *Achyranthes asper* (IVI: 33.395) and *Poa pratensis* (IVI: 28.436).

The sampling site T_2 (between proposed poer house & barrage site) is dominated by the tree species of *Alnus nepalensis* (IVI:43.559), *Pinus roxburghii* (IVI: 33.290), *Juglans regia* (IVI: 30.087) and *Boehmeria regulosa* (IVI:28.150). However, the shrubs were dominated by *Vibrunum mullaha* (IVI:50.449), *Sinarudinaria falcata* (IVI : 38.842), *Desmodium gangeticum* (IVI: 30.206) and *Chenopodium sp* (IVI:29.016). The herbs were dominantly represented by *Acyranthes asper* (IVI:47.458), *Impatiens bicolor* (IVI: 37.505) , *Tagetes erecta* (IVI: 33.608) and *Urtica dioica* (IVI: 25.267).

The sampling site T_3 (the proposed power house area) is dominated by the tree species of *Cedrella toona* (IVI: 49.096), *Ficus hispida* (IVI:48.556), *Populus ciliata* (IVI: 46.367) and *Pinus wallichiana* (IVI:44.409). The shrubs at the sampling site T_3 were dominated by *Zanthoxylum arnmatum* (IVI: 42.691), *Desmodium gangeticum* (IVI: 30.958), *Chenopodium* sp (IVI: 28.632) and Clematis sp (IVI:28.375). The herbs were dominantly represented by *Acyranthes asper* (IVI:43.176), *Ipomea nil* (IVI:34.938) and *Cynadon dectylon* (IVI:33.126).

TABLE -5.3
Frequency, density, abundance, basal area and importance value index (IVI) of plant species at sampling location T_1 (Barrage site and submergence area) during Summer Season

Plants	Frequency (%)	Density (ind.ha^{-1})	Abundance	Basal area (ha)	IVI	Diversity index (Shannon Weiner)
			Trees			
Aesculus indica	70	80	1.143	28.88	38.189	0.360
Alnus nepalensis	70	80	1.143	64.98	57.543	0.360
Betula alnoides	40	40	1.000	2.1632	13.306	0.238
Cedrella toona	70	80	1.143	27.38	37.385	0.360
Celtis australis	60	70	1.167	15.68	28.075	0.335
Juglans regia	70	80	1.143	33.62	40.730	0.360
Morus australis	40	40	1.000	2	13.219	0.238
Populas ciliata	50	50	1.000	1.62	16.051	0.274

Plants	Frequency (%)	Density (ind.ha^{-1})	Abundance	Basal area (ha)	IVI	Diversity index (Shannon Weiner)
Pinus wallichiana	30	40	1.333	5.78	13.658	0.238
Pyrus communis	50	50	1.000	0.8192	15.622	0.274
Quercus leucotrichophora	40	40	1.000	2.88	13.690	0.238
Rhus succedenea	40	40	1.000	0.72	12.532	0.238
Total		**690**				**3.156**
			Shrubs			
Artemisia niligerica	40	50	1.25	0.08	21.682	0.336
Berberis lycium	20	20	1	0.18	14.690	0.188
Cannabis sativa	60	60	1	0.0392	26.652	0.371
Chenopodium	40	60	1.5	0.0512	22.721	0.371
Desmodium Gengeticum	50	50	1	0.18	27.334	0.336
Girardinia diversifolia	60	60	1	0.0512	27.069	0.371
Pyracantha crenulata	40	40	1	0.1152	20.866	0.295
Rhamanus triqueter	30	30	1	0.2592	21.659	0.247
Rosa brunonii	30	30	1	0.18	18.905	0.247
Sinarundinaria falcta	50	50	1	0.2592	30.089	0.336
Vibrunum mullaha	20	20	1	0.98	42.514	0.188
Zanthoxylum armatum	20	20	1	0.5	25.820	0.188
Total		**490**				**3.475**
			Herbs			
Achyranthes asper	40	40	1	0.0050	19.393	0.232
Anaphalis contorta	30	30	1	0.0018	16.576	0.191
Andropogon ischamum	50	50	1	0.0005	22.211	0.267
Bistorta macrophylla	80	70	0.875	0.0012	28.259	0.327
Bulpleurum hamiltonii	30	30	1	0.0014	16.576	0.191
Fagopyrum esculentum	80	90	1.125	0.0032	33.067	0.375
Fragaria nubicola	50	50	1	0.0008	22.211	0.267
Gnaphalium hypoleucum	50	50	1	0.0008	22.211	0.267
Impatiens bicolor	80	90	1.125	0.0002	33.067	0.375
Mentha longifolia	70	80	1.143	0.0002	30.396	0.352

Plants	Frequency (%)	Density (ind.ha^{-1})	Abundance	Basal area (ha)	IVI	Diversity index (Shannon Weiner)
Poa pratensis	60	70	1.167	0.0026	27.774	0.327
Pilea scripta	80	70	0.875	0.0002	28.259	0.327
Total		**720**				**3.498**

TABLE -5.4
Frequency, density, abundance, basal area and importance value index (IVI) of plant species at sampling location T_2 (between proposed barrage and power house site) during summer season

Plants	Frequency (%)	Density (ind.ha^{-1})	Abundance	Basal area (ha)	IVI	Diversity index (Shannon Weinner)
Trees						
Albizia julibrissin	30	30	1	6.48	19.433	0.244
Alnus nepalensis	4	40	1	35.28	43.559	0.232
Boehmeria regulosa	50	50	1	6.48	28.150	0.267
Celtis australis	30	30	1	13.52	26.341	0.191
Ficus oligodon	30	40	1.333	0.98	16.037	0.232
Juglans regia	20	20	1	21.78	30.087	0.144
Morus australis	40	40	1	1.62	19.023	0.232
Neolitsea chinense	20	20	1	1.28	9.973	0.144
Phobe lanceolata	20	20	1	0.98	9.679	0.144
Populus ciliata	50	50	1	1.28	23.048	0.267
Prunus armenica	40	40	1	1.28	18.690	0.232
Pyrus pashia	40	60	1.5	1.28	22.690	0.299
Pinus roxburghii	50	60	1.2	9.68	33.290	0.299
Total		**500**				**2.924**
Shrubs						
Artemisia niligerica	60	90	1.500	0.08	27.444	0.372
Berberis lycium	50	50	1.000	0.18	25.681	0.265
Cannabis sativa	60	70	1.167	0.0288	21.888	0.324
Chenopodium	70	100	1.429	0.0512	29.016	0.393
Desmodium Gengeticum	60	70	1.167	0.18	30.206	0.324
Girardinia diversifolia	70	80	1.143	0.0512	26.276	0.350
Rhamanus triqueter	30	40	1.333	0.2312	23.557	0.230
Sinarundinaria falcta	70	120	1.714	0.18	38.842	0.428
Solanum surattense	60	70	1.167	0.1152	26.641	0.324
Vibrunum mullaha	30	40	1.333	0.72	50.449	0.230
Total		**730**				**3.240**

Plants	Frequency (%)	Density (ind.ha^{-1})	Abundance	Basal area (ha)	IVI	Diversity index (Shannon Weinner)
Herbs						
Achyranthes asper	40	40	1	0.0050	18.639	0.214
Anaphalis contorta	60	60	1	0.0018	24.139	0.278
Andropogon ischamum	40	50	1.25	0.0005	21.784	0.248
Cymbopogon sp	60	70	1.167	0.0008	26.649	0.305
Fagopyrum esculentum	60	60	1	0.0008	24.139	0.278
Impatiens bicolor	80	120	1.5	0.0002	38.397	0.408
Mentha longifolia	40	50	1.25	0.0026	21.784	0.248
Poa pratensis	60	60	1	0.0002	24.139	0.278
Pilea scripta	70	80	1.143	0.0002	29.216	0.330
Rumex nepalensis	60	60	1	0.0001	24.139	0.278
Tagetes erecta	90	160	1.778	0.0008	46.974	0.462
Total		**810**				**3.328**

TABLE 5.5
Frequency, density, abundance, basal area and importance value index (IVI) of plant species at sampling location T_3 (in proposed Power House area) during summer season

Plants	Frequency (%)	Density (ind.ha^{-1})	Abundance	Basal area (ha)	IVI	Diversity index (Shannon Weinner)
Trees						
Albizia julibrissin	30	30	1	4.50	48.139	0.352
Cedrella toona	40	40	1	3.38	49.096	0.408
Ficus hispida	50	50	1	2.00	48.556	0.451
Juglans regia	20	20	1	2.16	27.273	0.278
Populus ciliata	50	50	1	1.62	46.367	0.451
Pinus wallichiana	50	50	1	1.28	44.409	0.451
Pyrus pashia	30	30	1	2.42	36.160	0.352
Total		**270**				**2.742**
Shrubs						
Artemisia niligerica	70	80	1.143	0.065	26.312	0.310
Berberis lycium	20	20	1.000	0.157	16.501	0.122
Cannabis sativa	60	70	1.167	0.020	20.338	0.287
Chenopodium	70	110	1.571	0.039	28.632	0.371
Clematis	70	70	1.000	0.115	28.375	0.287
Desmodium Gengeticum	60	80	1.333	0.157	30.958	0.310
Girardinia diversifolia	60	60	1.000	0.051	21.101	0.260

Plants	Frequency (%)	Density (ind.ha^{-1})	Abundance	Basal area (ha)	IVI	Diversity index (Shannon Weinner)
Hypericum patalum	40	40	1.000	0.080	17.175	0.200
Rubus ellipticus	40	50	1.250	0.115	20.911	0.232
Solanum surettense	50	70	1.400	0.097	23.954	0.287
Spermadictyon sauveolens	60	60	1.000	0.080	23.052	0.260
Zanthoxylum armatum	30	30	1.000	0.500	42.691	0.164
Total		**740**				**3.089**
Herbs						
Achyranthes asper	40	40	1	0.00387	24.236	0.258
Andropogon ischamum	40	50	1.25	0.00039	28.211	0.296
Cymbopogon sp	50	70	1	0.00065	31.237	0.358
Cyprus	60	70	1.167	0.00039	34.881	0.358
Cynadon dectylon	80	140	1.75	0.00003	55.971	0.487
Oxalis corniculata	50	60	1.2	0.00180	31.467	0.329
Pogonantherum sacchaoidon	60	70	1.167	0.00007	34.881	0.358
Rumex nepalensis	40	40	1	0.00013	24.236	0.258
Tagetes erecta	60	70	1.167	0.00080	34.881	0.358
Total		**610**				**3.061**

TABLE -5.6
Frequency, density, abundance, basal area and importance value index (IVI) of plant species at sampling location T_1 (Barrage site and submergence area) during post-monsoon Season

Plants	Frequency (%)	Density (ind.ha^{-1})	Abundance	Basal area (ha)	IVI	Diversity index (Shannon Weiner)
Trees						
Aesculus indica	70	80	1.143	28.88	38.189	0.360
Alnus nepalensis	70	80	1.143	64.98	57.543	0.360
Betula alnoides	40	40	1.000	2.1632	13.306	0.238
Cedrella toona	70	80	1.143	27.38	37.385	0.360
Celtis australis	60	70	1.167	15.68	28.075	0.335
Juglans regia	70	80	1.143	33.62	40.730	0.360
Morus australis	40	40	1.000	2	13.219	0.238
Populas ciliata	50	50	1.000	1.62	16.051	0.274
Pinus wallichiana	30	40	1.333	5.78	13.658	0.238
Pyrus communis	50	50	1.000	0.8192	15.622	0.274
Quercus leucotrichophora	40	40	1.000	2.88	13.690	0.238

Plants	Frequency (%)	Density (ind.ha^{-1})	Abundance	Basal area (ha)	IVI	Diversity index (Shannon Weiner)
Rhus succedenea	40	40	1.000	0.72	12.532	0.238
Total		**690**				**3.156**
Shrubs						
Artemisia niligerica	40	50	1.25	0.08	21.682	0.336
Berberis lycium	20	20	1	0.18	14.690	0.188
Cannabis sativa	60	60	1	0.0392	26.652	0.371
Chenopodium	40	60	1.5	0.0512	22.721	0.371
Desmodium Gengeticum	50	50	1	0.18	27.334	0.336
Girardinia diversifolia	60	60	1	0.0512	27.069	0.371
Pyracantha crenulata	40	40	1	0.1152	20.866	0.295
Rhamanus triqueter	30	30	1	0.2592	21.659	0.247
Rosa brunonii	30	30	1	0.18	18.905	0.247
Sinarundinaria falcta	50	50	1	0.2592	30.089	0.336
Vibrunum mullaha	20	20	1	0.98	42.514	0.188
Zanthoxylum armatum	20	20	1	0.5	25.820	0.188
Total		**490**				**3.475**
Herbs						
Achyranthes asper	50	20	0.400	0.0050	33.395	0.138
Anaphalis contorta	30	20	0.667	0.0018	14.208	0.138
Andropogon ischamum	90	100	1.111	0.0005	19.481	0.385
Bistorta macrophylla	80	70	0.875	0.0012	19.552	0.317
Bulpleurum hamiltonii	30	30	1.000	0.0014	12.598	0.184
Delphinium denudatum	50	50	1.000	0.0032	26.104	0.258
Fagopyrum esculentum	80	90	1.125	0.0008	19.266	0.365
Fragaria nubicola	50	50	1.000	0.0008	13.156	0.258
Geranium sp	50	50	1.000	0.0002	9.919	0.258
Gnaphalium hypoleucum	90	120	1.333	0.0002	19.410	0.420
Impatiens bicolor	100	160	1.600	0.0026	36.502	0.473
Inula	40	40	1.000	0.0002	8.151	0.224

Plants	Frequency (%)	Density (ind.ha^{-1})	Abundance	Basal area (ha)	IVI	Diversity index (Shannon Weiner)
Mentha longifolia	70	80	1.143	0.0002	14.261	0.342
Poa pratensis	100	220	2.200	0.0002	28.436	0.518
Pilea scripta	70	90	1.286	0.0001	14.679	0.365
Vicoa biflora	60	50	0.833	0.0002	10.880	0.258
Total		**1,240**				**4.901**

TABLE-5.7

Frequency, density, abundance, basal area and importance value index (IVI) of plant species at sampling location T_2 (between proposed barrage & power house site) during post-monsoon Season

Plants	Frequency (%)	Density (ind.ha^{-1})	Abundance	Basal area (ha)	IVI	Diversity index (Shannon Weinner)
Trees						
Albizia julibrissin	30	30	1	6.48	19.433	0.244
Alnus nepalensis	4	40	1	35.28	43.559	0.232
Boehmeria regulosa	50	50	1	6.48	28.150	0.267
Celtis australis	30	30	1	13.52	26.341	0.191
Ficus oligodon	30	40	1.333	0.98	16.037	0.232
Juglans regia	20	20	1	21.78	30.087	0.144
Morus australis	40	40	1	1.62	19.023	0.232
Neolitsea chinense	20	20	1	1.28	9.973	0.144
Phobe lanceolata	20	20	1	0.98	9.679	0.144
Populus ciliata	50	50	1	1.28	23.048	0.267
Prunus armenica	40	40	1	1.28	18.690	0.232
Pyrus pashia	40	60	1.5	1.28	22.690	0.299
Pinus roxburghii	50	60	1.2	9.68	33.290	0.299
Total		**500**				**2.924**
Shrubs						
Artemisia niligerica	60	90	1.500	0.08	27.444	0.372
Berberis lycium	50	50	1.000	0.18	25.681	0.265
Cannabis sativa	60	70	1.167	0.0288	21.888	0.324
Chenopodium	70	100	1.429	0.0512	29.016	0.393
Desmodium Gengeticum	60	70	1.167	0.18	30.206	0.324
Girardinia diversifolia	70	80	1.143	0.0512	26.276	0.350
Rhamanus triqueter	30	40	1.333	0.2312	23.557	0.230
Sinarundinaria falcta	70	120	1.714	0.18	38.842	0.428
Solanum surattense	60	70	1.167	0.1152	26.641	0.324

Plants	Frequency (%)	Density (ind.ha^{-1})	Abundance	Basal area (ha)	IVI	Diversity index (Shannon Weinner)
Vibrunum mullaha	30	40	1.333	0.72	50.449	0.230
Total		**730**				**3.240**
Herbs						
Achyranthes asper	70	80	1.143	0.0050	47.458	0.285
Anaphalis contorta	60	60	1.000	0.0018	24.286	0.237
Andropogon ischamum	60	60	1.000	0.0005	16.228	0.237
Cymbopogon sp	60	60	1.000	0.0008	18.030	0.237
Fagopyrum esculentum	60	60	1.000	0.0008	18.030	0.237
Geranium sp	50	50	1.000	0.0002	12.106	0.211
Impatiens bicolor	80	120	1.500	0.0026	37.505	0.359
Mentha longifolia	40	50	1.250	0.0002	10.915	0.211
Poa pratensis	80	110	1.375	0.0002	21.559	0.343
Pilea scripta	70	80	1.143	0.0001	16.977	0.285
Rumex nepalensis	60	60	1.000	0.0008	18.030	0.237
Tagetes erecta	90	160	1.778	0.0012	33.608	0.415
Urtica dioica	60	70	1.167	0.0018	25.267	0.262
Total		**1,020**				**3.557**

TABLE -5.8
Frequency, density, abundance, basal area and importance value index (IVI) of plant species at sampling location T_3 (in proposed Power House area) during post-monsoon Season

Plants	Frequency (%)	Density (ind.ha^{-1})	Abundance	Basal area (ha)	IVI	Diversity index (Shannon Weinner)
Trees						
Albizia julibrissin	30	30	1	4.50	48.139	0.352
Cedrella toona	40	40	1	3.38	49.096	0.408
Ficus hispida	50	50	1	2.00	48.556	0.451
Juglans regia	20	20	1	2.16	27.273	0.278
Populus ciliata	50	50	1	1.62	46.367	0.451
Pinus wallichiana	50	50	1	1.28	44.409	0.451
Pyrus pashia	30	30	1	2.42	36.160	0.352
Total		**270**				**2.742**
Shrubs						
Artemisia niligerica	70	80	1.143	0.065	26.312	0.310
Berberis lycium	20	20	1.000	0.157	16.501	0.122
Cannabis sativa	60	70	1.167	0.020	20.338	0.287
Chenopodium	70	110	1.571	0.039	28.632	0.371
Clematis	70	70	1.000	0.115	28.375	0.287

Plants	Frequency (%)	Density (ind.ha^{-1})	Abundance	Basal area (ha)	IVI	Diversity index (Shannon Weinner)
Desmodium Gengeticum	60	80	1.333	0.157	30.958	0.310
Girardinia diversifolia	60	60	1.000	0.051	21.101	0.260
Hypericum patalum	40	40	1.000	0.080	17.175	0.200
Rubus ellipticus	40	50	1.250	0.115	20.911	0.232
Solanum surettense	50	70	1.400	0.097	23.954	0.287
Spermadictyon sauveolens	60	60	1.000	0.080	23.052	0.260
Zanthoxylum armatum	30	30	1.000	0.500	42.691	0.164
Total		**740**				**3.089**
Herbs						
Achyranthes asper	4	4	1	0.00387	43.176	0.181
Andropogon ischamum	10	9	1.111	0.00039	7.200	0.325
Cymbopogon sp	60	60	1.000	0.00065	25.547	0.237
Cyprus	60	70	1.167	0.00039	24.120	0.262
Cynadon dectylon	80	140	1.750	0.00003	33.126	0.389
Ipomea nil	50	50	1.000	0.00180	34.938	0.211
Oxalis corniculata	50	60	1.200	0.00007	17.566	0.237
Pogonantherum sacchaoidon	80	120	1.500	0.00013	31.475	0.359
Rumex nepalensis	40	40	1.000	0.00080	21.018	0.181
Tagetes erecta	60	70	1.167	0.00097	30.359	0.262
Tripogon filiformis	80	120	1.500	0.00013	31.475	0.359
Total		**743**				**3.004**

5.2.1.10 Diversity Indices

Species diversity index can be considered as a measure of environmental quality and indicates the well being of any ecosystem. Diversity indices of sampling site T_1 were computed to be 3.156 for trees, 3.475 for shrubs and 3.498 for herbs during summer season, however 3.156 for trees, 3.475 for shrubs and 4.901 for herbs during post monsoon season. The values for all the three components of plants indicate a good environmental quality of the ecosystem at barrage site.

Diversity index of sampling site T_2 was found to be 2.924 for trees, 3.240 for shrubs and 3.328 for herbs during summer season, however 2.924 for trees, 3.240 for shrubs and 3.557 for herbs during post monsoon. This indicates that the T_2 has a modrate biodiversity.

Diversity indices of sampling site T_3 were found to be 2.742 for trees, 3.089 for shrubs and 3.004 for herbs during summer however 2.742 for trees, 3.089 for shrubs and 3.004 for herbs during post monsoon. The values for all the three components of plants indicate the poor diversity at this site.

5.2.1.11 Threatened Status of Plants

Out of 27 species of trees present in the study area of Sainj HEP, *Betula alnoides* is the rare tree species, which is economically very important. Therefore, an effort should be made to minimize the damage to this tree species. Scanning the status of shrubs present in the project area, it has been found that two shrub species (*Desmodium gangeticum* and *Sorbus acuparia*) are of rare category. Two species of herbs (*Bistorta macrophylla and polygonatum verticiltum*) are of rare category. The protection and rehabilitation of the rare and threatened species (*in-situ)* in the vicinity of project area and *ex-situ* conservation has been suggested as a part of Environmental Management Plan (EMP).

5.2.2 FAUNA

The project area lies in the vicinity of Great Himalayan National Park (GHNP). A large amount of information on the faunal aspects is available in the project report of Forestry Research and Extension project on Great Himalayan National Park prepared by Wildlife Institute of India (WII 1999). In addition secondary information

from working Plan reports and interaction with forest department have been referred for faunal aspects of the study area.

5.2.2.1 Mammals

Mammals in the study area are represented by comprising 6 orders 30 species I,e, primates (2 species), Carnivora (12 species), Artiodactyla (7 species), Insectivora (3 species), Rodentia (5 species) and Lagomorpha (1 species). Primates are represented by rhesus macaque (*Macaca mulatta*) and common langur (*Presbytis entellus*) and are found to occur between 1440 and 3420m.

Among large carnivores, common leopard (*Panthera pardus*) and Asiatic black bear (*Ursus thibetanus*) are sighted rarely at altitudes ranging from 1440-3660 m. Black bear is found mostly in oak forests, and occasionally found in conifer forests. The presence of Snow leopard (*Panthera uncial*) in Jiwa and Sainj catchments area above 3,600 m has also been reported (WII, 1999). Himalayan brown bear (*Ursus arctos isabellinus)* inhabit the alpine meadows of Jiwa and Sainj areas above 3,500 m and descends down to lower elevations for feeding.

Among small carnivores, Red fox *(Vulpes vulpes*) is encountered in the alpine pastures. Yellow-throated marten (*Martes flavigula*) is commonly found on steep slopes of temperate and sub-alpine areas in an altitudinal range of 1,800-3,400 m; white Himalayan palm civet (*Paguma larvata*) is rarely sighted in the area. Jungle cat (*Felis chaus*) is reported at elevations above 2,000 m.

The most frequently encountered mammal in the area is goral (*Nemorhaedus goral*) which occupies a wide range of habitat from temperate to sub-alpine forests. Goral is found most frequently on open grassy slopes between 2,400 m and 2,800 m

inhabiting the steep south facing slopes in the temperate forests, which have a considerable area under grass cover developed due to frequent fires and grass cutting. Goral is one of the major preys for common leopard.

Both Himalayan thar (*Hemitragus jemlahicus*) and Himalayan musk deer (*Moschus chrysogaster*) are found occasionally between 2,800 and 4,000 m. Thar is found on steep rocky slopes in upper Jiwa Nal areas. Musk deer is one of the most endangered ungulates inhabiting the sub-alpine and alpine areas. GHNP provides only limited suitable habitats for musk deer (WII, 1999) and has been reported only from a few restricted patches.

Himalayan thar is one of the most hunted species in the area. This species mainly inhabits and steep south facing slopes of upper temperate, sub-temperate, sub-alpine and alpine regions. Barking deer (*Muntiacus muntjak)* is another heavily poached animal in the area and is rarely seen now-a-days. Blue sheep (*Pseudois nayaur*) has not been reported from most of these areas. Other rarely encountered mammals include Serow (*Capricornis sumatraensis*), Himalayan ibex (*Capra ibex sibirica)*, Himalayan weasel (*Mustela sibirica)* and Flying squirrels (*Petaurista petaurista and Hylopetes fimbtiatus*) while Pika or Himalayan mouse hare (*Ochotone roylei*) is encountered frequently in the alpine meadows.

5.2.2.2 Reptiles and Amphibians

The information on reptiles and amphibians is based on secondary sources as well as from Project report on GHNP (WII, 1999). The common reptiles with probability of occurrence in the area are Agama (*Agama tuberculata*), Gecko (*Cyrtodactylus lawderanus*), Himalayan pit viper (*Agkistrodon himalayanus)*, Russell's viper (*Vipera*

russelli), Skink (*Mabuya sp.)* and Indian rat snake (*Ptyas mucosus*), Marbled toad (*Bufo stomaticus)*, Stream frog (*Amolops formosus)* and Stoliczka's frog (*Rana vicina*).

5.2.2.3 Avi-fauna

The catchments of Sainj offer a diversity of habitats for the avi-fauna. Sainj catchment and its environs including the GHNP fall within one of the globally important Endemic Bird Areas identified by the International Council of Bird Preservation (ICBP). The avi-faunal diversity mainly comprises of a number of species of Babblers, Barbets, Blackbirds, Bulbuls, Bullfinches, Buntings, Chats, Choughs, Creepers, Crossbills, Cuckoos, Dippers, Doves, Drongos, Eagles, Finches, Flycatchers, Forktails, Goldcrests, Greenfinches, Griffons, Grosbeaks, Hawks, Kestrels, Kites, Martins, Minivets, Mynas, Nightjars, Niltavas, Nutcrackers, Nuthatches, Owls, Parakeets, Partridges, Peafowl, Pheasants Pigeons, Pipits, Redstarts, Rosefinches, Shrikes, Sparrows, Swifts, Thrushes, Tits, Tragopan, Vultures, Wagtails, Warblers, Woodpeckers and Wren-wrablers.

A total of 183 bird species have been recorded from the GHNP area comprising of 51 non-passerines and 132 passerines as compared to 71 non-passerines and 150 passerines recorded throughout the hilly region (above 1,500m) of Himachal Pradesh. The study area harbours more than 200 bird species belonging to 32 families. Five species of Pheasants, viz., Western tragopan (*Tragopan melanocephalus),* Cheer Pheasant (*Catreus wallichii*), Himalayan monal (*Lophophorus impejanus*), Koklas (*Pucrasia macrolopha*) and Kalij (*Lophura leucomelana*) are recorded from GHNP area and its surrounding habitats. Western

tragopan inhabits the temperate forest zone and GHNP incidently is the only National Park in India, which harbours their sizable population (WII, 1999). The endangered chir pheasant is rarely found in the area on the steep, south-facing grassy slopes below 2,200 m. Monal and Koklas are abundant in the area and inhabit the temperate and sub-alpine forests, while Kalij occurs in small numbers below 2,200 m.

5.2.2.4 Migratory Birds

The migration patterns in the avifauna of the Sainj valley and are quite varied. The habitats in these catchments harbour birds which are residents, local migrants, seasonal migrants, partial migrants, breeding migrants and altitudinal migrants.

The breeding migrants are the least but these assume much greater significance from the habitat conservation point of view. Since population build up of any species depends on the its breeding potential and the establishment of young ones, the integrity and naturalness of habitat becomes crucial for such species. Some of the important breeding migrants in this area are Ashy drango (*Dicrurus leucophaeus*). Dark-Sided flycatcher (*Muscicapa sibirica gulmergi*). Asian brown flycatcher (*M.dauurica)*, white-tailed rubythroat (*Luscinia pectoralis),* Barn swallow (*Hirundo rustica rustica),* Tickell's leaf warbler (*P. affinis affinis),* Greenish warbler (*P. trochiloides trochiloides*) and Golden-spectacled warbler (*Seicercus burkii whistleri)*. A number of these breeding migrants come far away from warm plains and also from foothills to these habitats for breeding. The habitat continuity for these birds is extremely crucial to their survival and maintenance of population sizes. It is well known that any species which does not build up its population size owing to non-

availability of proper breeding habitat and/or migration corridor can face possibilities of extinction.

5.2.2.5 Resident Birds

The majority of bird species being resident in these areas is an indication of rich vegetational diversity and diversity of habitats that an sustain them. Some of the commonly observed resident bird species of the area include: Himalayan snowcock (*Tetragallus himalayensis*), Chukar (*Alectoris chukar*), Western tragopan (*Tragopan melanocephalus*), Koklas pheasant (*Pucrasia macrolopha)*, Himalayan monal (*Lophophorus impejanus*), Kalik pheasant (*Lophura leucomelanos*), Cheer pheasant (*Catreus wallichii*), Brown-fronted woodpecker (*Dendrocopos auricepsauriceps*), Himalayan woodpecker (*D.himalayensis*), Scalybellied woodpecker (*Picus squamatus squamatus),* Grey-headed woodpecker (*Picus squamatus squamatus*), Grey headed woodpecker (*Picus canus sanguiniceps*), Great Barbet (*Megalaima virens marshalorum*), Creasted kingfisher (*Megaceryle lugubris*), Pied cuckoo (*Oxylophus jacobinus jacobinus),* Rose-ringed parakeet (*Psittacula Krameri manillensis),* Plum-headed parakeet (*P. cyanocephala bengalensis)*, Himalayan swiftlet (*Collocalia brevirostris brevirostris*), Mountain scops-owl (*Otusspilocephalus huttoni)*, Rock eagle-owl (*Bubo bubo bengalensis),* Tawny own (*Strix aluco nivicola*), Short-eared owl (*Asio flammeus flammeus*), Snow pigeon (*Columba leuconota leuconota*), Golden eagle (*Aquila chrysaetos*) and many other bird species.

5.2.2.6 Insects

Insects in general are suited for monitoring landscape changes because of these abundance, species richness ubiquitous occurrence and importance in the function

of the natural ecosystem. Insect are the major comoponent of the bio-diversity by virtue of their vast numbers of both species and individual they are vital determinants of terrestrial ecological processes. GHNP due to its strategic location and large altitudinal variation provides a diverse habitate of fauna and flora. A total 37 families of different froup of insects representing 108 genera and 125 species has been reported from GHNP. The details of these are given in Table-5.9. The order lapedoptera (butterfly and moth) represents higher diversity in terms of 55 genera and 61 species.

Table - 5.9
Insects Diversity inGHCL

Orden;	Families	Genus	Species
Coleoptera	1. Cerambvcidae	4	4
	2. Lampyridae	1	1
	3. Bupresudae	1	1
	4. Elateridae	5	5
	5. Cassididae	2	2
	6. Cicindelidae	2	3
	7. Luanidae	3	3
	8. Scan.baeidae	8	11
	9. Carabldae	1	1
	10. Coccindlidae	5	6
	11. Cucuiidae	1	1
	12. Curailionidae	5	5
	13. Chrysomelidae	2	3
	14. Mdoidae	1	1
	Sub-total order Coleoptera	41	' 47
Hymenoptera	1. Apidae	1	3
	2 Aodrenidae	1	1
	3. Xylocopidae	1	1
	4. Vespidae	2	2
	5. Halictidae	1	1
	Sub-total Hymenoptera	6	8
Diptera	1. Syrphidae	1	1
	Sub-total Diptera	1	1
Hemiptera	1. Cica'didae	1	1
	2. Aspicliotidae	1	1
	Sub-total Hemiptera	2	2

Orden;	Families	Genus	Species
Odonata	1. Aeshnidae	1	2
	2 Libellidae	3	4
	Sub-total Odonata	4	6
Lepidoptera (Burterflies)	1. Papilionidae	4	6
	2. Pieridae	8	9
	3. Nymphalidae	19	22
	4. Lycaenidae..	5	6
	S. Hesperidae	1	-1
(Moths)	6. Satumiidae	4	4
	7. Lasiocampidae	1	1
	8. Geometndae	2	2
	9. Arctiidae	2	2
	10. Noctuidae	4	4
	11. SphinRidae	2	2
	12. Lamantridae 13. ZYWlcoidae	1 1	1 1
	Sub-totali.epidoptera	54	61
Total	37	108	125

5.2.2.6 Faunal status in the study area

During field studies, discussions were held with locals and the Forest Department officials, and it was confirmed that large scale human interferences have depleted the forest cover in the project area and its surroundings.

The increased human interferences have resulted in illegal tree cutting, over grazing by livestock. Large scale tree felling in the area has taken place mainly to meet the requirements of packaging for the fruit industry. As a result of the above, the habitat for various wildlife species have been degraded.

However, it was told by the locals that during winter months, some of the wild animals from GHNP decends to lower elevations and are occasionally sighted even in the project area.

The major wildlife reported in the study area are given in Table- 5.10.

TABLE-5.10

Major faunal species reported in the study area

S. No.	Zoological Name	English Name/Local Name	Schedule as per Wildlife Protection Act
A. Mammals			
1.	*Canis lupus* (E)	Wolf	Schedule-I
2.	*Canis aureus*	Jackal	Schedule-I
3.	*Selenarctos thibetanus*	Himalayan Black Bear	Schedule-II
4.	*Ursus arctos* (E)	Brown Bear	Schedule-I
5.	*Panthera pardus* (E)	Leopard	Schedule-I
6.	*Muntiacus muntjak*	Barking deer	Schedule-III
7.	*Vulpes vulpes*	Fox	Schedule-IV
B. Birds			
1.	*Tragopan melanocephalus* (E)	Western tragopan	Schedule-I
2.	*Gyps himalavensis*	Himalayan Griffon vulture	Schedule-IV
3.	*Lophophorus impejanus*	Monal	Schedule-I
4.	*Arborophila toraueola*	Common hill partridge	Schedule-IV
5.	*Lophora leucomelana*	Kaleej pheasant	Schedule-IV
6.	*Pucrasia macropha*	Koklas pheasant	Schedule-IV
7.	*Catreus walichii* (E)	Chir pheasant	Schedule-I
8.	*Pavo cristatus*	Pea fowl	Schedule-I
9.	*Scolopax rusticola*	Wood cock	
10.	*Cuculus micropterus*	Indian cuckoo	Schedule-IV
11.	*Cuculus saturalus*	Himalayan cuckoo	Schedule-IV
12.	*Strix aluco*	Himalayan woo owl	Schedule-IV
13.	*Margalaima virono*	Himalayan great barbet	Schedule-IV
14.	*Cissa flavirostris*	Yellow billed blue magpie	Schedule-IV
15.	*Pyrrhocorax pyrrhocorax*	Red billed chough	
16.	*Paricrocotus ethologus*	Longtailed minivet	
17.	*Pteruthius flaviscopis*	Red winged strike babbler	Schedule-IV
18.	*Francolinus francolinus*	Black patridge	
19.	*Anas indicus*	Geer	
20.	*Alectoris gacea*	Chakor	
21.	*Arbosophis torquioa*	Chakor	
22.	*Genuoens hamiltonin*	White crested kalik pheasant	Schedule-IV
23	*Cariornis meerolophas*	Koklas pheasent	

S. No.	Zoological Name	English Name/Local Name	Schedule as per Wildlife Protection Act
C. Reptiles			
1.	*Agama tuberculata*	Common lizard/ Chhipkali	
2.	*Naja naja*	Indian cobra/ Nag	Schedule-II
3.	*Ptyas korras*	Rat snake	Schedule-IV
4.	*Varanus bengalensis*	Monitor lizard	Schedule-I
5.	*Bufo Himalayans*	Himalayan tode	
6.	*Bufo stomaticus*	Marbled toad	
7.	*Amalepas formosus*	Stream frog	
8.	*Rana vicina*	Staliczka's frog	Schedule-IV

Note : E – Endangered species

5.2.3 Protected areas

The barrage site is located close to the Great Himalayan National Park (GHNP). A map showing location of the project layout vis-à-vis Great Himalayan National Park is enclosed as Figure-5.2.

The Great Himalayan National Park (GHNP) has a total area of 754.4 sq.km. The park consists of the upper catchment areas of the Tirthan, Sainj, Parbati andJiwa Nallah flowing east to west, which are the tributaries of river Beas. The park is contiguous with the Rupi Bhabha Sanctuary (269 sq.km) in the south east, Pin Valley National Park (675 sq.km) in the east and Kanawar wildlife sanctuary in the north.

The altitude in the park area ranges from 1,300 m to 6,100 m. The terrain is characterized by numerous high ridges (over 4,000 metres high), deep gorges and precipituous cliffs, rocky crags, glaciers and narrow valleys. A little over half of the park lies above an altitude of 4,000 m.

To facilitate development programmes, an area of 265.60 sq.km. around the western periphery of the park has been earmarked for this purpose. The World Bank

supported eco-development approach project called FREE-GHNP was initiated in 1994 in the area. The project adopted participatory approach to ensure the participation of local community in the protection and management by developing livelihood alternatives and reduction of dependence of locals on the forests of the area. This was proposed to be achieved through ecologically sustained development (Eco-development) in the area. The park management has involved all the villagers, who were traditionally dependent on the forest and park resources. This zone has 124 villages having 2241 households, with a total population of about 12,705. In addition, there are two wildlife sanctuaries adjacent to the park, i.e. Sainj (90 sq.km) and Tirthah (61 sq.km.). The total area under the National Park Administration is 11,71 sq.km. The details are given in Table-5.11.

TABLE-5.11
Details of Great Himalayan National Park Conservation Area (GHNPFA)

S.No.	Park/Sanctuary	Area (sq.km)	Remark
1.	Great Himalayan National Park	754	
2.	Sainj Wildlife Sanctuary	90	
3.	Tirthan wildlife sanctuary	61	
4.	Additional Forest land	266	The land adjoin GHNP and management and administered by park management
	Total	**1,171**	

The Great Himalayan National Park (GHNP) was selected as one of the first national parks in India to demonstrate the approach of linking bio-diversity conservation with local social and economic development broadly known as eco-development. The mechanisms set up at GHNP for bio-diversity conservation through eco-development will receive close scrutiny for implementing a larger number of Eco-

development projects in India.

5.2.3.1 Flora and Fauna of Great Himalayan National Park (GHNP)

The plant communities are representative of temperate and alpine regions. About one-third of the National Park area is under closed canopy forests (from valley bottom to 3300-3600 m), and more than half of the area lies above 3,500-4,000 m, the approximate upper limit for alpine meadow communities in this part of Himalayas. The forest area consists of extensive stands of Oak *(Quercus semecarpifolia)* , coniferous forests of Blue Pine *(Pinus wallichiana),*- West Himalayan Silver Fir *(Abies pindrow),* west Himalayan Spruce *(Picea smithiana)* and Himalayan Cedar *(Cedrus deodara).* The broad-leaf forests contain *Aesculus indica, Rhododendron arboreum, Quercus leucotrichophora, Q.floribunda* at the lower altitude and pure patches of Birch *(Betula utillis)* at higher altitudes, Yew *(Taxus baccata)* is an important medicinal tree of the under storey. A rich variety of shrubs and patches of Ringal bamboo *(Arundinaria spathiflora)* are found as a dense under storey. The shrubs of *(Rhododendron campanulatum)* form the Krummholz patch in the sub-alpine zone. Other shrubs that are found at elevation above 3,700 m, are *Juniperus communis.* J. *pseudosabina, Lonicera, Berberis, Cotoneaster, Vibemum,* Rosa occur extensively above 3700 m. There are number of clearings in the forest areas which are locally known as 'thach'. These are grazing and camping ground for the migratory livestock (cattle, sheep and goats). The alpine flora occuring above 4,000 meters is characterized by species rich meadows with medicinal and economical values. They include *Aconitum violaceum, Salvia moorcraftiana, Viola serpens, Jurinea macrocephala, Rheum emodi, Berginia ciliata, Picrorhiza kurroo,*

Saussurea graminifolia etc.

The Great Himalayan National Park (GHNP), supports an extremely diverse wildlife population. It harbours one of the few known viable population of 'Western Tragopan' alongwith more than 300 species of birds and over 30 species of mammals.

Among mammals, GHNP has Serow *(Capricomis sumatraensis)* , Himalayan Tahr. Goral *(Nemorhaedus goral)* , BlueSheep (*Pseudols nayaur*) , Himalayan Black Bear *(Selenarctos thibetanus),* Himalayan Brown Bear *(Ursus- arctos),* Himalayan Red Fox *(Vulpes vulpes)* and Musk Deer *(Moschus moschiferus).* The Red Data Book has listed Musk Deer as a vulnerable species.

The GHNP has .recorded 183 bird species including 132 passerines and 51 non-passerines, Galliforms in GHNP constitute a very important and spectacular component of bio-diversity, The GHNP is one of two National Parks in the World with a population of endangered Western Tragopan *(Tragopan melanocephalus).* Another endangered pheasant, the Cheer(*Catreus wallichii)* is present on the steep, south-facing grassy slopes. Monal *(Lophphorus impegenus)* , and Koklas *(Pucrasia macrolopha)* , are in abundant in the temperate forest zone while Kaleej *(Lophura leucomelana)* occurs in small numbers below 2,000 m. The sightings of Snow Partridge *(Lerwa lerwa)*, Hill Partridge, *Arborophilatorqueola* and Himalayan Snow cock *(Tetragallus himalayana)* are very few.

5.3 AQUATIC ECOLOGY AND FISHERIES

5.3.1 Aquatic Ecology

As mentioned earlier, the river Sainj originates at an elevation of 5,500 m and a catchment area of 408 km^2 is proposed to be intercepted at the proposed barrage site. About 176 km^2 of the catchment area is above an altitude of 4,250 m and is permanently under snow cover. The aquatic ecological survey for summer and and post-monsoon seasons was conducted in the months of April 2007 and October 2007 respectively. The objectives of the aquatic ecological survey were to:

- Determine frequency, abundance and density of periphyton phytoplankton zooplanktons and. benthic –flora and fauna.
- Assess biological productivity of river Sainj in the study area

5.3.1.1 Sampling site and methodology

Keeping in view of difficult terrain following 3 sampling sites (AQ1, AQ2 and AQ3) were identified for sampling for acquatic ecology in the Sainj (Refer Figure-5.1).

AQ-1 near barrage site in the proposed submergence area
AQ-2 near confluence of Kartaul Khad with River Sainj
AQ-3 near proposed powerhouse site

Aquatic ecological analysis of Sainj River was made following the methods outlined in Wetzel and Likens (1991) and APHA (1998). Periphytons were collected using a timed scrapping technique following Ward (1974) with the help of a sharp knife for each replicate sample. The upper surfaces of at least cobble sized rocks were scrapped using a five-minute period. For enumeration of plankton population, bulk water samples were collected in polythene jars. For obtaining, net plankton from the water sample, 150 ml of bulk water was filtered through a 50 µm net and was centrifuged at 1500 rpm for 10-minute period. The sediment of the centrifuge tubes

was made to concentrate and was used for enumeration of zooplankton population. A plankton chamber of 0.5 ml capacity was used for counting of plankton under the Inverted Compound Microscope. The total number of plankters present in a litre of water sample was calculated using the following formula:

$$\text{Number of plankton (units } l^{-1}) = \frac{\text{Number of plankters in 0.5 ml aliquot X 0.5 X 1000}}{\text{Volume of sediment concentrate X Volume of water centrifuged}}$$

Primary productivity of periphyton-phytoplankton of Sainj River was determined by the 1.93 litre molded Polysterene Chamber Method *in situ* measurement of the rate of primary production. Three replicates were maintained for each sampling site. The experimental chamber was kept for 4 hrs under incubation in the Sainj River. The modified Winkler's method was used for determination of oxygen in the light and dark chambers. The calculation of primary production of phytoplankton-periphyton was made following the methods outlined in Strickland and Parsons (1960) and Benton and Werner Jr. (1972).

Respiration (R) = O_2 consumed = O_2 at start (-) O_2 at end in dark chamber

Gross Primary Productivity (P_g) = O_2 contents of light chamber (-) O_2 contents of dark chamber

Net Primary Productivity (P_n) = Pg (-) R

Macrozoobenthos colonizing the substrate were collected with the help of the Surber Sampler (0.50 mm mesh net) and by hand picking from stones. Quantitative estimation of macrozoobenthos was based on numerical counting (ind. m^{-2}). The surface area of the stones of the sampled area was estimated by using following formula:

S = n/3(LW+LH+WH)

Where, L = length; W = width; H = height of each stone to the nearest of 0.5 cm.

The biological analysis of aquatic organisms revealed that the periphyton, phytoplankton and macrophytes represented as primary producers. However, zooplankton and benthos represented as the secondary producers.

5.3.1.2 Periphyton and Phytoplankton

The Sainj River, a rhithronic stretch of the river, is dominated by the rapids, only a few pools were present in the stretch of the project area. Dominance of periphyton was observed in the rapids, while, few phytoplankton were present in the pools. Periphyton were represented by 21 members of the families of Bacillariophyceae, Chlorophyceae and Myxophyceae. However, only 12 members of phytoplanktons were represented by the families of Bacillariophyceae, Chlorophyceae and Myxophyceae. The data on frequency, density, abundance and diversity indices of periphyton dwelling in Sainj River have been presented in Tables 5.12 to 5.17. The total density of periphyton ranged from 1,376 ind. m^{-2} to 4,248 ind. m^{-2}, which was dominated by the members of Bacillariophyceae. Diversity indices (Shannon-Weiner) of periphyton ranged from 2.538 to 3.4879, which shows a good quality of aquatic ecosystem of Sainj River.

TABLE – 5.12
Frequency, density, abundance and diversity index (Shannon and Weiner) of periphyton in Sainj River at sampling site AQ_1 (near barrage site and submergence area) during summer season

Periphyton	Frequency (%)	Density (ind.m^{-2})	Abundance	Diversity index (Shannon Weiner)
Bacillariophyceae				
Tabellaria fenestris	88	308	3.500	0.494
Diatoma vulgaris	72	284	3.944	0.481
Fragilaria inflata	80	304	3.800	0.492

Periphyton	Frequency (%)	Density (ind.m^{-2})	Abundance	Diversity index (Shannon Weiner)
Nitzschia	16	20	1.250	0.094
Navicula radiosa	76	272	3.579	0.474
Cymbella cistula	12	16	1.333	0.079
Coconeis placetula	12	16	1.333	0.079
Synedra ulna	12	20	1.667	0.094
Cyclotella	8	8	1.000	0.046
Stauroneis	8	12	1.500	0.063
Ceratoneis	8	8	1.000	0.046
Denticula	4	4	1.000	0.026
Chlorophyceae				
Ulothrix zonata	4	8	2.000	0.046
Myxophyceae				
Oscillatoria tenuis	4	4	1.000	0.026
Total		**1,284**		**2.538**

TABLE-5.13
Frequency, density, abundance and diversity index (Shannon and Weiner) of periphyton in Sainj River at sampling site AQ_1 (near barrage site and submergence area) during post-monsoon season

Periphyton	Frequency (%)	Density (ind.m^{-2})	Abundance	Diversity index (Shannon Weiner)
Bacillariophyceae				
Tabellaria fenestris	84	280	3.333	0.2291
Diatoma vulgaris	84	328	3.905	0.2519
Amphora	68	152	2.235	0.1538
Fragilaria inflata	80	432	5.400	0.2940
Synedra ulna	80	224	2.800	0.1991
Nitzschia	80	260	3.250	0.2188
Navicula radiosa	92	328	3.565	0.2519
Cocconeis placentula	48	104	2.167	0.1178
Cymbella cistula	96	392	4.083	0.2788
Gomphonema	76	176	2.316	0.1699
Cyclotella	60	128	2.133	0.1365
Stauroneis	80	168	2.100	0.1647
Chlorophyceae				
Closterium leibleinii	64	112	1.750	0.1242
Zygnema	80	128	1.600	0.1365
Ulothrix zonata	76	152	2.000	0.1538
Spirogyra	76	152	2.000	0.1538

Periphyton	Frequency (%)	Density (ind.m^{-2})	Abundance	Diversity index (Shannon Weiner)
Myxophyceae				
Rivularia	36	64	1.778	0.0801
Oscillatoria tenuis	56	104	1.857	0.1142
Total		**3,684**		**3.2351**

TABLE-5.14
Frequency, density, abundance and diversity index (Shannon and Weiner) of periphyton in Sainj River at sampling site AQ_2 (near confluence of Khartaul khad) during summer season

Periphyton	Frequency (%)	Density (ind.m^{-2})	Abundance	Diversity index (Shannon Weiner)
Bacillariophyceae				
Tabellaria fenestris	76	328	4.316	0.493
Diatoma vulgaris	80	300	3.750	0.479
Fragilaria inflata	86	292	4.056	0.475
Nitzschia	16	24	1.500	0.102
Navicula radiosa	80	276	3.450	0.465
Cymbella cistula	28	36	1.286	0.138
Coconeis placentula	12	16	1.333	0.075
Synedra ulna	16	20	1.250	0.089
Cyclotella	12	16	1.333	0.075
Stauroneis	16	20	1.250	0.089
Ceratoneis	12	16	1.333	0.075
Denicula	8	12	1.500	0.060
Gomphonema	8	8	1.000	0.043
Chlorophyceae				
Ulothrix zonata	4	4	1.000	0.024
Myxophyceae				
Oscillatoria tenuis	4	8	2.000	0.043
Total		**1,376**		**2.723**

TABLE-5.15
Frequency, density, abundance and diversity index (Shannon and Weiner) of periphyton in Sainj River at sampling site AQ_2 (near confluence of Kartaul Khad) during post-monsoon season

Periphyton	Frequency (%)	Density (ind.m^{-2})	Abundance	Diversity index (Shannon Weiner)
Bacillariophyceae				
Tabellaria fenestris	80	312	3.900	0.1432
Diatoma vulgaris	84	344	4.095	0.1472
Amphora	68	192	2.824	0.1177
Fragilaria inflata	88	464	5.273	0.2998
Synedra ulna	80	208	2.600	0.1874
Nitzschia	80	312	3.900	0.2409
Navicula radiosa	92	352	3.826	0.2583
Cocconeis placentula	52	120	2.308	0.1291
Cymbella cistula	96	384	4.000	0.2712
Gomphonema	76	256	3.368	0.2138
Cyclotella	60	112	1.867	0.1229
Stauroneis	76	176	2.316	0.1679
Chlorophyceae				
Closterium leibleinii	68	152	2.235	0.1521
Zygnema	80	152	1.900	0.1521
Ulothrix zonata	76	216	2.842	0.1920
Spirogyra	76	192	2.526	0.1779
Myxophyceae				
Rivularia	36	120	3.333	0.1291
Oscillatoria tenuis	56	184	3.286	0.1729
Total		**4,248**		**3.2756**

TABLE – 5.16
Frequency, density, abundance and diversity index (Shannon and Weiner) of periphyton in Sainj River at sampling site AQ_3 (near power house site) during summer season

Periphyton	Frequency (%)	Density (ind.m^{-2})	Abundance	Diversity index (Shannon Weiner)
Bacillariophyceae				
Tabellaria fenestris	96	296	3.083	0.461
Diatoma vulgaris	76	300	3.947	0.463
Fragilaria inflata	88	268	3.045	0.443
Nitzschia	36	72	2.000	0.210
Navicula radiosa	84	280	3.333	0.451
Cymbella cistula	44	76	1.727	0.217
Coconeis placentula	28	36	1.286	0.129

Periphyton	Frequency (%)	Density (ind.m^{-2})	Abundance	Diversity index (Shannon Weiner)
Synedra ulna	41	40	1.429	0.139
Cyclotella	12	20	1.667	0.083
Stauroneis	24	28	1.167	0.107
Ceratoneis	12	16	1.333	0.070
Denticula	8	12	1.500	0.055
Gomphonema	12	16	1.333	0.070
Chlorophyceae				
Ulothrix zonata	12	16	1.333	0.070
Spirogyra	16	20	1.250	0.083
Myxophyceae				
Oscillatoria tenuis	8	12	1.500	0.055
Total		**1,508**		**3.105**

TABLE – 5.17

Frequency, density, abundance and diversity index (Shannon and Weiner) of periphyton in Sainj River at sampling site AQ_3 (near power house site) during post-monsoon season

Periphyton	Frequency (%)	Density (ind.m^{-2})	Abundance	Diversity index (Shannon Weiner)
Bacillariophyceae				
Tabellaria fenestris	80	280	3.500	0.2318
Diatoma vulgaris	84	288	3.429	0.2358
Amphora	68	152	2.235	0.1553
Fragilaria inflata	88	408	4.636	0.2889
Synedra ulna	80	196	2.450	0.1844
Nitzschia	80	248	3.100	0.2148
Navicula radiosa	92	312	3.391	0.2475
Cocconeis placentula	48	96	2.000	0.1121
Cymbella cistula	96	400	4.167	0.2858
Gomphonema	76	168	2.211	0.1663
Cyclotella	60	104	1.733	0.1188
Stauroneis	72	156	2.167	0.1581
Denticula	72	148	2.056	0.1525
Gomphoneis	72	156	2.167	0.1581
Chlorophyceae				
Closterium leibleinii	64	116	1.813	0.1285
Zygnema	80	148	1.850	0.1525
Ulothrix zonata	76	152	2.000	0.1553
Spirogyra	76	152	2.000	0.1553

Periphyton	Frequency (%)	Density (ind.m^{-2})	Abundance	Diversity index (Shannon Weiner)
Myxophyceae				
Phormidium	36	52	1.444	0.0708
Oscillatoria tenuis	56	100	1.786	0.1155
Rivularia	48	40	0.833333	0.0578
Total		**3,832**		**3.4879**

The data on frequency, density, abundance and diversity index (Shannon Weiner) of phytoplankton of Sainj River have been presented in Tables 5.18 to 5.23. The population of phytoplankton were sparse (101.1 - 329.6 ind. l^{-1}) at all the sampling sites. The diversity index was in range of 1.7565 to 2.0157 which shows the poor diversity of phytoplankton in Sainj river.

TABLE- 5.18
Frequency, density, abundance and diversity index (Shannon and Weiner) of phytoplanktons in Sainj River at sampling site AQ_1 (near barrage site and submergence area) during summer season

Phytoplankton	Frequency (%)	Density (ind.l^{-2})	Abundance	Diversity index (Shannon Weiner)
Bacillariophyceae				
Tabellaria fenestris	48	30.4	3.167	0.521
Diatoma vulgaris	44	28.8	3.273	0.516
Synedra ulna	4	0.8	1.000	0.055
Fragilaria inflate	44	31.2	3.545	0.523
Nitzschia	8	1.6	1.000	0.094
Navicula radiosa	20	5.6	1.400	0.230
Cymbella cistula	4	0.8	1.000	0.055
Gomphonema	4	0.8	1.000	0.055
Chlorophyceae				
Ulothrix zonata	4	0.8	1.000	0.055
Myxophyceae				
Oscillatoria tenuis	4	0.8	1.000	0.055
Total		**101.6**		**2.159**

TABLE -5.19
Frequency, density, abundance and diversity index (Shannon and Weiner) of phytoplanktons in Sainj River at sampling site AQ_1 (near barrage site and submergence area) during post-monsoon season

Phytoplankton	Frequency (%)	Density (ind.l^{-1})	Abundance	Diversity index (Shannon Weiner)
Bacillariophyceae				
Tabellaria fenestris	40	25.6	3.200	0.1789
Diatoma vulgaris	32	19.2	3.000	0.1459
Fragilaria inflata	36	20	2.778	0.1503
Nitzschia	28	17.6	3.143	0.1370
Navicula radiosa	44	32.8	3.727	0.2118
Cymbella cistula	28	28	5.000	0.1903
Ceratoneis arcus	40	16	2.000	0.1278
Astrionella	24	12.8	2.667	0.1084
Chlorophyceae				
Ulothrix zonata	32	25.6	4.000	0.1789
Spirogyra	32	17.6	2.750	0.1370
Myxophyceae				
Oscillatoria tenuis	44	28	3.182	0.1903
Total		**243.2**		**1.7565**

TABLE 5.20

Frequency, density, abundance and diversity index (Shannon and Weiner) of phytoplanktons in Sainj River at sampling site AQ_2 (near confluence of Kartaul Khad) during summer season

Phytoplankton	Frequency (%)	Density (ind.l^{-2})	Abundance	Diversity index (Shannon Weiner)
Bacillariophyceae				
Tabellaria fenestris	48	31.2	3.250	0.522
Diatoma vulgaris	64	29.6	2.313	0.517
Synedra ulna	8	1.6	1.000	0.093
Fragilaria inflata	56	32.0	2.857	0.524
Nitzschia	4	0.8	1.000	0.054
Navicula radiosa	12	3.2	1.333	0.155
Cymbella cistula	4	1.6	2.000	0.093
Cocconeis	4	0.8	1.000	0.054
Gomphonema	4	0.8	1.000	0.054
Chlorophyceae				
Ulothrix zonata	4	0.8	1.000	0.054
Myxophyceae				
Oscillatoria tenuis	4	0.8	1.000	0.054
Total		**103.2**		**2.176**

TABLE 5.21
Frequency, density, abundance and diversity index (Shannon and Weiner) of phytoplanktons in Sainj River at sampling site AQ_2 (near confluence of Kartaul khad) during post-monsoon season

Phytoplankton	Frequency (%)	Density (ind.l^{-1})	Abundance	Diversity index (Shannon Weiner)
Bacillariophyceae				
Tabellaria fenestris	36	28.8	4.000	0.1932
Diatoma vulgaris	36	25.6	3.556	0.1781
Fragilaria inflata	52	40	3.846	0.2404
Nitzschia	72	38.4	2.667	0.2341
Navicula radiosa	36	27.2	3.778	0.1858
Cymbella cistula	36	27.2	3.778	0.1858
Cocconeis	36	11.2	1.556	0.0976
Ceratoneis arcus	4	1.6	2.000	0.0205
Astrionella	36	16	2.222	0.1273
Chlorophyceae				
Ulothrix zonata	36	19.2	2.667	0.1453
Spirogyra	32	17.6	2.750	0.1364
Myxophyceae				
Oscillatoria tenuis	60	25.6	2.133	0.1781
Total		**278.4**		**1.9227**

TABLE 5.22
Frequency, density, abundance and diversity index (Shannon and Weiner) of phytoplanktons in Sainj River at sampling site AQ_3 (near power house site) during summer season

Phytoplankton	Frequency (%)	Density (ind.l^{-2})	Abundance	Diversity index (Shannon Weiner)
Bacillariophyceae				
Tabellaria fenestris	60	38.4	3.200	0.524
Diatoma vulgaris	56	35.2	3.143	0.516
Synedra	4	1.6	2.000	0.081
Fragilaria inflata	56	36.0	3.214	0.519
Nitzschia	4	0.8	1.000	0.047
Navicula radiosa	8	2.4	1.500	0.111
Cymbella cistula	12	2.4	1.000	0.111
Cocconeis placentula	8	1.6	1.000	0.081
Gomphonema	4	0.8	1.000	0.047
Denticula	4	0.8	1.000	0.047
Chlorophyceae				
Ulothrix zonata	8	1.6	1.000	0.081

Phytoplankton	Frequency (%)	Density (ind.l^{-2})	Abundance	Diversity index (Shannon Weiner)
Spirogyra	4	0.8	1.000	0.047
Myxophyceae				
Oscillatoria tenuis	4	0.8	1.000	0.047
Total		**123.2**		**2.261**

TABLE -5.23
Frequency, density, abundance and diversity index (Shannon and Weiner) of phytoplanktons in Sainj River at sampling site AQ_3 (near power house site) during post-monsoon season

Phytoplankton	Frequency (%)	Density (ind.l^{-1})	Abundance	Diversity index (Shannon Weiner)
Bacillariophyceae				
Tabellaria fenestris	60	46.4	3.867	0.2549
Diatoma vulgaris	60	42.4	3.533	0.2406
Fragilaria inflata	64	55.2	4.313	0.2841
Nitzschia	52	43.2	4.154	0.2435
Navicula radiosa	68	3.2	0.235	0.0347
Cymbella cistula	72	40	2.778	0.2317
Cocconeis	32	12.8	2.000	0.1034
Ceratoneis arcus	24	6.4	1.333	0.0606
Astrionella	20	8	2.000	0.0721
Chlorophyceae				
Ulothrix zonata	24	22.4	4.667	0.1558
Spirogyra	36	27.2	3.778	0.1785
Myxophyceae				
Oscillatoria tenuis	32	22.4	3.500	0.1558
Total		**329.6**		**2.0157**

5.3.1.3 Zooplankton

Zooplankton population in the torrential water current of river Sainj was very low (refer Tables 5.24 to 5.26). Zooplanktons were represented by the taxa *cladocera* (01) and *Rotifera* (03). Density of zooplankton was present in the range of 36.7 – 143 ind. l^{-1}. The diversity index was in the range of 1.0865 – 1.2976 at all the sites. It indicates the poor diversity of zooplankton in river Sainj.

TABLE -5.24
Frequency, density, abundance and diversity index (Shannon and Weiner) of zooplanktons in Sainj River at sampling site AQ_1 (near barrage site and submergence area) during summer season

Zooplankton	Frequency (%)	Density (ind.l^{-2})	Abundance	Diversity index (Shannon Weiner)
Cladocerans				
Daphnia	4	0.8	1.000	0.118
Rotifers				
Trichocera	44	19.2	2.182	0.495
Keratella	40	17.6	2.200	0.513
Total		**36.7**		**1.126**

TABLE – 5.25
Frequency, density, abundance and diversity index (Shannon and Weiner) of zooplanktons in Sainj River at sampling site AQ_1 (near barrage site and submergence area) during post-monsoon season

Zooplankton	Frequency (%)	Density (ind.l^{-1})	Abundance	Diversity index (Shannon Weiner)
Cladocera				
Daphnia	44	19.2	2.182	0.2496
Rotifera				
Trichocera	48	29.6	3.083	0.3248
Keratella	40	20.8	2.600	0.2626
Asplanchna	40	19.2	2.400	0.2496
Total		**88.8**		**1.0865**

TABLE-5.26
Frequency, density, abundance and diversity index (Shannon and Weiner) of zooplanktons in Sainj River at sampling site AQ_2 (near confluence of Kartaul khad) during summer season

Zooplankton	Frequency (%)	Density (ind.l^{-2})	Abundance	Diversity index (Shannon Weiner)
Cladocerans				
Daphnia	4	0.8	1.000	0.126
Rotifers				
Trichocera	40	18.4	2.300	0.483
Keratella	36	14.4	2.000	0.526
Asplanchna	4	0.8	1.000	0.126
Total		**34.4**		**1.261**

TABLE -5.27
Frequency, density, abundance and diversity index (Shannon and Weiner) of zooplanktons in Sainj River at sampling site AQ_2 (near confluence of Kartaul khad) during post-monsoon season

Zooplankton	Frequency (%)	Density (ind.l^{-1})	Abundance	Diversity index (Shannon Weiner)
Cladocera				
Daphnia	76	34.4	2.263	0.3773
Rotifera				
Brachionus	52	28	2.692	0.3377
Euchlanis	56	30.4	2.714	0.3533
Trichocera	16	10.4	3.250	0.1800
Total		**103.2**		**1.2483**

TABLE 5.28
Frequency, density, abundance and diversity index (Shannon and Weiner) of zooplanktons in Sainj River at sampling site AQ_3 (near power house site) during summer season

Zooplankton	Frequency (%)	Density (ind.l^{-2})	Abundance	Diversity index (Shannon Weiner)
Cladocerans				
Daphnia	4	1.6	2.000	0.170
Rotifers				
Trichocera	40	20.0	2.500	0.522
Keratella	48	22.4	2.333	0.504
Asplanchna	8	1.6	1.000	0.170
Total		**45.6**		**1.364**

TABLE -5.29
Frequency, density, abundance and diversity index (Shannon and Weiner) of zooplanktons in Sainj River at sampling site AQ_3 (near power house site) during post-monsoon season

Zooplankton	Frequency (%)	Density (ind.l^{-1})	Abundance	Diversity index (Shannon Weiner)
Cladocera				
Daphnia	56	32	2.857	0.3044
Rotifera				
Brachionus	48	33.6	3.500	0.3133
Euchlanis	72	40.8	2.833	0.3497
Trichocera	68	36.8	2.706	0.3302
Total		**143.2**		**1.2976**

5.3.1.4 Macrozoobenthos

Macrozoobenthos of Sainj River were represented by the members of Ephemeroptera (08), Trichoptera (07) and Diptera (04). Ephemeroptera contribution was maximum to the total macrozoobenthos. The density of macrozoobenthos was

present in the range of 436– 1,996 ind. m^{-2}. A maximum density was observed at AQ_3. It was also noticed that the health of aquatic Ephemeroptera was very good at AQ_3. The diversity index of macrozoobenthos ranged from 2.8809 to 4.2524 in Sainj River project area (Tables 5.30 to 5.35), which confirms the rich diversity of aquatic insects and good environmental quality of aquatic ecosystem.

TABLE – 5.30
Frequency, density, abundance and diversity index (Shannon and Weiner) of benthos in Sainj River at sampling site AQ_1 (near barrage site and submergence area) during summer season

Benthos	Frequency (%)	Density (ind.m^{-2})	Abundance	Diversity index (Shannon Weiner)
Ephemeroptera				
Baetis rhodani	36	48	1.330	0.379
Baetis niger	52	72	1.380	0.456
B. muticus	24	36	1.500	0.324
Rithrogena	32	44	1.360	0.362
Heptagenia sulphurea	48	84	1.750	0.483
H. lateratis	48	64	1.330	0.434
Trichoptera				
Glossosoma	4	8	2.000	0.118
Hydropsychae	8	8	1.000	0.118
Leptocela	4	4	1.000	0.069
Isoperla	4	4	1.000	0.069
Diptera				
Tendipes	4	8	2.000	0.118
Chironomus	8	8	1.000	0.118
Total		**376**		**2.885**

TABLE – 5.31
Frequency, density, abundance and diversity index (Shannon and Weiner) of benthos in Sainj River at sampling site AQ_1 (near power house site) during post-monsoon season

Benthos	Frequency (%)	Density (ind.m^{-2})	Abundance	Diversity index (Shannon Weiner)
Ephemeroptera				
Heptagenia	60	140	2.333	0.3184
Baetis niger	48	84	1.750	0.2321
B. muticus	60	100	1.667	0.2596
B. rhodani	56	48	0.857	0.1583
Ecdynurus	52	48	0.923	0.1583
Centroptilum	68	48	0.706	0.1583
Ephemerella ignita	64	56	0.875	0.1764
Rithrogena	48	68	1.417	0.2016

Benthos	Frequency (%)	Density (ind.m^{-2})	Abundance	Diversity index (Shannon Weiner)
Trichoptera				
Rhyacophila	40	32	0.800	0.1180
Hydropsyche	64	60	0.938	0.1851
Perla	76	32	0.421	0.1180
Glossoma	36	12	0.333	0.0555
Polycentropus	48	24	0.500	0.0951
Leptocella	24	24	1.000	0.0951
Isoperla	44	40	0.909	0.1389
Diptera				
Tendipes	84	88	1.048	0.2392
Simulium	4	4	1.000	0.0227
Chironomous	28	24	0.857	0.0951
Dixa	12	12	1.000	0.0555
Total		**944**		**2.8809**

TABLE – 5.32
Frequency, density, abundance and diversity index (Shannon and Weiner) of benthos in Sainj River at sampling site AQ_2 (near confluence of Kartaul khad) during summer season

Benthos	Frequency (%)	Density (ind.m^{-2})	Abundance	Diversity index (Shannon Weiner)
Ephemeroptera				
Baetis rhodani	36	60	1.670	0.393
Baetis niger	20	24	1.200	0.230
B. muticus	40	64	1.600	0.406
Rithrogena	52	72	1.380	0.429
Heptagenia sulphurea	48	88	1.830	0.466
H. lateratis	32	64	2.000	0.406
Trichoptera	16	24	1.500	0.230
Glossosoma				
Hydropsychae	4	8	2.000	0.105
Leptocela	8	12	1.500	0.142
Isoperla	8	8	1.000	0.105
Diptera				
Tendipes	8	12	1.500	0.142
TChironomus	4	4	1.000	0.062
otal		**436**		**3.084**

TABLE – 5.33
Frequency, density, abundance and diversity index (Shannon and Weiner) of benthos in Sainj River at sampling site AQ_2 (near confluence of Kartaul khad) during post-monsoon season

Benthos	Frequency (%)	Density (ind.m^{-2})	Abundance	Diversity index (Shannon Weiner)
Ephemeroptera				
Heptagenia	80	300	3.750	0.4003
Baetis niger	76	256	3.368	0.3694
B. muticus	72	124	1.722	0.2404
B. rhodani	72	156	2.167	0.2780

Benthos	Frequency (%)	Density (ind.m^{-2})	Abundance	Diversity index (Shannon Weiner)
Ecdynurus	56	100	1.786	0.2086
Ameletus	0	0	0.000	0.0000
Centroptilum	88	200	2.273	0.3224
Ephemerella ignita	80	152	1.900	0.2736
Rithrogena	76	132	1.737	0.2503
Trichoptera				
Rhyacophila	76	152	2.000	0.2736
Hydropsyche	68	120	1.765	0.2354
Glossoma	36	12	0.333	0.0424
Isoperla	56	120	2.143	0.2354
Diptera				
Tendipes	68	144	2.118	0.2645
Dixa	12	12	1.000	0.0424
Simulium	4	8	2	0.0401
Total		**1,980**		**3.4366**

TABLE – 5.34
Frequency, density, abundance and diversity index (Shannon and Weiner) of benthos in Sainj River at sampling site AQ_3 (near power house site) during summer season

Benthos	Frequency (%)	Density (ind.m^{-2})	Abundance	Diversity index (Shannon Weiner)
Ephemeroptera				
Baetis rhodani	40	52	1.300	0.321
Baetis niger	24	40	1.667	0.274
B. muticus	36	44	1.222	0.290
Rithrogena	44	72	1.636	0.383
Heptagenia sulphurea	40	64	1.600	0.360
H. lateratis	36	60	1.667	0.348
Trichoptera	28	32	1.143	0.238
Glossosoma				
Hydropsychae	40	44	1.100	0.290
Leptocela	28	36	1.286	0.256
Isoperla	24	32	1.333	0.238
Diptera	16	16	1.000	0.148
Tendipis				
Chironomus	32	40	1.250	0.274
Ephemeroptera	16	20	1.250	0.173
Total		**552**		**3.598**

TABLE – 5.35
Frequency, density, abundance and diversity index (Shannon and Weiner) of benthos in Sainj River at sampling site AQ_3 (near power house site) during post-monsoon season

Benthos	Frequency (%)	Density (ind.m^{-2})	Abundance	Diversity index (Shannon Weiner)
Ephemeroptera				
Heptagenia	60	164	2.733	0.2959
Baetis niger	48	144	3.000	0.2733
B. muticus	60	160	2.667	0.2915
B. rhodani	56	104	1.857	0.2218
Ecdynurus	52	136	2.615	0.2637
Ameletus	56	100	1.786	0.2161
Sipholonurus	68	100	1.471	0.2161
Centroptilum	68	48	0.706	0.1291
Ephemerella ignita	64	112	1.750	0.2329
Rithrogena	48	112	2.333	0.2329
Trichoptera				
Rhyacophila	40	72	1.800	0.1727
Hydropsyche	64	104	1.625	0.2218
Perla	76	72	0.947	0.1727
Glossoma	36	72	2.000	0.1727
Polycentropus	48	72	1.500	0.1727
Leptocella	24	80	3.333	0.1858
Isoperla	44	64	1.4545	0.1589
Diptera				
Tendipes	84	132	1.5714	0.2588
Simulium	4	4	1.0000	0.0179
Chironomous	28	72	2.5714	0.1727
Dixa	12	72	6.0000	0.1727
Coleoptera				
Psephanus	32	56	1.7500	0.1444
Total		**1,996**		**4.2524**

5.3.1.5 Primary Productivity

Primary productivity of river Sainj was mainly contributed by periphyton-phytoplatnkton assemblage. The data on gross primary productivity (P_g), net primary productivity (P_n) and P/R ratio have been presented in Table 5.36 & 5.37. The data on P_g, P_n and P/R have been presented on terms of biomass (dry), g m^{-3}, carbon

value (g C m^{-3}) and calories of energy (K cal m^{-3}) per hour (hr) and per month. The photoperiod (sunshine value) during the month of October 2007 was 12 hours.

The gross primary productivity (P_g) was in the range from 0.470 to 0.680 gCm^{-3} during April 2007 however 0.507 to 0.605 g C m^{-3} hr^{-1} during October 2007. The net primary productivity (P_n) of Sainj River was estimated to be in the range from 0.289 to 0.939 Cm^{-3} hr^{-1} however 0.038 to 0.083 g C m^{-3} hr^{-1} during October 2007.

TABLE 5.36
Gross primary productivity (P_g), respiration (R), net primary productivity (P_n) per month and P/R ratio of aquatic periphyton and phytoplankton in Sainj River during summer season

Sites	Gross primary productivity (P_g)			Respiration (R)			Net Primary Productivity (P_n)			P/R ratio
	Biomass (dry) g m^{-3} hr^{-1}	Carbon value g C m^{-3} hr^{-1}	Calories of energy K Cal m^{-3} hr^{-1}	Biomass (dry) g m^{-3} hr^{-1}	Carbon value g C m^{-3} hr^{-1}	Calories of energy K Cal m^{-3} hr^{-1}	Biomass (dry) g m^{-3} hr^{-1}	Carbon value g C m^{-3} hr^{-1}	Calories of energy K Cal m^{-3} hr^{-1}	
AQ_1	0.940	0.470	5.172	0.888	0.444	4.882	0.053	0.026	0.289	1.059
AQ_2	1.147	0.573	6.307	1.057	0.528	5.812	0.090	0.045	0.495	1.085
AQ_3	1.361	0.680	7.484	1.190	0.595	6.544	0.171	0.085	0.939	1.144

TABLE – 5.37
Gross primary productivity (P_g), respiration (R), net primary productivity (P_n) per hour and P/R ratio of aquatic periphyton and phytoplankton in Sainj River during post-monsoon season

Sites	Gross primary productivity (P_g)			Respiration (R)			Net Primary Productivity (P_n)			P/R ratio
	Biomass (dry) g m^{-3} hr^{-1}	Carbon value g C m^{-3} hr^{-1}	Calories of energy K Cal m^{-3} hr^{-1}	Biomass (dry) g m^{-3} hr^{-1}	Carbon value g C m^{-3} hr^{-1}	Calories of energy K Cal m^{-3} hr^{-1}	Biomass (dry) g m^{-3} hr^{-1}	Carbon value g C m^{-3} hr^{-1}	Calories of energy K Cal m^{-3} hr^{-1}	
AQ_1	1.211	0.605	6.658	1.134	0.567	6.235	0.077	0.038	0.423	1.068
AQ_2	1.013	0.507	5.574	0.938	0.469	5.161	0.075	0.038	0.413	1.080
AQ_3	1.164	0.582	6.400	0.998	0.499	5.492	0.165	0.083	0.908	1.165

5.3.1.6 Trophic Status of Sainj River

The P/R ratio of Sainj River was estimated to be in the range from 1.059 to 1.165. It shows that the primary productivity (P_g) is somewhat higher to community respiration, which is the indicator of autotrophic nature of the aquatic ecosystem. The higher P/R ratio (1.165) is the clear indication of better trophic status present at the sampling site AQ_3.

5.3.1.7 Aquatic Macrophytes

Some of the aquatic macrophytes were recorded along the bank of the Sainj River. These macrophytes were identified as *Equisetum* sp*., Adiantum* and *Selaginella spp.* Aquatic macrophytes were present in the wet area of riparian zone of Sainj river.

5.3.2 Fisheries

The river Sainj and its tributaries have varity of cold water fishesdominated by trout. The highly oxygenated cold water as well as rich in benthic fauna river offer excellent habitate for breading feeding of these fishes. The major fishes species reported in river sainj and its tributaries are given in Table 5.38

TABLE 5.38

The major fishes species reported in river Sainj and its tributaries

Scientific Name	Local Name
Schizothorax plagiostromus	Snow Trout
Schizothorax progastus	Snow Trout
*Schizothorax richardsonii**	Snow Trout
*Salmo trutta fario**	Brown trout
*Salmo gairdneri gairdneri**	Rainbow trout
Barilius spp.	-
Nemacheilus spp.	-

***** Species observed during survey

The fisheries survey was conducted during April 2007 and October 2007 using cast net having mesh size of 1 cm in different sections of the river. One gillnet was also set across the river sainj for 10 hours at each site near barrage site ,near confluence of Kartaul khad and near proposed power house site. Only three species *Schizothorax richardsonii, Salmo trutla fario* and *Salmogairdneri gairdneri* were observed during the survey. It would be worthwhile to mention that these three species were observed near power house area only. The catch per man-hour was 250 gm. The size observed 100 mm to 200 mm. The catch composition are given in Table-5.39.

TABLE-5.39

Catch composition of fish species during survey

Fish species	**Composition %**	
	April 2007	**October 2007**
Schizothorax richardsoni	80	100
Salmotruta fario	10	-
Salmogairdneri gairdneri	10	-

It is evident from the table that diversity of fishes is less in Sainj. Only cold water species are found as water temperature hardly exceeds 12^0C. This provides excellent growth of cold water fishes particularly trouts.

Fish Migration

Schizothorax richardsonii is the only commercial species observed in river Sainj in the project area. This species in normal course of its life cycle undertakes long journey during winter months to migrate in the lower reaches in warmer waters. With the warming of water in the lower reaches, in summer season the species migrates

towards the upstream reaches. During its upstream movement, in the months of May and June, this species breeds in the several side streams.

It was observed during fishery survey that all three species *Salmo truta fario Salmo gairdneri* and *Schizothorax richardsonii* observed were near the confluence of the Jiwanala. The presence of these species near confluence of Jiwa Nallah indicates that there is a possibility of migration of these species in Jiwa Nallah.

Spawning and breeding grounds

There is no specific spawning or breeding ground observed in the study area. However, the presence of fingerling in the catch near confluence of Jiwa Nallah indicate the possibility of breeding in the area near the proposed power house area.

Commercial fishing does not exist in Sainj. However, district Kullu is considered to be an angler's paradise and this sport is getting popular up day by day. The surface water resources of Kullu district have been divided into two main categories:

- Angling Reserve Water
- Open Water

Sport fishery is practiced in Sainj river and mainly constitutes brown trout, *(Salmo trutta fario)* and rainbow trout *(Salmo gairdneri).* The game fishing observed in Sainj river mainly near confluence of Jiwa Nallah and Kartaul Khad. The crystal clear water, terrain and climate support good potential for the development of sport fishery in the area. The trout fish, which is most suitable for this area was introduced in the district in 1909 by G.C.L. Hovel and General Orborn. Since then, this variety of fish has spread to larger area in the main river Beas and its tributaries. The Sainj river

comes in the former category and has been declared as trout water vide section 3(i) B Himachal Pradesh Fisheries Act 1976 and only sport fishing is allowed i.e. rod and line method only. The license for fishing is issued by the district fishery officer during the open season (i.e. from March to October) every year for the fees of Rs. 10, Rs. 50, and Rs. *350/-* for Angling daily, weekly and yearly respectively. Rod and line method can be used with lures such as artificial fly, spinning bait with the limit of 6 trouts of minimum 35 cm size per day.

There are two hatcheries in the region. One of the hatcheries is at Patlikuhal, which was set up as a part of Indo-Norvegion trout farming project and about 60 km from project site. The other hatchery is located at Nagani which is about 45 km from barrage site. About 5,000 to 6,000 fry of Brown & Rainbow trout are stocked every year in river Sainj.

The pressure due to anglers in river Sainj and its tributaries so far has been negligible as compared to river Beas. The number of fishing licences issued during the year 2005 to 2007-08 are listed in Table-5.40.

TABLE-5.40

Number of fishing licences issued in the area

Year	No. of fishing licences issued
2005-06	432
2006-07	401
2007-08	605

CHAPTER 6

SOCIO-ECONOMIC ASPECTS

6.1 INTRODUCTION

As part of the EIA study, a comprehensive assessment of socio-economic aspects was undertaken. The objective of this study was to ascertain the overall socio-economic conditions prevailing in the study area. Further, the impacts that are likely to occur during the construction and operation phase of the proposed project on the socio-economic aspects of the environment too have been assessed as a part of the Chapter 7 of this report. Mitigation measures have been suggested as a part of the EIA study to ameliorate the potential negative impact on socio-economic environment. A Resettlement and Rehabilitation (R&R) plan has been devised for the Project Affected Families (PAFs) who are likely to lose land, homestead or both due to land acquisition for various project appurtenances as a part of the present studies. The same has been outlined as a part of the R&R plan outlined in a separate volume of this report, covering Environmental Management Plan (EMP). This chapter also outlines the study approach and methodology adopted to carry-out the socio-economic assessment. The Policy guideline has been used for the formulation of the Resettlement and Rehabilitation Plan for the project affected families (PAFs).

A socio-economic survey has been carried-out in those villages where land is proposed to be acquired for the proposed Sainj hydro-electric project. For the purpose of assessment in this report, the villages which are directly impacted by the project due to the process of land acquisition would be referred to as the impact zone/ area. This includes areas coming under dam site, power house site and other project working areas including contractor facility areas, storage areas, etc. vertically, the

impact area would extend from the river-bed to the level of full reservoir level at 1752 m mean sea level (MSL), proposed adits, dumping areas, proposed road alignments, surge shaft area, etc.

6.2 STUDY APPROACH

Most of the information required to assess the socio-economic profile and property enumeration for preparation of Resettlement and Rehabilitation Master Plan was collected with the help of a detailed quantitative 100% survey of the PAFs in the affected villages. For identification of PAFs, i.e., families likely to lose their lands and/or homesteads, extensive use of Record of Rights (ROR), viz., revenue records was made. The families thus identified were covered as a part of the socio-economic survey. The information on the following socio-economic parameters was collected:

- Transhumance
- Demographic profile
- Educational levels
- Occupational Profile
- Land holding pattern
- Cropping pattern
- Assets owned
- Livestock and other socio-economic parameters etc.

6.2.1 Preparation

Before the actual survey work started, collection of base-line information, mainly from the secondary sources was undertaken. Discussions with the project officials were held, and secondary data was collected, which included review existing documents, reports and other publications relevant to the project. Thereafter, information and database was also collected from the Revenue authorities. This included *Jamabandi* (Right of Record) and *khasra* maps of the project affected villages. This data was computerized and based on the khasra numbers proposed to be acquired; a list of all

the affected plots and land holders was prepared. The ownership of the affected plots was correlated with the ROR to ascertain the owners/shareholders of the affected/ to be acquired plots of land.

Based on our preliminary field investigations, and through literature review, a household level survey schedule will be devised, which would capture the overall socio-economic status of the PAFs and would also highlight their personal properties. The survey schedule will be formulated to be a series of prompts, rather than a structured questionnaire, to allow the investigators to phrase queries according to the circumstance during interpersonal interviews with PAFs. This survey schedule was pre-tested in the field, and was finalized after necessary modifications, to make it more project and area specific.

6.2.2 Field work

For the process of primary data collection, a survey team comprising of local investigators was formulated. Members of the survey team (investigators/ surveyors) were local educated youths. Special care was taken about the investigators' comprehension of Hindi language (as the schedules had to be filled-in this language) and at the same time that they are well versed with the local customs and language/dialect, while recruiting them. Training was imparted to the members of the survey team, wherein they are appraised about the purpose of the survey and on the method of interaction with the PAFs and to elicit required information and how to filled-in the survey schedules. The survey team traversed the entire project area, including submergence area, dam alignment and sites of other project appurtenances in each of the project affected villages. The survey team visited 3 gram panchayats in which land

is proposed to be acquired, namely, Sachen, Shanshar and Gara Parli. As per our assessment, about 216 project affected persons were identified, who are expected to lose land (agricultural/non-agricultural/homestead) in varying proportion. This list was verified during the survey work, and by the end of the work, the survey team had covered 148 project affected families. The survey team coordinator scrutinized the filled-in survey schedules for internal discrepancies and missing information; which were eliminated in the field, in some cases by either going back to the concerned families, before it was coded for computerization.

6.2.3 Data compilation, Analysis and Reporting

The filled-in survey schedules were scrutinized at WAPCOS headquarters (Delhi) as well, before they were coded and computerized using database computer software. The raw data was then compiled and systematized before it was analyzed for various socio-economic parameters. Data analysis was undertaken using Statistical Package for Social Sciences (SPSS) computer software. The analyzed outputs have been used in reporting the findings of the socio-economic survey.

6.2.4 Formulation of R&R Plan

The Resettlement and Rehabilitation Plan for the Project Affected Families of the proposed Sainj hydro-electric project has been prepared in line with the provisions and/or guidelines as given in The National Rehabilitation and Resettlement Policy, 2007 has been prepared by the Ministry of Rural Development (Department of Land Resources).

6.3 KULLU DISTRICT : AN OVERVIEW

Location: District Kullu forms part of the Central Himachal Pradesh. It is surrounded by Lahaul and Spiti districts in the north and east, by the districts of Shimla and Kinnaur in the south and south-east and by the districts of Mandi and Kangra in the west and south-east. The district has a total area of about 5503 sq.km.

Topography and climate: district Kullu is marked with a varied topographical diversity. Altitudes ranges between 1220 m to over 6000 m above mean sea level. The district has a mountainous terrain with valleys, ridges and peaks, and the climatic conditions largely depends on the elevation.

History: Ancient people regarded Kullu as the farthest limit of human habitation and in the traditional folklore, it is often referred to as Kulanthpith means the end of habitable world. The original name of Kullu was Kulata, which finds mention in the Vishnu Purana, Ramayana and other mythological literatures. Kullu was most probably the most ancient state next to Kashmir and Kangra. The Chinese pilgrim Hiuen Tsiang (AD 629 – 645) described the country of Kui-lu-to situated at 117 miles to the north-east of Jhandhara which corresponds to the position of Kulata. According to the known history, it was founded in the first century of Christian era by the Behangamani Pal whose forefathers originally came from Tripura and had migrated there to Allahabad and then to Mayapuri near Haridwar. It appears that the people of the upper valleys of Kullu were suffering from the repressive regime of the Thakurs of Spiti. It was during this time that Behangamani Pal organized, what may be rightly called the upper valleys first revolution, which sparked off at Jagatsukh. Thus the Pal dynasty was established, which had its capital at Jagatsukh, and nearly 10 generations ruled

from here, before the capital shifted to Naggar. Subsequently, after about 1400 years of rule from Naggar, the capital finally shifted to Kullu.

The people: The ethnic groups inhabiting Kullu form a very interesting and complex pattern. It was reported and observed descendents of aboriginal tribes of the Kolis and the ancient Kunindas, tribes related to the southern Himalayans Mongoloids, the Khasas, Khasht. Traces of the numerous invaders from Central Asia and the North-West, remnants of continuous Tibetian infiltrations as well as the important Rajputs and other penetrations from lower India are also observed. The isolated Malana Valley constitutes a unique and relatively undisturbed island of the early inhabitants of this region. This rich pattern has still survived in one form or the other and is reflected in a very interesting and varied ethnic group composition.

Fairs and festivals: Kullu is called the land of gods. Kullu is also called the land of fairs and festivals; almost every village in Kullu has its own fair every year. The fairs that have acquired more local popularity are called, Phagli, Jetha-Kaunah, Veershu, Kanika, Shanauli, Shan-eri, Dasmi, Bir-Puja and Dyali. The local deota (deity) is taken out in a procession in decorated palanquins accompanied by traditional orchestra in these fairs.

6.4 SOCIO-ECONOMIC PROFILE OF THE STUDY AREA

The study area comprises of 21 villages, which includes 18 influence zone villages, and including 3 impact zone villages. Amongst the 21 study area villages (SAV) 01 village lies in Tehsil Kullu, 14 villages lie in Tehsil and sub-tehsil Sainj and 6 villages are situated in Tehsil Banjar in the district Kullu.

6.4.1 Demography

The total population within the study area (influence area villages including impact area villages) is 29438 residing in 5459 households. The percentage of male and female population is 50.99% and 49.01% respectively. The overall average sex ratio in the study area is 961 females per 100 males. The population below the age of 6 years (or infant population) accounted for about 16.49% of the total population. The average family size in the study area villages is 5 persons per household. The village-wise demographic details in the study area villages Study Area Villages are shown in Table 6.1.

TABLE – 6.1

Demographic profile of the Study Area Villages

S. No.	Study Area Villages	No of Households	Total Population	Male Population	Female Population	Population < 6 yrs	Sex Ratio	Average Family Size
Tehsil Kullu								
1	Bhallan-I (42/106)	475	2485	1329	1156	350	870	5
Tehsil Sainj (S.T)								
1	Raila (42/105)	675	3637	1878	1759	560	937	5
2	Bhalan-II (42/106)	147	771	395	376	167	952	5
3	Rote-I (42/107)	326	1885	999	886	303	887	6
4	Kotla (1/1)	447	2176	1113	1063	348	955	5
5	Chakurtha (1/2)	215	1242	646	596	201	923	6
6	Kanon (1/3)	235	1297	642	655	245	1020	6
7	Dhaugi (1/4)	307	1848	915	933	269	1020	6
8	Dusharh (2/5)	267	1269	658	611	179	929	5
9	Manyashi (2/6)	189	1043	519	524	155	1010	6
10	Sachen (2/7)	277	1544	785	759	262	967	6
11	Shanshar (41/104)	371	2105	1070	1035	375	967	6
12	Gara Parli (41/103)	149	804	413	391	169	947	5
13	Shangarh (3/9)	162	753	399	354	119	887	5
14	Lapah (3/8)	70	308	164	144	62	878	4
Tehsil Banjar (T)								
1	Deotha (5/14)	139	699	327	372	132	1138	5
2	Thani Char (5/15)	128	650	324	326	119	1006	5
3	Chanon (5/19)	360	2032	977	1055	341	1080	6
4	Seohli (5/16)	120	639	331	308	103	931	5
5	Jauri ((5/17	167	908	453	455	178	1004	5

S. No.	Study Area Villages	No of Households	Total Population	Male Population	Female Population	Population < 6 yrs	Sex Ratio	Average Family Size
6	Thati Bir (5/18)	233	1343	674	669	220	993	6
Total		**5459**	**29438**	**15011**	**14427**	**4857**	**961**	**5**

Source: Primary Census Abstract, 2001.

The total population within the project affected villages is 4453 residing in 797 households. The percentage of male and female population is 50.93% and 49.07% respectively. The overall average sex ratio in the study area is 963 females per 1000 males. The population below the age of 6 years (or infant population) accounted for about 18.10% of the total population. The average family size in the project affected villages is 5.6 persons per household. The village-wise demographic details in the project affected villages are shown in Table – 6.2.

TABLE – 6.2

Demographic profile of the Project Affected Villages

S. No.	Study Area Villages	No of Households	Total Population	Male Population	Female Population	Population < 6 yrs	Sex Ratio	Average Family Size
1.	Sachen (2/7)	277	1544	785	759	262	967	5.6
2.	Shanshar (41/104)	371	2105	1070	1035	375	967	5.7
3.	Gara Parli (41/103)	149	804	413	391	169	947	5.4
Total		**797**	**4453**	**2268**	**2185**	**806**	**963**	**5.6**

Source: Primary Census Abstract, 2001.

6.4.2 Caste profile in the study area

As already mentioned, the total population residing in the study area is about 29438 persons. The Scheduled Tribe (ST) population is observed to be present, but in minuscule numbers, which constitutes a mere 0.72% of the total population of the Study Area Villages. The Scheduled Castes (SC) population constitutes about 32.62% of the total population within the Study Area Villages. However, population belonging

to other castes is observed in sizable numbers, accounting for about 66.66% of the total population of the Study Area Villages. The village-wise details of the caste profile in the Study Area Villages are summarized in Table – 6.3.

TABLE – 6.3

Caste profile in the study area villages

S. No.	Study Area Villages	Total Population	General Caste Population	Scheduled Caste Population	Scheduled Tribe Population
Tehsil Kullu					
1	Bhallan-I (42/106)	2485	1562	917	6
Tehsil Sainj (S.T)					
1	Raila (42/105)	3637	2802	827	8
2	Bhalan-II (42/106)	771	406	365	0
3	Rote-I (42/107)	1885	1464	414	7
4	Kotla (1/1)	2176	1549	626	1
5	Chakurtha (1/2)	1242	934	308	0
6	Kanon (1/3)	1297	809	481	7
7	Dhaugi (1/4)	1848	1174	546	128
8	Dusharh (2/5)	1269	893	347	29
9	Manyashi (2/6)	1043	791	227	25
10	Sachen (2/7)	1544	1001	543	0
11	Shanshar (41/104)	2105	975	1129	1
12	Gara Parli (41/103)	804	547	257	0
13	Shangarh (3/9)	753	470	283	0
14	Lapah (3/8)	308	280	28	0
Tehsil Banjar (T)					
1	Deotha (5/14)	699	488	211	0
2	Thani Char (5/15)	650	450	200	0
3	Chanon (5/19)	2032	1091	941	0
4	Seohli (5/16)	639	599	40	0
5	Jauri ((5/17	908	592	316	0
6	Thati Bir (5/18)	1343	747	596	0
Total		**29438**	**19624**	**9602**	**212**

Source: Primary Census Abstract, 2001.

As already mentioned, total population residing in the project affected villages is 4453. The ST population is observed to be present, but in minuscule numbers, i.e., accounting a mere 0.02% of the total population. The Scheduled Castes (SC) population constitutes about 43.32% of the total population followed by population

belonging to the general caste category, comprising of about 56.66% of the total population in the impact area. The village-wise details of the caste profile in the project affected villages are depicted in Table – 6.4.

TABLE – 6.4

Caste profile in the project affected villages

S. No.	Study Area Villages	Total Population	General Caste Population	Scheduled Caste Population	Scheduled Tribe Population
1.	Sachen (2/7)	1544	1001	543	0
2.	Shanshar (41/104)	2105	975	1129	1
3.	Gara Parli (41/103)	804	547	257	0
Total		**4453**	**2523**	**1929**	**1**

Source: Primary Census Abstract, 2001.

6.4.3 Literacy Levels in the study area

The overall average literacy rate in the Study Area Villages is about 58.3%. The male and female literacy rates are 68.7% and 47.5% respectively. The village-wise details of literate population in the study area villages are given in Table – 6.5.

TABLE – 6.5

Village-wise Literate population in the study area villages

S. No.	Study Area Villages	Total Population	Literate Population	Male Literates	Female Literates
Tehsil Kullu					
1	Bhallan-I (42/106)	2485	1618	971	647
Tehsil Sainj (S.T)					
1	Raila (42/105)	3637	2047	1253	794
2	Bhalan-II (42/106)	771	378	236	142
3	Rote-I (42/107)	1885	1214	747	467
4	Kotla (1/1)	2176	1337	817	520
5	Chakurtha (1/2)	1242	705	449	256
6	Kanon (1/3)	1297	740	432	308
7	Dhaugi (1/4)	1848	1074	623	451
8	Dusharh (2/5)	1269	785	468	317
9	Manyashi (2/6)	1043	640	374	266
10	Sachen (2/7)	1544	884	538	346
11	Shanshar (41/104)	2105	1047	637	410
12	Gara Parli (41/103)	804	327	204	123
13	Shangarh (3/9)	753	421	276	145

S. No.	Study Area Villages	Total Population	Literate Population	Male Literates	Female Literates
14	Lapah (3/8)	308	165	104	61
Tehsil Banjar (T)					
1	Deotha (5/14)	699	451	241	210
2	Thani Char (5/15)	650	406	233	173
3	Chanon (5/19)	2032	1186	663	523
4	Seohli (5/16)	639	364	232	132
5	Jauri ((5/17	908	563	334	229
6	Thati Bir (5/18)	1343	819	479	340
Total		**29438**	**17171**	**10311**	**6860**

Source: Primary Census Abstract, 2001.

On the other hand, the overall average literacy rate in the project affected villages is about 50.7%. The male and female literacy rates are 60.8% and 40.2% respectively. The village-wise details of literate population in the project affected villages are given in Table – 6.6.

TABLE – 6.6

Village-wise Literate population in the project affected villages

S. No.	Study Area Villages	Total Population	Literate Population	Male Literates	Female Literates
1.	Sachen (2/7)	1544	884	538	346
2.	Shanshar (41/104)	2105	1047	637	410
3.	Gara Parli (41/103)	804	327	204	123
Total		**4453**	**2258**	**1379**	**879**

Source: Primary Census Abstract, 2001.

6.4.4 Occupational Profile of the study area

The village-wise details on occupational profile within the Study Area Villages are outlined in Table – 6.7. It is observed that about 66.3% of the total population in the Study Area Villages is engaged in different economically productive activities, and have been classified as “Total Workers” by the Census Department. On the other hand, remaining 33.7% are non-workers or dependent population. Among the working population, about 66.3% constitute the Main workers, while the Marginal workers

comprise about 33.6% of the total population.

TABLE – 6.7

Occupational profile in the study area villages

S. No.	Study Area Villages	Total Population	Total Working Population	Main Workers	Marginal Workers	Non Working Population
Tehsil Kullu						
1	Bhallan-I (42/106)	2485	1629	1294	335	856
Tehsil Sainj (S.T)						
1	Raila (42/105)	3637	2182	1800	382	1455
2	Bhalan-II (42/106)	771	579	208	371	192
3	Rote-I (42/107)	1885	1358	549	809	527
4	Kotla (1/1)	2176	1420	807	613	756
5	Chakurtha (1/2)	1242	968	499	469	274
6	Kanon (1/3)	1297	941	516	425	356
7	Dhaugi (1/4)	1848	1473	967	506	375
8	Dusharh (2/5)	1269	777	483	294	492
9	Manyashi (2/6)	1043	725	444	281	318
10	Sachen (2/7)	1544	1059	731	328	485
11	Shanshar (41/104)	2105	1456	989	467	649
12	Gara Parli (41/103)	804	398	305	93	406
13	Shangarh (3/9)	753	495	210	285	258
14	Lapah (3/8)	308	199	147	52	109
Tehsil Banjar (T)						
1	Deotha (5/14)	699	442	354	88	257
2	Thani Char (5/15)	650	400	340	60	250
3	Chanon (5/19)	2032	1506	971	535	526
4	Seohli (5/16)	639	329	220	109	310
5	Jauri ((5/17	908	457	450	7	451
6	Thati Bir (5/18)	1343	724	669	55	619
Total		**29438**	**19517**	**12953**	**6564**	**9921**

Source: Primary Census Abstract, 2001.

The village-wise details on occupational profile within the project affected villages are outlined in Table 6.8. It is observed that about 65.4% of the total population in the project affected villages is engaged in different economically productive activities, and have been classified as “Total Workers” by the Census Department. On the other hand, remaining 34.6% are non-workers or dependent population. Among the working population, about 69.5% constitute the Main workers, while the Marginal workers comprise of about 30.5%.

TABLE – 6.8

Occupational profile in the project affected villages

S. No.	Study Area Villages	Total Population	Total Working Population	Main Workers	Marginal Workers	Non Working Population
1.	Sachen (2/7)	1544	1059	731	328	485
2.	Shanshar (41/104)	2105	1456	989	467	649
3.	Gara Parli (41/103)	804	398	305	93	406
Total		**4453**	**2913**	**2025**	**888**	**1540**

Source: Primary Census Abstract, 2001.

6.5 SOCIO-ECONOMIC PROFILE OF THE PROJECT AFFECTED FAMILIES

Commissioning of development projects invariably brings about a number of desired and undesired impacts along with it. Most often, development projects are planned based on the availability of exploitable natural resources. Upon commissioning, these areas act as growth foci. This attracts flow of finances, investments, job and other livelihood opportunities, which brings in people from different cultural and social backgrounds. Such planned activities not only provide impetus to the local economy but also bring about a multi-dimensional social and cultural change in the once dormant area. Most often it has been observed, such development projects are commissioned in economically and socially backward areas, which are inhabited by some of the most indigenous populations.

The Sainj hydro-electric project is likely to be located in one of the backward regions of district Kullu, which thrives on the tourism industry. A detailed socio-economic study was undertaken in mid-October 2007. The study was taken up to understand the overall social and economic status of the project affected families (PAFs) of this project, their life-style and to assess the likely impacts of the project in terms of loss of personal and community property of the PAFs.

This Chapter outlines the overall socio-economic status of the PAFs residing in the project area. A total of 11 hamlets/villages are likely to get affected as a result of land acquisition due to the proposed project. All these villages are located in Sainj sub-tehsil of district Kullu. The list of project affected villages, affected due to the process of land acquisition is outlined in Table 6.9.

TABLE 6.9

Project affected hamlets/villages due to the process of land acquisition

S. No.	Name of Project Affected hamlets/ villages
1	Bahuti
2	Darmeda
3	Jangla Bihali
4	Jeeva
5	Kartah
6	Khayan
7	Mail
8	Majhan
9	Manahara
10	Niharni
11	Wahi-Thi

6.5.1 Demographic Profile of Affected Population

The detailed description of the socio-economic profile is highlighted in the following sub-sections, which gives an overall summary of the socio-economic conditions of the affected population residing in the project study area. Census survey covering 100% of the PAFs were conducted in the 11 project affected villages that reckoned about 146 families. Amongst these 146 families, a total population of 436 persons was covered.

(A) Religious Affiliation

The religious affiliation amongst the project affected families is Hinduism. During

survey, it was observed that the entire population within the project area is primarily Hindus.

(B) Caste distribution of PAFs

The caste-wise distribution of population is outlined in Table 6.10. Out of the total 146 project-affected families, about 93.8% belong to the upper caste category, belonging *Brahmins*, *Kshatriyas* and *Vaishyas Castes*, who also form the dominant caste category among the project affected families. The Scheduled Castes (SC) accounted for about 3.4% of the total population, followed by the Backward Caste category, which comprises of about 0.68% of the total PAFs. For about 2.05% of the project affected families, their caste particulars could not be gathered. As per the data, the project affected villages did not have any Scheduled Tribe (ST) population.

TABLE 6.10
Village-wise Distribution of PAFs on the basis of Caste

Village/ Hamlet	BC	GC	SC	DNA	Grand Total
Bahuti		4			4
Darmeda		7	1		8
Jangla Bihali	1	17	1		19
Jeeva		10		1	11
Kartah		35			35
Khayan		1			1
Mail		2			2
Majhan		1			1
Manahara		8			8
Niharni		50	3	1	54
Wahi-Thi		1			1
(Blank)		1		1	2
Grand Total	**1**	**137**	**5**	**3**	**146**

***Source*: Primary Survey, October 2007**

Legend:
GC = General Caste
BC = Other Backward Caste
SC = Schedule Caste
DNA = Data Not Available

(C) Population Characteristics

The demographic profile of the affected villages is given in Table 6.11. As per WAPCOS survey, the total affected population is of the order of 436 persons. Out of this population, males and females constitute about 54.36% and 40.82% of the total affected population. The average family size ranges between 2 to 6 persons per family.

The average sex ratio, i.e. the number of females per 1000 males amongst the project affected population is about 751. The female population was observed to equal in the following villages, Kartah, Khayan and Mail.

TABLE 6.11

Village-wise distribution of PAPs

Village/ Hamlet	Female	Male	DNA	Grand Total	Avg. Family Size
Bahuti	10	4		14	3.5
Darmeda	21	24		45	5.6
Jangla Bihali	28	39	1	68	3.6
Jeeva			11	11	1.0
Kartah	72	72	8	152	4.3
Khayan	2	2		4	4.0
Mail	2	2		4	2.0
Majhan	2	4		6	6.0
Manahara	15	17		32	4.0
Niharni	21	67	1	89	1.6
Wahi-Thi	2	3		5	5.0
(Blank)	3	3		6	3.0
Grand Total	**178**	**237**	**21**	**436**	**3.0**

***Source*: Primary Survey, October 2007**

Further, information pertaining to marital status of the affected population was also collected, which is depicted in Table 6.12. About 34.40% of the affected population is single or un-married. Married population constitutes about 52.06% of the total affected population. A small proportion of the affected population, about 1.15% is widows/widower. In addition, data pertaining to the marital status of certain affected

persons could not be ascertained, which comprises of about 12.38% of the total project affected population.

Table 6.12

Marital status of PAPs

Village/ Hamlet	Married	Single	Widow	Widower	DNA	Grand Total
Bahuti	6	8				14
Darmeda	22	22	1			45
Jangla Bihali	35	24	1	1	7	68
Jeeva					11	11
Kartah	63	55			34	152
Khayan	3	1				4
Mail	4					4
Majhan	6					6
Manahara	15	17				32
Niharni	69	17	2		1	89
Wahi-Thi	2	3				5
(Blank)	2	3			1	6
Grand Total	**227**	**150**	**4**	**1**	**54**	**436**

***Source*: Primary Survey, October 2007**

During primary data collection, information about resident and non-resident population was also collected from the project affected population (PAPs). The details of the same are given in Table 6.13. It is observed that about 86.93% of the surveyed population is resident, and lives in their respective villages. On the other hand there are about 13.07% of the surveyed population that is either non-resident or those persons for whom information could not be collected. Among the migrants, it was observed that they had migrated out of their respective villages in search of jobs/vocations, living with their family members, and have thus settled there or migrated-out for pursuing their studies.

TABLE 6.13

Resident and Non-resident population

Village/ Hamlet	Residents	Non Residents/ DNA	Grand Total
Bahuti	14		14
Darmeda	45		45
Jangla Bihali	66	2	68
Jeeva		11	11
Kartah	120	32	152
Khayan	4		4
Mail	4		4
Majhan	6		6
Manahara	32		32
Niharni	77	12	89
Wahi-Thi	5		5
(Blank)	6		6
Grand Total	**379**	**57**	**436**

***Source*: Primary Survey, October 2007**

6.5.2 Educational profile

The educational profile among the surveyed population as collected through the primary survey is given in Table-6.14. As per the socio-economic survey, about 39.45% of the project-affected population is illiterate/ not going to school. The remaining population (60.55%) is either literate or is presently continuing with their education. Amongst the surveyed population, persons educated upto or pursuing the primary school level is about 23.39% of the total surveyed population. The percentage of population educated or undergoing their education in middle school and high school is of the order of 16.28% and 17.66% respectively. Individuals who manage to complete school level and have taken-up higher education and who are presently undergoing/have completed graduate (includes BA, BCom, BSc) level comprise 3.21% of the total surveyed population respectively.

TABLE 6.14

Educational Profile of the PAPs

Village Name	Illiterate/ Not going to school (*Incl. DNA)	Completed/ continuing Primary School (Class 1-5)	Completed/ continuing Middle School (Class 6-8)	Completed/ Continuing High School (Class 9-12)	Completed/ continuing Graduate	Grant Total
Bahuti	5	1	1	7	0	14
Darmeda	18	9	6	7	5	45
Jangla Bihali	18	19	16	15	0	68
Jeeva	11	0	0	0	0	11
Kartah	71	36	15	21	9	152
Khayan	0	3	1	0	0	4
Mail	4	0	0	0	0	4
Majhan	3	2	1	0	0	6
Manahara	5	14	5	8	0	32
Niharni	32	17	24	16	0	89
Wahi-Thi	0	1	2	2	0	5
(Blank)	5	0	0	1	0	6
Grand Total	**172**	**102**	**71**	**77**	**14**	**436**

***Source**: Primary Survey, October 2007*

6.5.3 Occupational profile

The occupational profile of the affected population is shown in Table 6.15. As per our survey, it is observed that out of the total of 436 persons, about 36.47% are gainfully engaged in an economic activity. This group consists of persons engaged in cultivation, government service, private service, business, artisans and labour, which constitute about 29.81%, 3.89%, 0.92%, 0.46%, 0.46 and 0.92% respectively of the total surveyed population.

TABLE-6.15

Occupational profile of PAPs

Village/ Hamlet	Not Working	HH Chores	Student	Cultivation	Govt. Service	Pvt. Service	Shopkeeper/ business	Handicraft/ Artisan	Daily wage Labour	DNA	Grand Total
Bahuti		4	5	5							14
Darmeda	4	13	19	4	2			2	1		45
Jangla Bihali	9	13	13	21	3		1			8	68
Jeeva										11	11
Kartah	18	37	38	22	11	2	1		3	20	152
Khayan		2		2							4
Mail		2		2							4
Majhan		3		3							6
Manahara	6	8	7	11							32
Niharni	1	16	9	58		2				3	89
Wahi-Thi		2	2		1						5
(Blank)	3	1		2							6
Grand Total	**41**	**101**	**93**	**130**	**17**	**4**	**2**	**2**	**4**	**42**	**436**

Source: *Primary Survey, October 2007*
DNA *= Data Not Available*

About 53.89% of the surveyed population does not contribute economically or in monetary terms, but nevertheless is engaged in some activity. This group constitutes of persons engaged in household chores (primarily women folk) (23.16%) and students (21.33%) and those that were engaged in various vocations and presently drawing pensions, or aged and small children (9.40%).

6.5.4 Livestock holding pattern

During the survey, it was observed that practically all the affected families reared domesticated animals for milk, meat, eggs and labor. The details of livestock holding pattern are shown in Table 6.16.

It is clear from the above Table 6.16 that amongst the livestock, cattle is the most dominant. Cows are mainly reared for their milk. It was observed that bulls are used extensively for ploughing the agricultural fields, which is also evident from the

statistics as well. It is also clear that few families own buffaloes as well. Goats and sheep are also reared by some of the project affected families.

TABLE 6.16

Livestock Holding Pattern of the PAFs

S. No.	Village Name	L1	L2	L3	L4	L5	L6	L7	L8	L9	L10	L11
1	Bahuti	5	4	2	1	0	0	0	0	16	0	3
2	Darmeda	12	8	10	7	0	0	0	0	0	0	0
3	Jangla Bihali	35	22	25	17	0	0	0	0	30	0	3
4	Jeeva	17	10	19	10	0	0	0	0	0	0	0
5	Kartah	24	18	24	10	2	0	0	0	7	0	1
6	Khayan	0	0	0	0	0	0	0	0	0	0	0
7	Mail	0	0	0	0	0	0	0	0	0	0	0
8	Majhan	0	0	0	0	0	0	0	0	0	0	0
9	Manahara	5	5	5	0	0	0	0	0	0	0	0
10	Niharni	62	39	52	41	2	1	1	6	7	27	21
11	Wahi-Thi	1	1	1	0	0	0	0	0	0	0	0
12	(Blanks)	2	2	2	0	0	0	0	0	0	0	0
Grand Total		**163**	**109**	**140**	**86**	**4**	**1**	**1**	**6**	**60**	**27**	**28**

***Source*: Primary Survey, December 2001**

Legend:

L1 = Cows (milch + non-milch; excluding calves)
L2 = Milch cows
L3 = Bulls
L4 = Calves
L5 = He-buffalo
L6 = Buffaloes (milch + non-milch; excluding calves)
L7 = Milch Buffaloes
L8 = Buffalo Calves
L9 = Goats
L10 = Milch goats
L11 = Sheep

6.5.5 Housing

Information regarding Housing details was also collected from the affected families during the socio-economic survey. It was found that no family was houseless. Mixed layout of housing was observed in the project affected villages. The settlement layout as observed during the survey ranged from dispersed to compact settlements. Also linear settlement (on either sides of a village lane) was also observed in some of the project affected villages. The residential unit served the purpose of housing one or many families (off-spring), including their cattle, fuel wood, and other material possessions of these families.

It was observed during socio-economic survey that only 37% of the houses were electrified. It was observed that many of the houses were single storey, and some houses had more than one floor. Further, it was observed that the houses on an average had about 2 to 3 rooms. Stone, brick and mud were used to build the walls of the houses, while the roof was mostly made of wood and tiles. It was observed that most of the houses had a defined space for housing cattle, with about one room for housing cattle on an average. A small percentage of the houses had provision for separate bathroom and toilet facilities. Otherwise, it was observed that most of the residents either made use of the rivulets and streams for washing and cleaning purposes. For sanitation purposes, drains and other means of water outlets were absent in most of the villages.

6.5.6 Sources of Water

Information on sources of water for different uses by the villagers was also collected. It was observed that river/streams are used primarily to meet the water requirement for meeting drinking, washing and cleaning requirements. It was observed that PAFs made use of pipe and tap which is connected to a system of pipe network connected to taps which were either locally assembled or provided by the government. It includes a storage tanks near a source and connected through a network of pipelines, which is subsequently connected to tap dispensers.

6.5.7 Material Assets Holding Pattern

Information on various material assets owned by the surveyed population was also collected. The details of material assets and other assets are shown in Table 6.17. It is clear that many PAFs, if not all, own some material assets. These assets include television sets, tape recorders, transistor radio, LPG cylinder, refrigerators, bicycle,

motor cycles, four wheelers, etc. In addition, there are some families who own agricultural implements such as, ploughs, pump sets, cultivators, chaff cutters, threshers, etc.

TABLE 6.17

Possession of material assets owned by PAFs

Srl	Village/ Hamlet	Television Set	Tape Recorder	Radio Set	LPG Cylinder	Refrigerator	Bicycle	Thresher	Pump Set	Two Wheeler	Four Wheeler	Plough	Cultivator	Chaff Cutter
1	Bahuti	0	0	0	0	0	0	0	0	0	0	2	0	0
2	Darmeda	3	1	1	1	0	0	0	0	0	0	7	0	0
3	Jangla Bihali	11	4	5	3	1	0	0	1	0	0	9	0	1
4	Jeeva	5	0	0	0	0	0	0	0	0	0	9	0	0
5	Kartah	9	2	2	2	2	0	0	0	0	0	11	5	0
6	Khayan	0	0	0	0	0	0	0	0	0	0	0	0	0
7	Mail	0	0	0	0	0	0	0	0	0	0	0	0	0
8	Majhan	0	0	0	0	0	0	0	0	0	0	0	0	0
9	Manahara	4	1	2	2	1	1	0	0	0	1	3	0	0
10	Niharni	21	7	10	13	1	0	2	0	3	1	17	2	1
11	Wahi-Thi	1	0	1	0	0	0	0	0	0	0	1	0	0
12	(Blanks)	1	0	0	0	0	0	0	0	0	0	0	0	0
	Grand Total	**55**	**15**	**21**	**21**	**5**	**1**	**2**	**1**	**3**	**2**	**59**	**7**	**2**

Source: Primary Survey

6.5.8 Ownership of Trees

As a part of the survey, information regarding number of fruit bearing and commercial trees owned by the project affected families was also collected. The village-wise details of trees owned by all the affected families are given in Table 6.18.

TABLE -6.18

Village-wise details of ownership of trees

Village/ Names of Tree	Darmeda	Jangla Bihali	Kartah	Manahara	Niharni	Wahi-Thi	Grand Total
Adu	56	13		10	3	2	84
Akhrot		5	2	4			11
Amrut					0		0
Apple	159	184	30	198	219	60	850
Barlot					10		10
Japani		3					3
Khuani	47		4		5	1	57
Lemon		3			2		5
Narab		50		99			149
Nashpati	55	99	42	99	16	2	313
Orange		3			2		5
Plum	65	20	20	70			175
Ringal			38				38
Sathi		8					8
Surai				99			99
Grand Total	**382**	**388**	**136**	**579**	**257**	**65**	**1807**

Source: Primary Survey, October 2007

6.5.9 Loans and Grants

Information pertaining to the financial assistance received/ taken by the PAFs was also collected. As per our survey, only two individuals from Darmeda had taken loans for construction/ renovation of homestead and purchase of vehicle respectively. It was observed that both these individuals had taken loan from a finance company.

In addition, information about individuals who had received grants was also collected and it was found that, no PAFs had received grants from the government.

6.5.10 Awareness about Project

As a part of the field studies, the information on awareness among the PAFs about the proposed project was also collected. It was observed that more than 75% of the PAFs were aware about the proposed Sainj hydro-electric power project.

CHAPTER-7

PREDICTION OF IMPACTS

7.1 GENERAL

Based on the project details and the baseline environmental status, potential impacts as a result of the construction and operation of the proposed Sainj hydroelectric project have been identified. This Chapter addresses the basic concepts and methodological approach for conducting a scientifically based analysis of the potential impacts likely to accrue as a result of the proposed project. The Environmental Impact Assessment (EIA) for quite a few disciplines is subjective in nature and cannot be quantified. Wherever possible, the impacts have been quantified and otherwise, qualitative assessment has been undertaken. This Chapter deals with the anticipated positive as well as negative impacts due to construction and operation of the proposed project. The mitigation measures have also been given where ever is possible.

The impacts which have been covered in the present Chapter are categorized as below:

- Impacts on Water Environment
- Impacts on Air Environment
- Impacts on Noise Environment
- Impacts on Land Environment
- Impacts on Biological Environment
- Impacts on Socio-Economic Environment

7.2 IMPACTS ON WATER ENVIRONMENT

The various aspects covered under water environment are:

- Water quality
- Sediments
- Water resources and downstream users

7.2.1 Water quality

a) **Construction phase**

The major sources of surface water pollution during project construction phase are as follows:

- Sewage from labour camps/colonies.
- Effluent from crushers.
- Effluents from other sources

i) Sewage from labour camps

The project construction is likely to last for a period of 4 years. The peak labour strength likely to be employed during project construction phase is about 800 workers and 200 technical staff. The employment opportunities in the area are limited. Thus, during the project construction phase, some of the locals may get employment. It has been observed during construction phase of many of the projects; the major works are contracted out, who bring their own skilled labour. However, it is only in the unskilled category, that locals get employment.

The construction phase, also leads to mushrooming of various allied activities to meet the demands of the immigrant labour population in the project area.

The following assumptions have been made for assessing the emigrating population in the area:

- 80% of workers and technical staff emigrating into the area are married.
- In 80% of the family of workers both the husband and wife will work.
- In 100% of the family of technical staff, only husband will work.
- 2% of total migrating population has been assumed as service providers.
- 50% of service providers will have families.
- Family size has been assumed as 5.

Based on experience of similar projects and above referred assumptions, the increase in the population as a result of migration of labour population during construction phase is expected to be of the order of 3200.

The domestic water requirement has been estimated as 70 lpcd. Thus, total water requirements work out to 0.22 mld. It is assumed that about 80% of the water supplied will be generated as sewage. Thus, total quantum of sewage generated is expected to be of the order of 0.18 mld. The BOD load contributed by domestic sources will be about 144 kg/day. Generally, labour population resides in 2 to 3 colonies. Considering the worst-case scenario for the purpose of assessment of impacts on water quality, it is assumed that all the sewage generated from various labour camps/colonies outfalls at a common point. It is also assumed that the sewage is discharged without any treatment. For these conditions, the minimum flow required for dilution of sewage is about 2 cumec.

Detailed DO modelling was done using Streeter Phelp's model. The D.O. level was estimated using the following equation:

$$D_t = \frac{K_1 L_A [10^{-K1t} - 10^{-K2t}]}{K_2 - K_1} + D_A 10^{-K2t}$$

D_t = D.O. deficit downstream at time t.
K_1 = Deoxygenation rate
K_2 = Reaeration rate
L_A = Ultimate upstream BOD
D_A = D.O. deficit upstream
t = Time of stream flow upstream to point at which D.O. level is to be estimated

The D.O. level in the river was taken as 8.0 mg/l (from Tables 4.12 to 4.14). The minimum flow in the river Sainj was taken as 4.82 cumec (from Table-4.6). The results of D.O. model are summarized in Table-7.1.

TABLE-7.1
Results of D.O. Modelling due to disposal of sewage from labour camps in river Sainj

Distance from outfall (km)	D.O. (mg/l)
0.1	8.00
0.2	8.00
0.3	8.00
0.4	8.00
0.5	8.00
1.0	8.00

It can be observed from Table-7.1, that no impact is anticipated on river water quality, as a result of disposal of sewage from labour camps. Normally, during project construction, the labour population is concentrated at 2 or 3 locations. Thus, in the proposed project too, sewage/BOD loading would outfall into the river Sainj through 2 or 3 drains, which means that impacts on DO level of river Sainj would be even lesser than that estimated earlier in this section. Even though no impact is envisaged on water quality of river Sainj, it is recommended to commission units for treatment of sewage generated from labour camps. During construction phase, normally large scale secondary treatment facilities are not commissioned, because they are likely to remain unutilized, once the construction activities are over.

In the present project, it is proposed to commission septic tanks to treat effluent generated by the population residing in labour camps. The details are covered in Environmental Management Plan covered in separate volume of this Report.

ii) Effluent from crushers

During construction phase, at least one crusher will be commissioned at the quarry site by the contractor involved in construction activities. It is proposed only crushed material would be brought at construction site. The total capacities of the two crushers are likely to be of the order of 120-150 tph. Water is required to wash the boulders and to lower the temperature of the crushing edge. About 0.1 m^3 of water is required per tonne of material crushed. The effluent from the crusher would contain high-suspended solids. About 12-15 m^3/hr of wastewater is expected to be generated from each crusher. The effluent, if disposed without treatment can lead to marginal increase in the turbidity levels in the receiving water bodies. The natural slope in the area is such that, the effluent from the crushers will ultimately find its way in river Sainj. This amounts to a discharge of 0.0033 to 0.0042 cumecs. Even the lowest 10 day minimum

flow in river Sainj is 4.82 cumecs. The effluent from crusher will have suspended solids level of 3000-4000 mg/l. On the other hand, suspended solids as observed at various sampling locations, during water quality monitoring studies was observed to be <0.1 mg/l. The composite value of suspended solids would increase by 0.25 mg/l, which is insignificant. Thus, no adverse impacts, are anticipated due to small quantity of effluent and large volume of water available in river Sainj for dilution. Even then, it is proposed to treat the effluent before disposal so to ameliorate even the marginal impacts likely to accrue on this account.

iii) Effluent from other sources

Substantial quantities of water would be used in the construction activities. With regard to water quality, waste water from construction activities and runoff from construction site would mostly contain suspended impurities. Adequate care should be taken so that excess suspended solids in the wastewater are removed before discharge into water body. The effluent is proposed to be treated by collecting the waste water and runoff from construction sites and treating the same in settling tanks.

b) Operation phase

The major sources of water pollution during project operation phase include:

- Effluent from project colony.
- Impacts on reservoir water quality.
- Eutrophication risks
- Sediments

i) Effluent from project colony

During project operation phase, due to absence of any large-scale construction activity, the cause and source of water pollution will be much different. Since, only a small number of O&M staff will reside in the area in a well-designed colony with sewage treatment plant and other infrastructure facilities, the problems of water pollution due to disposal of sewage are not anticipated.

In the operation phase, about 100 families (total population of 500) will be residing in the project colony. About 0.23 to 0.27 mld of sewage will be generated. The total BOD loading will be order of 68 to 81 kg/day. It is proposed to provide biological treatment facilities including secondary treatment units for sewage so generated from the BOD load after treatment will reduce to 10 to 12 kg/day. It shall be ensured that sewage from the project colony be treated in a sewage treatment plant so as to meet the disposal standards for effluent. Thus, with commissioning of facilities for sewage treatment, no impact on receiving water body is anticipated. Thus, no impacts are anticipated as a result of disposal of effluents from the project colony.

ii) Impacts on reservoir water quality

The flooding of previously forest and agricultural land in the submergence area will increase the availability of nutrients resulting from decomposition of vegetative matter. Phytoplankton productivity can supersaturate the euphotic zone with oxygen before contributing to the accommodation of organic matter in the sediments. Enrichment of impounded water with organic and inorganic nutrients will be the main water quality problem immediately on commencement of the operation. However, this phenomenon is likely to last for a short duration of few years from the filling up of the reservoir. In the proposed project, most of the land coming under reservoir submergence is barren, with few patches of trees. These trees too are likely to be cleared before filling up of the reservoir. The proposed project is envisaged as a runoff the river scheme, with significant diurnal variations in water level. In such a scenario, significant re-aeration from natural atmosphere takes place, which maintains Dissolved Oxygen in the water body. Thus, in the proposed project, no significant reduction in D.O. level in reservoir water is anticipated.

iii) Eutrophication risks

Another significant impact observed in the reservoir is the problem of eutrophication, which occurs mainly due to the disposal of nutrient rich effluents from the agricultural fields. However, in the present case, fertilizer use in the project area is negligible, hence, the runoff at present does not contain significant amount of nutrients. Even in the post-project phase, the use of fertilizers in the project catchment area is not expected to rise significantly. Another factor to be considered that the proposed project is envisaged as a run off the river scheme, with significant on diurnal level variations. Thus, residence time would be of the order of few days, which is too small to cause any eutrophication. Thus, in project operation phase, problems of eutrophication, which is primarily caused by enrichment of nutrients in water, are not anticipated.

7.2.2 Sediments

When a river flows along a steep gradient, it could carry a significant amount of sediment load, depending on the degradation status of the catchment. When a hydraulic structure is built across the river, it creates a reservoir, which tends to accumulate the sediment, as the suspended load settles down due to decrease in flow velocity. The proposed project is envisaged as a runoff the river scheme, with a barrage. At regular intervals, the gates of the barrage shall be opened to flush out the sediments. Thus, in the proposed project, sedimentation problems are not anticipated.

7.2.3 Water resources and downstream users

The proposed project is a run of the river scheme. The river flow will be diverted through a small-gated barrage and no major storage is envisaged in the project. Water will be diverted through a tunnel for power generation and the tail race discharge outfall in Sainj river about 8 km downstream from the barrage. The river stretch

downstream of the barrage site upto the confluence point of tailrace discharge (about 8 km) will have reduced flow i.e. 0.60 cumec. The flow will be augmented by contribution of flow by Kartol nallah (2.5 km downstream) joining the Sainj river on its right bank and other small khads joining the river from the left bank, which are Kotli, Khad (4 km downstream), Shana Khad (6 km downstream) and Nuhara Khad (7.5 km downstream) of the barrage. The flow in various streams in the intervening stretch downstream of barrage site upto confluence point of tail race discharge is given in Table-7.2.

TABLE-7.2
Lean season flow in the intervening stretch between barrage site and tail race disposal point

Name	Distance downstream of barrage site (km)	Flow (cumec)
Kartaul Nallah	2.5	0.6
Kotlu Nallah	4.0	0.5
Shana khad	6.0	0.1
Nuhara Khad	7.5	0.1
Total		**1.3**

Thus, river Sainj will not be completely dry, in the intervening stretch. The reduction in flow or drying of the river in the intervening stretch is not likely to have any adverse impact on the downstream users. This is mainly because of the fact that settlements/ villages within this dry stretch are not dependent on the water of river Sainj, as the villagers use water of small streams or nallahs flowing adjacent to their habitation.

7.3 IMPACTS ON AIR ENVIRONMENT

a) Construction phase

In a water resources project, air pollution occurs mainly during project construction phase. The major sources of air pollution during construction phase are:

- Fuel combustion in various construction equipment, e.g. crushers, drillers, rock bolters, diesel generating vehicles, etc.
- Fugitive emissions from crusher
- Impacts due to vehicular movement

i) Pollution due to fuel combustion in various equipment

The operation of various construction equipment requires of combustion of fuel. Normally, diesel is used in such equipment. The major pollutant, which gets emitted as a result of diesel combustion, is SO_2. The SPM emissions are minimal due to low ash content. Based on past experience in similar projects, SPM and SO_2 are not expected to increase significantly. Thus, in the proposed project, no significant impact on ambient air quality is expected as a result of operation of various construction equipment.

ii) Emissions from various crushers

The operation of the crusher during the construction phase is likely to generate fugitive emissions, which can move even upto 1 km in predominant wind direction. During construction phase, one crusher each is likely to be commissioned at the barrage and powerhouse sites. During crushing operations, fugitive emissions comprising of the suspended particulate will be generated. There could be marginal impacts to settlements close to the sites at which crushers are commissioned. However, based on past experience, adverse impacts on this account are not anticipated. However, during finalizing the project layout, it should be ensured that the labour camps, colonies, etc. are located on the leeward side and outside the impact zone (about 1.5 to 2 km) of the crushers. In addition, appropriate management measures has been suggested as a part of the Environmental Management Plan.

iii) Impacts due to vehicular movement

During construction phase, there will be increased vehicular movement for transportation of various construction materials to the project site. Large quantity of dust is likely to be entrained due to the movement of trucks and other heavy vehicles. However, such ground level emissions do not travel for long distances. Thus, no major adverse impacts are anticipated on this account.

7.4 IMPACTS ON NOISE ENVIRONMENT

a) Construction phase

In a water resource projects, the impacts on ambient noise levels are expected only during the project construction phase, due to earth moving machinery, etc. Likewise, noise due to quarrying, blasting, vehicular movement will have some adverse impact on the ambient noise levels in the area.

i) Impacts due to operation of construction equipment

The noise level due to operation of various construction equipment is given in Table-7.3.

TABLE-7.3

Noise level due to operation of various construction equipment

Equipment	**Noise level dB(A)**
Earth moving	
Compactors	70-72
Loaders and Excavator	72-82
Dumper	72-92
Tractors	76-92
Scrappers, graders	82-92
Pavers	86-88
Truck	84-94
Materials handling	
Concrete mixers	75-85
Movable cranes	82-84
Stationary	
Pumps	68-70
Generators	72-82
Compressors	75-85
Others	
Vibrators	69-81
Saws	74-81

Under the worst-case scenario, considered for prediction of noise levels during construction phase, it has been assumed that all these equipment generate noise from a common point. The increase in noise levels due to operation of various construction equipment is given in Table-7.4.

TABLE-7.4

Increase in noise levels due to operation of various construction equipment

Distance (m)	Ambient noise levels dB(A)	Increase in noise level due to construction activities dB(A)	Increased noise level due to construction activities dB(A)	Increase in ambient noise level due to construction activities dB(A)
100	40	76	76	36
200	40	70	70	30
500	40	62	62	22
1000	40	56	56	16
1500	40	52	52	12
2000	40	50	50	10
2500	40	48	49	9
3000	40	46	47	7

It would be worthwhile to mention here that in absence of the data on actual location of various construction equipment, all the equipment have been assumed to operate at a common point. This assumption leads to over-estimation of the increase in noise levels. 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-7.5.

TABLE-7.5

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 project 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 alignment of the tunnel portion. It would be worthwhile to mention that no major wildlife is observed in and around the project site. Hence, no significant impact is expected on this account.

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 barrage site. During construction phase, the increase in vehicular movement is expected to increase upto a maximum of 5 to 6 trucks/hour.

As a part of EIA study, impact on noise level due to increased vehicular movement was studied using Federal Highway Administration model. The results of modelling are outlined in Table-7.6.

TABLE-7.6

Increase in noise levels due to increased vehicular movement

Distance (m)	Ambient noise level dB(A)	Increase in noise level due to increased vehicular movement dB(A)	Noise levels due to increased vehicular movement dB(A)	Increase in ambient noise level due to increased vehicular movement dB(A)
10	40	72	72	32
20	40	67	67	27
50	40	61	61	21
100	40	57	57	17
200	40	52	52	12
500	40	46	47	7
1000	40	42	44	4

As mentioned earlier, there will be significant attenuation due to various factors, e.g. absorption by construction material, air absorption, atmospheric inhomogeneties, and vegetal cover. Thus, no significant impact on this account is anticipated. Since, the project site is located in vicinity of Great Himalayan National Park and Sainj Wildlife Sanctuary, appropriate measures have been suggested as a part of Environmental Management Plan (EMP) report to minimize impacts on wildlife.

7.5 IMPACTS ON LAND ENVIRONMENT

a) Construction phase

The major impacts anticipated on land environment during construction are as follows:

- Quarrying operations
- Operation of construction equipment
- Soil erosion
- Muck disposal
- Acquisition of land

i) Quarrying operations

A project of this magnitude would require significant amount of construction material. The details are given in Table-7.7.

TABLE-7.7

Details of Construction Material Required

Material	Quantity
Coarse aggregate	0.111 Mm^3
Fine aggregate	0.066Mm^3
Cement	63800 ton
Structural steel	1000 ton
Reinforced steel	10400 ton
BQ steel	1190 ton

The cement will be transported from ACC Barmana and Ambuja cement factories. The steel transported from Jalandhar by road. However the requirement of concrete can be met from quarry has already been acquired for Larji Project to be utilized for Sainj project also. The quarry site is located at Silly Larji and about 30 km from the barrage site. A part of the concrete can be met by using the muck generated during excavation of the tunnel, powerhouse and other project appurtenances, by crushing it into the required size. The quantum of muck utilization as construction material would depend on the engineering properties of the muck and its suitability for construction.

The quarrying operations are semi-mechanized in nature. Normally, in a hilly terrain like Himanchal Pradesh, quarrying is normally done by cutting a face of the hill. A permanent scar is likely to be left, once quarrying activities are over. With the passage of time, the rock from the exposed face of the quarry under the action of wind and other erosion forces, get slowly weathered and after some time, they become a potential source of landslide. Thus it is necessary to implement appropriate slope stabilization measures to prevent the possibility of soil erosion and landslides in the quarry sites.

Similarly, the proposed project would require significant amount of fine material, which can be met either by crushing the aggregates or by excavation from borrow areas. In the proposed project, large quantity of fines shall be required, which would entail

excavation from borrow pits. Normally, such sites are left untreated after excavation of the construction material. The pit so created impedes the natural drainage, increases the potential for soil erosion and stores rain water and runoff. These pools of water can serve as habitats for proliferation of mosquitoes, which can lead to increased incidence of vector-borne diseases.

ii) Operation of construction equipment

During construction phase, various types of equipment will be brought to the site. These include crushers, batching plant, drillers, earthmovers, rock bolters, etc. The siting of this construction equipment would require significant amount of space. Similarly, space will be required for storing of various other construction equipment. In addition, land will also be temporarily acquired, i.e. for the duration of project construction for storage of quarried material before crushing, crushed material, cement, rubble, etc. Efforts must be made for proper siting of these facilities. The various criteria for selection of these sites would be:

- Proximity to the site of use
- Sensitivity of forests in the nearby areas
- Proximity from habitations
- Proximity to drinking water source

Efforts must be made to site the contractor's working space in such a way that the adverse impacts on environment are minimal, i.e. to locate the construction equipment, so that impacts on human and faunal population is minimal.

iii) Soil erosion

The runoff from the construction sites will have a natural tendency to flow towards river Sainj or its tributaries. For some distance downstream of major construction sites, such as barrage, power house, etc. there is a possibility of increased sediment levels which will lead to reduction in light penetration, which in turn could reduces the photosynthetic activity to some extent of the aquatic plants as it depends directly on

sunlight. This change is likely to have an adverse impact on the primary biological productivity of the affected stretch of river Sainj. Since, river Sainj has significant flow, hence, impacts on this account are not expected to be significant. However, runoff from construction sites, entering small streams would have significant adverse impact on their water quality. The runoff would increase the turbidity levels with corresponding adverse impacts on photosynthetic action and biological productivity. The impacts on these streams and rivulets thus, would be significant. Adequate measures need to be implemented as a part of EMP to ameliorate this adverse impact to the extent possible.

iv) Muck disposal

A large quantity of muck is expected to be generated as a result of tunneling operations, construction of roads, etc. The component use detail of muck to be generated are given in Table-7.8.

TABLE-7.8
Component use detail of muck to be generated

S. No.	Name of components where Muck/ Debries is to be produced	Total Quantity of muck to be produced (m^3)	Less quantity @ 35% of the muck to be used on various works (m^3)	Quantity of muck to be dumped on compaction basis (m^3)	Factor for increase in muck quantity due to bulking (m^3)	Total Quantity of muck on the basis of increase due to bulking (m^3)	Net Quantity of muck to be dumped on the basis of increase due to bulking (m^3)	Total capacity of dumping proposed in different dumping sites.		
								Sl. No	Dumping site	Capacity of dumping site (m^3)
1	Diversion Barrage	100800	35280	65520	1.40	91728	91728	1	Dumping site No.-1 at Niharni	116864.00
2	Intake structure	1200	420	780	1.40	1092	1092	2	Dumping site No.-2 at Kartaul	163431.00
3	Desanding arrangement	104300	36505	67795	1.40	94913	94913	3	Dumping site No.-3 at Sambha	41439.00
4	Head Race Tunnel	136300	47705	88595	1.40	124033	124033	4	Dumping site No.-4 at Kartah	231306.00
5	Surge Shaft	20300	7105	13195	1.40	18473	18473	5	Dumping site No.-5 at Dharmehara	507035.00
6	Pressure Shaft	14000	4900	9100	1.40	12740	12740	6	Dumping site No.-6 at Karehala near Surge Shat.	42323.00
7	Power House Complex	84800	29680	55120	1.40	77168	77168	7	Dumping site No.-7 at Suind near TRT.	58686.00
8	Tail Race Tunnel	12400	4340	8060	1.40	11284	11284			
9	Roads	331500	116025	215475	1.40	301665	301665			
	Total	**805600**	**283960**	**523640**		**733096**	**733096**	**Total capacity in cum**		**1161084**

The total quantity of muck expected to be generated has been estimated to be of the order of 0.8 Mm^3. Based on the geological nature of the rocks and engineering properties of the soil, about 30% of the muck generated can be used as construction material. However, the balance needs to be suitably disposed. Considering bulking of muck of the order of 40%, the total quantum of muck to be disposed is (1.4 * 0.524) of the order of 0.735 Mm^3. Normally, muck is disposed in low-lying areas or depressions. Trees, if any, are cut before muck disposal, however, shrubs, grass or other types of undergrowth in the muck disposal at sites perish. The total area earmarked for muck disposal is 10.729 ha. The average height at muck disposal site shall be of the order of 6.9 m. The muck disposal sites will be suitably stabilized on completion of the muck disposal. The details are covered in Environmental Management Plan covered in separate volume of this Report.

v) Construction of roads

The project construction would entail significant vehicular movement for transportation of large construction material, heavy construction equipment. New access roads would have to be constructed. Some of the existing roads in the project area, would require widening. The construction of roads can lead to the following impacts:

- The topography of the project area has steep to precipitatuous slope, which descends rapidly into narrow valleys. The conditions can give rise to erosion hazards due to net downhill movement of soil aggregates.
- Removal of trees on slopes and re-working of the slopes in the immediate vicinity of roads can encourage landslides, erosion gullies, etc. With the removal of vegetal cover, erosive action of water gets pronounced and accelerates the process of soil erosion and formation of deep gullies. Consequently, the hill faces are bared of soil vegetative cover and enormous

quantities of soil and rock can move down the rivers, and in some cases, the road itself may get washed out.

- Construction of new roads increases the accessibility of a hitherto undisturbed areas resulting in greater human interferences and subsequent adverse impacts on the ecosystem.
- Increased air pollution during construction phase.

Approach roads 5/7 m wide of total length 19.50 km will be constructed to connect different sites of the project. The existing road from Suind to Neuli (8 Km long) has also been proposed to be widened. The details of proposed road to be constructed are given in Table-7.9.

TABLE-7.9

Details of roads proposed to be constructed

Description	**Length (km)**
5/7 m wide road from Neuli to Barrage	4.0
5/7 m wide road to desanding basin and intake	0.5
5/7 m wide road from Sambha to deflushing tunnel & HRT adit-I at Kartaul nallah	2.0
5/7 m wide road from Suind to bottom of surge shaft	7.0
5/7 m wide road from bottom of the surge shaft to top of surge shaft	2.5
7/10 m wide road from Suind to MAT and tail race	1.5
5/7 m wide road from quarry sites, dumping areas & colony etc.	2.0
Widening of existing road from Suind to Neuli (from 2.75/5m to 5/7m)	8.0
Total	**19.5**

Various management measures have been recommended for control of adverse impacts due to construction of roads. The details are covered in Environmental Management Plan covered in separate volume of this Report.

vi) Acquisition of land

The total land to be acquired for the project is 56.763 ha. A part of this land is required for labour camps, quarry sites, muck disposal storage of construction material, siting of construction equipment, which will be required temporarily and returned once the construction phase is over. Permanent acquisition of land is required for barrage axis, submergence area, project colony, etc.

The details of land required for various project appurtenances is given in Table-7.10.

TABLE-7.10

Land required for various project appurtenances

Unit: ha

Description	Main structure	Submergence	Tunnel (Underground)	Township	Resettlement	Other infrastructure	Total
Agriculture a) Irrigation b) Un-irrigation	- 0.10	- 0.1	- -	- 0.564	- -	- 7.906	- 8.77
Homestead	-	-	-	-	-	-	-
Forest	0.5	5.044	6.053	1.663	-	34.733	47.993
Grazing	-	-	-	-	-	-	-
Fallow	-	--	-	-	-	-	-
Water bodies	-	-	-	-	-	-	-
Marshes	-	-	-	-	-	-	-
Other	-	-	-	-	-	-	
Total	**0.60**	**5.144**	**6.053**	**2.327**	**-**	**42.639**	**56.763**

7.6 IMPACTS ON BIOLOGICAL ENVIRONMENT

a) Construction phase

7.6.1 Impacts on Terrestrial flora

i) Increased human interferences

The direct impact of construction activity of any water resource project in a Himalayan terrain is generally limited in the vicinity of the construction sites only. As mentioned earlier, a large population (3,200) including technical staff, workers and other group of people are likely to congregate in the area during the project construction phase. It can be assumed that the technical staff will be of higher

economic status and will live in a more urbanized habitat, and will not use wood as fuel, if adequate alternate sources of fuel are provided. However, 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. There will be an increase in population by about 3200 of which about 2400 are likely to use fuel wood. On an average, the fuel wood requirements will be of the order of (1.0 x 365 x 2400 x 10^{-3}) 879 m^3. The wood generated by cutting tree is about 2 to 3 m^3. Thus every year fuel wood equivalent to bout 400-500 trees will be cut, which means every year on an average about 1-2 ha of forest area will be cleared for meeting fuel wood requirements, if no alternate sources of fuel are provided. Hence to minimize impacts, community kitchens have been recommended. These community kitchens shall use LPG or diesel as fuel. The details are covered in Environmental Management Plan covered in separate volume of this Report.

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. Since, labour camps are proposed to be constructed by the contractor along with necessary facilities, such impacts are not envisaged.

Acquisition of forest land

During project construction phase, land will be required for location of construction equipment, storage of construction material, muck disposal, widening of existing roads and construction of new project roads. The total land requirement for the project is 55.986 ha of which 47.993 ha is forest land. The forest in the area has

already been degraded due to a large-scale human interference. Though the project area is located in an ecologically sensitive area, the forest in and around the project area are quite degraded. The tree density in the submergence area and power house area is about 610 and 270 trees/ha. Normally in a dense forest, tree density is of the order of 1000-1200 trees/ha. Thus, in land to be acquired for the project, the tree density is low to moderate. No rare or endangered species are observed, hence, acquisition of land for the project is not expected to have any significant adverse impact on the bio-diversity of the area.

7.6.2 Impacts on Terrestrial fauna

i) Disturbance to wildlife

Total forestland requirement for the project is 47.993 ha. During construction phase, large number of machinery and construction labour will have to be mobilized. The operation of various construction equipment, and blasting is likely to generate noise. These activities can lead to some disturbance to wildlife population. Likewise, siting of construction equipment, godowns, stores, labour camps, etc. can lead to adverse impacts on fauna in the area.

The proposed barrage site, lies in close vicinity to GHNP, hence, it is proposed that during construction phase, anti-poaching measures be adopted.

Stray animals, however, may some times drift to the construction site. It should be ensured through stringent anti-poaching surveillance that the stray animals are not killed. Detailed measures for the same have been suggested in Environmental Management Plan covered in separate volume of this Report.

ii) Avi-fauna

The area has a large bird population. The whole area supports good vegetation and the birds are well distributed in the region. A small amount of vegetation patch will be required for the project as compared to vast expanse of vegetation in the adjoining areas. Such small amount of acquisition is not likely to cause any significant adverse impact on the avi- faunal population. On the other hand, increased vehicular movement, blasting, increased human interferences could adversely affect the avi-faunal population in the area. Appropriate management measures have been recommended in the Environmental Management Plan outlined in separate volume of this report.

b) Operation phase

i) Increased accessibility

During the project operation phase, the 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 in the form of illegal logging, lopping of trees, collection of non-timber forest produce, etc. Since significant wildlife population is not found in the region, adverse impacts of such interferences are likely to be marginal. The details of measures to improve the terrestrial ecology of the area are covered in separate volume of this Report.

7.6.3 Aquatic Flora

a) Construction phase

During construction phase wastewater mostly from domestic source will be discharged mostly from various camps of workers actively engaged in the project

area. Around 0.22 mld of water is required for the workers during the peak construction phase out of which 80% (i.e. about 0.18 mld) will be discharged back to the river as wastes, more or less as a point sources from various congregation sites where workers will reside. The average minimum flow during lean season is about 4.82 cumecs. However, sufficient water for dilution will be available in Sainj to keep the DO of the river to significantly high levels.

b) Operation phase

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

7.6.4 Impacts on Aquatic Fauna

a) Construction phase

The construction of the proposed Sainj hydroelectric would involve large-scale extraction of different types of construction material from the riverbed including

boulders, stones, gravel, sand, etc. Extraction of gravel and sand causes considerable damage to fish stocks and other aquatic life by destabilizing the sub-stratum, increasing the turbidity of water, silting of the channel bottom and modifying the flow, which in turn may result in erosion of the river channel. These alterations upset the composition and balance of aquatic organisms. The material at the river sub-stratum like stones and pebbles often provide anchorage and home to the invertebrates that remain attached in a fast flowing stream. During fish spawning season, the fertilized eggs are laid amidst the gravel, where it is made sure, that eggs are not washed away in fast flowing stream. The eggs of almost all species are sticky in nature, which provide additional safety. The turbidity in excess of 100 ppm brought by suspended solids chokes the gills of young fish. Fine solids in concentration greater than 25 mg/l, adversely affects the development of fish eggs and fish.

b) Operation phase

Among the aquatic animals, it is the fish life, which would be most affected. The migratory fish species, e.g. snow trouts are likely to be adversely affected due to obstruction created by the proposed barrage.

With the completion of barrage, flow in the downstream stretch of the river would be reduced considerably more so during the lean period. The most important changes, which can be expected, are:

- Reduced flow rate
- Increase in water temperature
- Reduction in availability of stano-thermal aquatic animals
- Increase in population of euro-thermal species.

Unless the desired flow is maintained downstream of the barrage, aquatic ecology in general and fisheries in particular would be affected. The mitigative measures for minimizing these impacts have been covered in separate volume of this Report.

7.7 IMPACTS ON SOCIO-ECONOMIC ENVIRONMENT

A project of this magnitude is likely to entail both positive as well as negative impacts on the socio-cultural fabric of the area. During construction and operation phases, a lot of allied activities will mushroom in the project area.

7.7.1 Impacts due to influx of labour force

During the construction phase a large labour force, including skilled, semi-skilled and un-skilled labour force of the order of about 1000 persons, is expected to immigrate into the project area. It is felt that most of the labour force would come from other parts of the country. However, some of the locals would also be employed to work in the project. The labour force would stay near to the project construction sites.

The project will also lead to certain negative impacts. The most important negative impact would be during the construction phase. The labour force that would work in the construction site would settle around the site. They would temporarily reside there. This may lead to filth, in terms of domestic wastewater, human waste, etc. Besides, other deleterious impacts are likely to emerge due to inter-mixing of the local communities with the labour force. Differences in social, cultural and economic conditions among the locals and labour force could also lead to friction between the migrant labour population and the total population.

7.7.2 Economic impacts of the project

Apart from direct employment, the opportunities for indirect employment will also be generated which would provide great impetus to the economy of the local area.

Various types of business like shops, food-stall, tea stalls, etc. besides a variety of suppliers, traders, transporters will concentrate here and benefit immensely as demand will increase significantly for almost all types of goods and services. The business community as a whole will be benefited. The locals will avail these opportunities arising from the project and increase their income levels. With the increase in the income levels, there will be an improvement in the infrastructure facilities in the area.

7.7.3 Impacts due to land acquisition

Another most important deleterious impact during construction phase will be that, pertaining to land acquisition. About 56.763 ha of land proposed to be acquired for the proposed Sainj hydro-electric project. Of this about 8.77 ha is private land (un-irrigated land) while about 47.993 ha is forest land. The details of land acquisition, project appurtenances-wise and land-use wise, are depicted in Table – 7.10 of this Chapter. The overall quantum of land required for acquisition is given in Table – 7.11.

TABLE – 7.11

Details of land required for acquisition

Description	**Area (ha)**
Agricultural land	
➢ Irrigated land	-
➢ Un-irrigated land	8.770
Homestead	-
Forest Land	47.993
Total	**56.763**

Note: Of the total of 47.993 ha of forest land to be acquired, 41.94 ha is actual forest land, while 6.053 ha is notional land

It is observed that about 8.77 ha of private land is proposed to be acquired from 3 villages, namely, Sachen, Shanshar and Gara Parli. It is observed that about 216

PAFs are likely to lose land (agricultural and/or homestead) in varying proportions. The details of PAPs losing land is depicted in Table – 7.12.

TABLE – 7.12
Village-wise details of project affected families

Village Name	Total
Suchehan Kothi Vanogi	2
Fati Shainshar Koti Shainshar	129
Fati Gada Parli	76
Total	**206**

7.7.4 Increased incidence of water-related diseases

The construction of a barrage would convert riverine ecosystem into a lacustrine ecosystem. The vectors of various diseases may breed in shallow parts of the impounded water. The magnitude of breeding sites for mosquitoes and other vectors in the impounded water is in direct proportion to the length of the shoreline. Since, this is a run-of river project in a mountainous region, increase in water spread area will be marginal and it would remain mostly confined in the gorge of the river, the increase in the incidence of water borne disease is not expected. Further, mosquitoes are normally observed upto a maximum elevation of about 2000 m above sea level. The proposed project is located just above this elevation. Hence, increase in incidence of mosquitoes is not expected at the barrage site. However, other project appurtenances which are at a lower elevation could face increased incidence of malaria as a result of various factors like aggregation of labour, formation of stagnant pools near labour camps, colonies, etc. may lead to the increased incidence of such diseases around the project area.

Labour camps located at lower elevations, especially close to the power house site could be vulnerable to increased incidence of water-borne diseases, if adequate measures are not undertaken.

7.7.5 Impacts on cultural/religious/historical monuments

Apart from village temple in the study area, monuments of cultural, religious, historical or archaeological importance are not reported in the project as well as the study area. Thus, no impact on such structures is envisaged.

ANNEXURE-II

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
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) If there are 250 mg/l of sulphates, Mg content can be increased to a maximum of 125 mg/l with the reduction of sulphates at the rate of 1 unit per every 2.5 units of sulphates	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
Toxic materials		
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
Radio Activity		
Gross Alpha activity	3p Ci/l	3p Ci/l
Gross Beta activity Pci = pico curie	30p Ci/l	30p (Ci/l)

Notes :-

*1. The figures indicated under the column `Acceptable' are the limits upto 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 upto the limits indicated under column "Cause for Rejection" above which are supply will have to be rejected.

*3. It is possible that some mine and spring waters may exceed these radio activity limits and in such cases it is necessary to analyse the individual radionuclides in order to assess the acceptability or otherwise for public consumption.

ANNEXURE-III

National Ambient Air Quality Standards (Unit: $\mu g/m^3$)

Pollutants	Time weighted Average	Industrial Area	Residential Area	Sensitive Area
SO_2	Annual Average * 24 hours **	80 120	60 80	15 30
NOx	Annual * 24 hours **	80 120	60 80	15 30
SPM	Annual * 24 hours **	360 500	140 200	70 100
RSPM	Annual * 24 hours **	120 150	60 100	50 75

* Annual Arithmetic mean of minimum 104 measurements in a year taken twice a week 24 hourly at uniform interval.

** 24 hourly/8hourly values should be met 98^{th} percentile of the time in a year. However, 2% of the time, it may exceed but not on two consecutive days.

NOTE :

1. National Ambient Air Quality Standards: the levels of air quality with an adequate margin of safety, to protect the public health, vegetation and property.
2. Whenever and wherever two consecutive values exceeds the limit specified above for the respective category, it would be considered adequate reason to institute regular/continuous monitoring and further investigation.

Source : S.O. 384 (E), Air (Prevention & Control of Pollution) Act, 1981 dated April
11, 1994 and [EPA Notification : GSR 176 (E), April 2, 1996]

ANNEXURE-IV

Ambient Noise Standards

Area Code	Category of Area	Limits in dB(A)Leq	
		Day time	Night time
A.	Industrial Area	75	70
B.	Commercial Area	65	55
C.	Residential Area	55	45
D.	Silence Zone	50	40

Note : 1. Day time 6 A.M. and 9 P.M.

2. Night time is 9 P.M. and 6 A.M.

3. Silence zone is defined as areas upto 100 meters around such premises as hospitals, educational institutions and courts. The silence zones are to be declared by competent authority. Use of vehicular horns, loudspeakers and bursting of crackers shall be banned in these zones.

4. Environment (Protection) Third Amendment Rules, 2000 Gazette notification, Government of India, date 14.2.2000.