UTTARAKHAND JAL VIDYUT NIGAM LIMITED

COMPREHENSIVE ENVIRONMENTAL IMPACT ASSESSMENT

FOR

BOWALA NAND PRAYAG HYDROELECTRIC PROJECT (300MW)

DRAFT REPORT

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Contents

CONTENTS

LIST OF TABLE

LIST OF FIGURES

LIST OF ANNEXURE

Executive Summary

EXECUTIVE SUMMARY

1 INTRODUCTION

The state of Uttarakhand has got tremendous potential of developing hydroelectric power, which is estimated to about 25,000 MW Hydropower schemes are being planned and executed in the state of Uttarakhand ever since its inception to bridge the gap between the demand for power and its availability. The Bowala Nand Pryag hydroelectric project forms a part of an overall development plan to harness the potential of the Alkahnanda River for hydroelectric generation.

2 PROJECT DESCRIPTION

Bowala Nand Prayag Hydro-Electric Project is a run of the river scheme on river Alakhnanda. The project is situated in Tehsil Chamoli, district Chamoli of Uttarakhand state The Bowala Nand Prayag hydroelectric power project envisages an installed capacity of 300 MW and a total average annual energy production of 1069 GWh or Million Units for 90% dependable year and 1351 for 50% dependable year. The plant will comprising a concrete barrage, an intake structure, desilting basin, a headrace tunnel, a restricted orifice type surge tank, pressure shaft, underground penstocks, a surfaced powerhouse. The design discharge is 239.4m^3/s cumecs. The catchment area of river Alaknanda at Bowala is 5590 sq.km out of which the snow bound area is 2700 sq.km and rainfed area is 2850 sq.km. The barrage will be gated type with crest length of 123m. Head race tunnel will be horse shoe type of 10.375km length. The power house will be a surface type of 300MW installed capacity. The power house is 120m long, 22.2m wide and 44m high. Total cost of the project is 1862.17 crores at September 2006 and the construction is likely to be completed in about 60 months.

3 BASELINE ENVIRONMENTAL DATA

The data has been compiled for: Land Environment, Water Environment; Air Environment; Noise Environment; Ecological Environment and Socio-economic Environment. Primary data related to the environmental attributes like air, noise level, water quality and soil was collected from field studies during three different seasons. Public consultations were held and a structured questionnaire was used for collection of primary information on socio-economic aspects. Ecological information was collected from field studies. The other information has been collected from various sources.

Land Environment

Parameters involved in land environment are physiography, geology, minerals, soils, land use pattern and seismicity.

Physiography**: Situated in the Himalyas, the district which is nearly half the size of its parent district, Garhwal, is broad in the north and narrow toward the south and is somewhat cup shaped, its length from north to south being about 129km and its breadth form west to east about 117km. To its north lies Tibet and to the northwest the district of Uttarkashi. On the east it is bounded by the Pithoragarh, on the south and south-east by the Almora, on the south west by the Garhwal and on the west by the Tehri Garhwal districts. The land use pattern of Chamoli district indicates that forests are spread over 68.17% of the district area, Net cultivable area occupies 5.21% and Barren land not suitable for cultivation comprises 15.95%. Satellite image of the 10 km radius study area indicates that 83.31% of the area is covered with vegetation out of which 54.18 % is* *dense type. Agricultural land makes 13.37 %,scrubs/bushes 1.47 % and water bodies 0.92% of the area. Settlement makes only 0.71% of the study area.* ***Geology: *The project is located in the rocks Berinag Formation of Garhwal Group. The formation comprises fine to medium grained white quartzite with or without penecontemporaneous mafic volcanics, minor amounts of chlorite phyllite and biotite-chlorite phyllite. These rocks are exposed around Chamoli in the northern limb of Maithana Syncline and between Sunla and Nandpryag in the southern limb, locally referred to as the Patroli quartzite. he rocks are mostly covered with debris and fluvioglacial material and are exposed in the river section, road cutting, and foot tracks. The rocks are moderately to closely jointed.* ***Soils and Minerals:*** *Mainly mountain soil occurs in district Chamoli. The nature and type of soil is quite inconsistent. Mild hill slopes are covered with a layer of fragmented rocks and gravel mixed with soil, whereas top-cover has scoured from steeper slopes. The soils in the valley are alluvial of red and brown colour, being thin on the hillsides. Soil test results indicate that soil in the project area is sandy. Low organic content and the levels of NPK indicate that productivity of soil is moderate. It does not indicate extensive use of fertilizers. The sodium levels do not indicate any potential for soil salinization or adverse impact on soil productivity. In general the pH value is around 7, which indicates neutral characteristics of the soil. The minerals that are found in the district are Asbestos, magnestic, Soapstone or Steatite, copper, iron, graphite, gold, gypsum, lead, slate, limestone, building stone, sulphur and bitumen. The project area falls in zone-IV of the Seismic Zoning Map of India.*

Water Environment

Water environment consists of water resources such as streams, lakes, estuaries, water use, and quality. The water regimes of Uttarakhand comprise mainly three basins. The first type of water basin includes the rivers originating from glacial regions of the Higher Himalayas like the Ganga, Yamuna and Kali rivers. The second and third regimes are the non-glacial rivers originating from ground water sources in lesser Himalayas like Ramganga, Kosi etc. and the seasonal rivers in the Siwaliks. Water quality parameters of the surface water, which is the main source of water in the project area, have been studied for assessing the water environment and to evaluate its suitability for drinking purpose along with anticipated impacts of the proposed project on water environment.

Water Quality*: It is observed from the test results that BOD of all the samples is well within permissible limits of drinking water, which indicates the absence of organic pollution loading. This is mainly due to low population density and absence of industrial activities in the catchment. The iron content of all the samples is above the permissible limits (i.e. 0.3 mg/l). This may be due to the soils rich in iron or dissolution of ferrous minerals. The higher presence of DO is due to the cascading effect of the river and less polluting organic matter. From the results it could be concluded that surface water at the site is fit for human consumption after preliminary treatment like chlorination and sedimentation.*

Sedimentation: *The proposed project being a diversion scheme, silting up of reservoir is not of much importance. However it is essential to remove sediments as these are very much injurious to the runner blades of the turbine and also to the water condutor system. To prevent the turbines and tunnel lining sedimentation tank is designed to exclude particle size 0.2mm and above.*

Air Environment

Meteorology: *As the elevation of the district ranges from 800 mts. to 8000 mts above sea level the climate of the district very largely depend on altitude. The winter season is from about mid November to March. As most of the region is situated on the southern slops of the outer Himalayas, monsoon currents can enter through the valley, the rainfall being heaviest in the monsoon from June to September.* ***Temperature:*** *January is the coldest month after which the temperature begin to rise till June or July. Temperature vary with elevation. During the winter cold waves in the wake of western disturbances may cause temperature to fall appreciably. Snow accumulation in valleys is considerable.* ***Rainfall:*** *Most of the rainfall occur during the period June to September. About 70 to 80 percent of the annual precipitation is accounted for in the southern half of the district and 55 to 65 percent in the northern half.* ***Humidity****: The relative humidity is high during monsoon season, generally exceeding 70% on the average. The driest part of the year is the pre monsoon period when the humidity may drop to 35% during the afternoon. During the winter months humidity increases toward the afternoon at certain high stations.* ***Cloud cover****: Skies are heavily clouded during the monsoon months and for short spells when the region is affected by the passage of western disturbances. During the rest of the year the skies are generally clear to lightly clouded*

Air Quality: *The ambient air quality for suspended particulate matter (SPM); oxides of nitrogen (NOx), carbon monoxide (CO) and hydrocarbon (HC) have been assessed. Two Ambient Air Quality Monitoring (AAQM) stations Near Barrage site at Birehi, and Powerhouse site at Pursari were selected. The air quality monitoring results show that concentration of any of the four pollutant, at any of the two locations, during any time (among three different seasons) have not exceeded the concentration limits of these pollutants specified by CPCB for residential area. Further the presence of gaseous pollutants is either below detectable limits or very low which shows existence of very good quality air in the project area.*

Noise Environment: *Noise levels have been measured at barrage site and powerhouse site during three different seasons. The observations were recorded in the morning (8:00hrs to 10:00 hrs), afternoon (12:00 hrs to 14:00hrs), evening (16:00 hrs to 18:00 hrs) and Night (12:00 hrs to 02:00 hrs). The results of observations indicate that noise levels at the two sites exceeded the limit prescribed for residential area (55 dBA) the reason being the monitoring sites are close to the river.*

Ecological Environment

An ecological study of the ecosystem is essential to understand the impact due to project development activities on the existing flora and fauna of the area. The present study was undertaken to predict change as a result of the project activities and to suggest measures for maintaining the conditions. Three sampling sites (S1, S2 and S3) were identified in the project area. The sampling site S_1 was identified in the submergence area near the confluence of Alaknanda and Birahi rivers(1,042 m above m.s.l.), while the S_2 site was identified near Bowala village (1,032 m above m.s.l.). The sampling site S_3 (892 m above m.s.l.) was identified near power house.

Terrestrial Ecology: *Considering the difficult terrain, quadrate method was used for sampling of the vegetation. Taking into consideration, the size of the vegetation patches, 25 random quadrates of 10m x 10m size were laid to study the trees and shrubs, and 25 random quadrates of 1m x 1m size were laid to study the herbaceous component at each sampling site. The major forest type of the project area is a sub-montane forest. A total number of 127 plant species were recorded during the floristic* *survey in the project area. Plant diversity of the project area encompasses 27 species of trees, 40 species of shrubs, 41 species of herbs, 4 species of climbers and 5 species of grasses in addition to 3 species of Pteridophytes, 3 species of Bryophytes, 3 species of Lichens and 1 species of fungi. At S1 the most dominant tree species were Pinus roxburghii (IVI: 235.87) and Sapium insigne (IVI 64.13). The shrubs were dominantly represented by the species of Blumia spp (IVI: 43.73) followed by Parthenium hysterophorus (IVI 40.85) and Eupatorium adscendensce (IVI: 40.02). The dominant herbs were the species of Aribidopsis thaliana (IVI: 35.84), Ageratum conyazoides (IVI: 34.25) and Bidens pilosa (IVI: 29.10). S2 is dominated by the tree species of Pinus roxburghii (IVI: 213.59) and Sapium insigne (IVI: 65.33). However, the shrubs were dominated by Eupatorium adscendensce (IVI: 46.03), Parthenium hysterophorus (IVI: 44.42) and Colebrookia oppositifolia (IVI: 33.01). The herbs were dominantly represented by the species of Cassia tora (IVI: 39.66), Ageratum conyzoides (IVI: 38.89) and Arabidopsis thaliana (IVI: 37.96). Sampling site S3 is dominated by the tree species of Pinus roxburghii (IVI: 147.57) and Mallotus phillipinenses (IVI: 53.49) and Sapium insigne (IVI: 50.79). The shrubs at the sampling site S3 were dominated by the species of Parthenium hysterophorus (IVI: 43.75) and Eupatorium adscendense (IVI: 43.58). The dominant herbs present at site S3 were Ageratum conyzoidus (IVI: 42.28), Euphorbia hirta (IVI: 39.05) and Euphorbia prolifera (IVI: 37.04).*

Terrestrial Fauna: *On the basis of enquiry from local inhabitants, personal survey and the survey of secondary data, it was revealed that 05 species of mammals, 10 species of birds and three species of reptiles were found to occur in the project area. However, two bird species Himalayan Dove (Streptopelia orentalis) and Cheer Pheasant (Catreus wallichii) were encountered during the ecological survey. Among reptiles, the common rock lizard (Agama tuberculata) was frequently seen in the area*

4 SOCIO ECONOMIC ASSESSMENT

Bowala-Nandprayag Hydro Electric Power project is proposed to develop under the public sector company (UJVNL) of Uttarakhand state. These activities shall necessitate acquisition of about 81.004 ha land, out of which 10.43ha is Reserve Forest land, 27.92 ha is Van panchayat land, 21.99 ha is Civil Forest land, 9.604 ha private agricultural land and the rest 11.06 ha is Underground land. It is also observed that the project does not require acquisition of any built-up or homestead land. Expropriation of lands fromcurrent owners/users (private owners) may lead to some extent of loss of livelihood and economic loss for the project-affected families/people (PAFs/PAPs). This land acquisition needs to be handled with utmost care and fore thought for issues relating to Resettlement and Rehabilitation of Project Affected Families. Such approach is more sensitive since the project area is in remote, where all segments of the society are concerned such as SC, ST, OBC and General. The PAPs include marginal farmers, widows and women. For successful implementation of the project, it is necessary to cultivate a productive relationship between the project offices and the affected families. While implementing the project, there is a need to take into account these disturbances and losses due to the project, their impact on socio-economic condition of the PAPs and plan for their mitigation measures to minimize any negative impacts. The opinion of project affected people/public through consultations/ discussions was collected and the impacts of the project are analyzed. Finally a Resettlement and Rehabilitation Plan is prepared to minimize the stress of PAPs in post project phase. A Socio-Economic Survey (SES) was undertaken to study and understand the socio economic conditions of project-affected families/people and to examine the impact of the proposed project thereupon.

Private land from five villages namely - Bowala, Dusat, Maithana, Pursari and Nandprayag shall be required for the project. The private land from 50 persons (households) has been / shall be acquired for the project. RITES carried out a sample socio-economic survey and public consultations. A sample of 26 households (approximately 52%) spread over these five villages was randomly selected for the survey.

Data Collection: *Primary data for the study was collected through Interview Schedule with the project-affected people with the help of pre-tested and well-structured questionnaire.* ***Data Analysis:*** *The data, so collected, have been compiled, processed and analyzed critically for the purpose of this project.*

SOCIO-ECONOMIC ANALYSIS OF PROJECT AFFECTED FAMILIES (PAFs):

Sex and Age of Project Affected People (PAPs): *Total population of the surveyed households is 207. Among them 112 (54.11%) are male and 95 (45.89%) are female. About 34.78% are in the age group of 19-35 years closely followed by 22.22% are in the age group of 36-60, 18.84% in the age of 0-6 years, 10.63% in 7-12 years, 10.14% are above 60 years, 3.38% in the age group of 13-18 years. Lowest percentage 3.38% has been observed in the age group of 13-18 years, however highest in the age group (19-35 years) of working people.* ***Educational Attainment:*** *It is observed that 15.94% of the PAPs have their education up to primary level, 9.18 and 21.74% of them have their education up to middle and high school level respectively. The highest percentage (22.17%) of PAPs has attained the education at college level. 11.59% of the PAPs are illiterate.* ***Religion and Caste****: Hindu families fully dominate in all surveyed villages. Among PAFs General castes group comprises 96.15% and OBC holds 3.85%.* ***Occupation:*** *Majority of the project-affected families (73.08%) have agriculture as their main occupation. About 11.54% reported in service, 11.54% reported in business and 3.85% indicates that they are involved in other works****. Family Income:*** *highest percentage of (34.62%) of project affected families fall under the income group of Rs. 20,001-50,000/= per annum, however 15.38% managed their households with the income of under Rs. 20,000 per annum. The mean average income of project affected families is Rupees 1,14,625.30 per annum.* ***Marital Status****: 53.14% are married (male 49.11% and female 57.89%) and 43% are unmarried (male 50.89% and female 33.68%) and remaining 3.86% of total population are widows in which 8.42% are widows****. Family Pattern and Size****: 53.85% live in joint family and 46.15% live in nuclear family consisting husband, wife and children. There is no individual family among the PAFs. 34.62% are medium and remaining 15.38% are small in size. The mean average size of family is 7.96.* ***Enlistment:*** *It is observed that all eligible members of the surveyed project affected families have been included in the voter list and hold voter identity card. All the surveyed PAFs have ration cards.* ***Family Assets and Acquisition: Land:*** *The average size of landholding by household is 5.34 Acres. 15.38% of households owned land up to 01 Acre, 23.08% owned up to 1.1 to 2 Acres, 38.46% hold land between 2.1 to 4. Those holding more than 4 Acres of the land constituted 23.08% of the total respondents. It is noted from the data that the households (38.46%) having land are marginal farmers.* ***Houses:*** *04 houses were kuchcha (wooden), 19 houses were pucca with cemented roof and the remaining 03 houses were mixed type (half bricks and half wooden structure). All the surveyed households were electrified for more than 3 years, and the average household electricity bill was about Rupees 115/= per month. Trees: 42.31% of the total households have grown both fruit bearing as well as non-fruit bearing trees within their possessions of land.*

PUBLIC CONSULTATIONS: *The public consultations were held on 17th - 21st January, 2007 by Project proponents and RITES team. The venue for the public consultation was* *fixed in four villages namely - Maithana, Dusat, Pursari and Nandprayag. The response of the people in all villages was quite positive. All the likely to be affected people were found to be apprehensive about the compensation to be paid for their lands. However they assured to their all support to make the project successful. Project Options suggested by them included: proper cash compensation, job opportunities in the project itself for at least one each from each PAFs.* ***SOCIAL IMPACT ANALYSIS****:* ***Loss of Agriculture Land:*** *The extent of loss of agriculture land varied between 0.006 hectare to 0.058 hectare. Loss of agriculture land has major impact on their well being. The loss of agriculture land will be limited to 50 families, which is 6.92% of the total families in the five affected villages. Assuming average sale value as Rs. 42.5 Lac per hectare total cost of land is Rs. 408.17 lakh at the same price for 9.604 ha private land.* ***Loss of Crop Yield:*** *The average yield is approximately 25 quintals per hectare for paddy (Kharif), 10 quintal for wheat (Rabi) and 5 quintal for pulses (Rabi) per hectare respectively. Total land to be acquired is 9.604 ha loss of composite crop for two year works out to be Rs. 21.30 lakh- at the same price.* ***Employment Opportunities****: project will provide direct/indirect employment in general to the local people.* ***Benefits to the Economy:*** *Development of infrastructure and availability of reliable power supply as a result of the project realization would contribute towards better economic activities.* ***Recreation and Tourism Potential****: Improvement of infrastructure facilities in the area is likely to boast tourism and revenue generation from the same****. Pressure on Existing Infrastructure:*** *The construction of hydroelectric project will take about 60 months, during which the workers migrating from outside of the project area, aggregation of workers along with their families is likely to put significant pressure on exiting infrastructure facilities in the project area. Thus management of problems due to population needs to be looked into critically.* ***Cultural Conflicts****: During construction period, migrant population is expected from other parts of the country having different cultural habits however, no cultural conflict is foreseen due to these migrants, as they will be largely settled in separate conglomerates having all facilities and less interactions with the local people.*

Cost of Living and Inflation *Minor increase in cost of living and inflation would be experienced in the project area as a result of increased commercial activities however the same factors will also increase the per capita income of the people in the area and take care of the inflation.*

REHABILITATION AND RESETTLEMENT OF THE PROJECT: *Ministry of Rural Development, Department of Land Revenue, Land Reform Division, Government of India has published the National Rehabilitation and Resettlement Policy for Project Affected Families (NRRP-2007) on 31st October, 2007. The policy addresses the resettlement and rehabilitation (R&R) issues of the Project Affected Families (being displaced) in case of compulsory acquisition of land for public purpose including infrastructure projects. The policy says that it will be applicable to projects displacing 400 families or more enmass in plain areas and 200 families or more en mass in hilly areas, DDP blocks mentioned in Schedule V and Schedule VI of the constitution of India. It also states that the rehabilitation grants and other monetary benefits proposed in the Policy would be minimum and applicable to all project affected families whether belonging to BPL (Below Poverty Line) or non-BPL families. States where R&R packages are higher than proposed in the Policy are free to adopt their own package.*

The R&R benefits shall be extended to all the PAFs whether belonging to BPL (below poverty line) or non-BPL. Due to this project about 50 families are affected due to acquisition of 9.604 ha of private land. The number of affected families is 50, that is much less than 200 and the project area and Chamoli region of Uttarakhand does not fall in the Schedule category of the Constitution. Hence the Separate Social Impact Assessment (SIA) under NRRP-2007 is not compulsorily applicable in this case. It is reported that the state of Uttarakhand also does not have any R&R policy in place, as *on date. But keeping the needs of people, executing agency and other concerned body, a brief R&R plan has been made for the use.* ***Community Development Scheme (CDS)*** *has been envisaged for the project.* ***Methodology:*** *The CDS shall aim to have a specific community development program for the project-affected area, in which the following steps shall be involved: Creation of separate CDS Cell; Identification of affected families; Conducting demographic and socio-economic survey; Establishment of "participative mechanisms"; Project Execution Mechanism; the Community Welfare Committee shall execute the program.* ***Works to be carried out under CDP in project affected area (villages):*** *CDS is an essential component of the R&R to support PAPs for their betterment and also for the region. Following assigned works has been proposed to be carried out by the project developer under this segment in the project affected area: Livelihood Enhancement Works; Animal Husbandry: Horticulture and Medicinal Plants; Public health Support; Gender Support; Infrastructure Development Support; Education Assistance; Direct and Indirect Employment Opportunities in Project; Other Development Works in the Area*

Monitoring and Concerted Evaluation: *A system shall be evolved to have a continuous feed back for implementation of the program. A separate body comprising the representatives from project management & public representatives shall be formed for monitoring and concerted evaluation of the CDS.* ***Public Information System and Grievance Redressal:*** *It is one of the most important tools to keep a continuous interaction with the affected areas and to keep them informed with the actions, achievement and program underway. It shall have to be ensured that there is no communication gap between project authorities and the affected persons. The composition, powers functions of the grievance cell shall be as per prevailing norms, however it must include one male and one female from the project affected people. The project-affected-people could elect these representatives among themselves. Any aggrieved persons from the affected area could move his/her application to the cell and it is finally concluded. Cost Estimate for CDS and R&R: The estimated cost of CDS and R&R works out to* ***1071.55 Lakh*** *for the project.*

5 ENVIRONMENTAL IMPACTS

In the process of development there has been intensive use of natural resources, very often leading to ecological imbalance. The impacts of the project could be positive or negative. Both types of impact have been studied and wherever possible, have been quantified. ***Impacts Identification:*** *The potential impacts of the proposed hydel project on the environment can be in different phases of project cycle namely location, construction and operation. The type and magnitude of the impacts, however depends on the specific attributes of the given environment.*

Impacts due to Project Location

Loss of Land / Change in Land use: *Permanent change in land use shall be due to construction of various permanent features of the project on ground like; barrage, head regulator, sedimentation tank, head race tunnel, surge tank, penstock, power house, tail race works and colonies. Land will also be required for Infrastructure facilities like access road and storage of magazines and for dumping areas. It is observed that out of the total 81.004 hectare land requirement of the project, 10.43 is Reserve forest, 27.92 ha is Van Panchayat land, 21.99 hectare is Civil Forest land, 9.604 ha is private land, and remaining 11.06 hectare is Underground land.* ***Encroachment into Forest/Govt Land:*** *The proposed project envisages acquisition of 60.34 hectares forest land.* ***Encroachment into Wildlife Habitat/Corridor:*** *The project area of 10-km radius with barrage site as its center does not encroach into any wildlife sanctuary or any other type* *of natural reserve. No rare or endangered species of wildlife/trees have been reported within the 10-km radius area.* ***Loss of Historical, Cultural and Religious Monuments/Structures:*** *No historical, religious or cultural monuments will be lost due to the project location or its activities.* ***Loss of Infrastructure:*** *There is no house or structure coming under this project. Only agricultural land would be required for various project facilities.*

Disruption of Hydrological Balance: *The flow of water in about 11 km long stretch of the river, downstream of the barrage site, would be affected due to the construction of barrage. It is observed during site inspection that water is not drawn from the affected portion of the river (between barrage site and power house) for irrigation or any kind of industrial use. The people residing in the nearby locality rarely use it for washing, bathing etc. There are four perennial tributary between barrage and power house which joins Alakhnanda river. These perennial tributary are Bhim Dhara (3 d/s from Barrage), Bal Khila (7Km d/s of Barrage) Pole Nala (8 km d/s from Barrage), Pursadi Nala (12 Km d/s of Barage). Some seasonal streams also join the Alakhnanda river between the point of diversion and the tailrace outlet. These perennial streams have a total discharge of more than 85.65 cusec (2.42 cumec). The total streams/nallahs between the diversion location and Tail Race location, which are perennial in nature, on the left bank are 3 and one on the right bank. A minimum sacrificial flow of about 4.3 cumecs would also be maintained from barrage. This total lean season discharge of 6.72cumecs would be available to the local downstream villages, as the waters from these streams are not planned to be tapped by the Project. Impacts of only minor magnitude are anticipated on the hydrological balance of the project area.* ***Risk due to Earthquake :*** *The project area falls in zone IV of the Indian Standard Seismic Map and quite sensitive from seismic point of view. For safety of the structures, necessary factors and appropriate co-efficient have to be incorporated in designing the structures under worst combination of forces. Provided with the appropriate design of the barrage, tunnel, penstock, power house and other structures of the scheme, the risk due to earthquake can be minimized to desired limits.*

Impacts Due to Project Construction

Increased Soil Erosion at Construction Sites: *Runoff from unprotected excavated areas, muck disposal sites, quarry sites, etc., would result in increased soil erosion. Excavations on slopes would also decrease its stability. Given with the topography of the area, unprotected excavations on sloping grounds will make them landslide prone sites, especially during the rainy season.* ***Muck Generation from Tunneling Operation:*** *About 24,00,000 cum of muck would be generated from various construction activities, out of which 3,00,000 will be used for backfill. 21,00,000 cum needs to be disposed in nearby area. Muck disposal sites shall present large surfaces with loose soil liable to erosion.* ***Transportation of Muck and Construction Material:*** *Considering that one dumper trip carries 6 cum muck and the construction activities are completed in 60 months, each month having 26 working days, there would be about 224 dumper trips every working day. In addition, about 295000 tonnes of cement, 17000 cum of stone, 18693 tonnes of steel, and electrical/ mechanical equipment will have to be transported from Rishikesh/ Haridwar Dehradun.* ***Health Risk:*** *Health risk during construction phase of the barrage and other works, include disease hazards due to lack of sanitation (water supply and human waste disposal), vector borne diseases and hazards due to local carriers.* ***Air Pollution:*** *The increase in concentration of air pollutants during construction would be of temporary nature and would remain well within the prescribed limits. The project is unlikely to cause any kind of air pollution during operation. It is, therefore, considered that the project will not cause any air pollution of any significance.* ***Noise Pollution:*** *The major sources of noise pollution during construction are movement of vehicles for transportation of construction material* *to the construction yard and the noise generating activity at the yard itself. Construction activities are expected to produce noise levels at source in the range of 80-130 dB (A), which will decrease with increase in distance. The construction works will be carried out during the daytime. The impact of noise produced during the construction will, however, be limited to a distance of about 50 to 200 meters at which the noise level of various equipment will come down below 55 dB (A). It could therefore be concluded that the construction activities would not have a significant impact on existing ambient noise levels.* ***Water Pollution and Quality:*** *The total sewage production from workers camp will be about 0.80 x 70x3000 = 168* m^3*/ day. The BOD load contributed by the domestic sewage will be about 240-kg/ day. The sewage from workers camp and other establishments need be treated before its final disposal.* ***Quarry Operation on Ground and in River Bed:*** *The project would require about 550000 tonnes of stone/river boulder to fulfill the requirement of coarse aggregate and stone for construction, which shall be quarried from the riverbeds of Alakhnanda River and by crushing nearby available boulders. Excavation on hill slope shall have its impact on the stability of slope, whereas excavation in riverbed shall increase the turbidity of water temporarily. The quarrying operation may cause dust pollution. However, the impact of dust pollution will be temporary and can be minimized by regular sprinkling of water to suppress dust during the working season.* ***Impact of Tunneling on Surface and Groundwater Resources*** *Tunneling work could result in ruptures in the overburden layers, through which water may leak into the tunnel during construction. The water leakage could result in drying of the groundwater source i.e. springs falling in the tunnel influence zone and channels crossing the tunnel alignment. The leakage may also result in lowering down of the ground water table in the tunnel influence zone. Water resources of Sendungra, Rupa. Dusadgaon, Harmani, Baratt which fall in the vicinity of the tunnel alignment, may be affected.* ***Safety Hazards of Tunnel Construction:*** *The major causes of accidents during tunnel construction are; Uncontrolled contact between personnel and material or equipment; Failure of temporary structure; Inherent construction hazard such as use of explosives and unsafe practices or carelessness by individual workers.*

Impacts Due To Project Operation

The impacts due to project operation shall be long term and can be both positive and negative in nature. ***Deforestation:*** *During operation phase, all the activities and the staff will be mostly confined to the Power House area which is far away from the forest thus it will not affect forest area. On the other hand the requirements of fuel wood for heating and cooking will be replaced by cheap electricity generated by hydropower project, ultimately reducing deforestation.* ***Effect on wildlife:*** *The human activities have already pushed the wild life away from these places. The operation of project would increase the human activities in the area, however, it is not expected to affect the wildlife which is already away from the project area.* ***Increased Incidences of water borne diseases:*** *The project being a run of the river scheme, does not have any significant impoundment of water. Regular testing of water for these factors would be carried out for prevention & control of water borne diseases. Additional health facilities will improve the future status. However, field survey showed that the typical vector borne diseases are not common in the project area.* ***Impact on Aquatic Life and Fish Migration:*** *Minimum water requirement downstream of barrage/head works will be maintained for survival of aquatic life. The length of river in which the flow will be reduced due to withdrawal of water in between barrage and tailrace tunnel is just 11.0 km. In downstream, arrangement will be made to release a minimum sacrifice discharge of 4.3 cumec.* ***Public Health Facilities:*** *In all about 118 residential quarters are likely to be constructed for operation of the project in the colony. Domestic water requirements @ 135 liters/capita/day: assuming 4 persons per family for 118 units works out to 63,720 lpd say, 64 cum per day. Adding the water requirement for 118 person in office @*

70liter/person, the total requirement of water during operation works out to about 0.072 mld, which could be met with the water from springs and the river using pumping arrangements. However, the water needs preliminary treatment like chlorination and sedimentation before use.

Positive Impacts

The positive impacts have been listed under the following headings: ***Clean and Renewable Source of Energy:*** *On completion, the project would provide 300 MW of electricity. Hydropower is a non-polluting and renewable source of energy, which accounts for more than 97% of the electricity generated in the country by renewable sources.* ***Employment Opportunities:*** *The project will provide short and long term employment opportunities An average of about 1200 persons are likely to work during construction period. (Equivalent to 1200 persons X 26 working days X 60 months=18.72 lakhs mandays). In operation phase, about 118 persons will be deployed for operation and maintenance of the project. (Equivalent to 118 persons X 312 working days per year = 36934 mandays per year) This employment will be at all levels starting from unskilled worker to plant operator and administrator.* ***Recreation and Tourism Potential:*** *Chamoli is synonymous with natural splendours and scenic wonders and is famous for being the gateway for Badrinath, Hemkund Sahib, Joshimath, Valley of flowers The world-class winter games resort Auli is around 50 kms from Chamoli Improvement of access road and other infrastructure facilities due to the project is also likely to boost tourism in the area. Benefit in terms of revenue generation from tourism will depend upon the size and kind of infrastructure developed.* ***Benefit to the economy*** *Expansion of industrial and agricultural activity will receive a boost as a result of this project. Long term stationing of permanent staff would lead to allied economic activities in the project area.* ***Less Fuel Consumption:*** *The project capacity is 300MW and it would generate 1069 Mu (GWh) power annually on 90% dependability. Considering specific consumption of coal as 1.06kg/Kwh, in no project scenario, in order to generate this power by thermal power plant, about 1.13 milion tones of coal would be utilized. With the implementation of this project equal amount of coal is saved. This will directly benefit to the tune of Rs.1360 million per year.* ***Reduction in Air Pollution:*** *With the existing system of no hydropower scenario, the total estimated pollution load to install 300MW thermal power plant is 8626 tonnes per year.* ***Reduction in Greenhouse Gas (Carbon Dioxide) Emission:*** *About 1.066 million ton of CO_2 will be emitted from 300MW coal fired thermal power plant. With the construction of proposed hydropower plant equal amount will be eliminated. This will reduce 1.066 million tones of green house gas contribution to the global environment every year. The cumulative reduction in Green House gas (CO_2) taking 70 years lifetime of the project thus works out to 74.61 million tones.* ***Increased Infrastructure:*** *Present infrastructure is either likely to be upgraded or new infrastructure to be set up with the implementation of the new project. Basic infrastructure required to be developed are roads, health facilities, educational facilities etc.*

Checklist Of Impacts*: Based on negative and positive impacts a screening checklist of environmental impacts has been prepared and presented in the report. Environmental impacts at various stages of the project e.g. location, construction and operation are listed and the degree of environmental impact is shown. The terms none, minor, medium and major are used in the checklist to classify the magnitude of impact. In the checklist, the location, construction and operation phases have been considered separately in order to distinguish the short term and long term impacts.*

6 ENVIRONMENTAL MANAGEMENT PLANS

*An EMP for the project has been prepared and presented, which defines actions to be undertaken during the pre-construction (including those already undertaken), construction, and operation stage of the project. The important actions during the **pre-construction stage** would be/have been; site selection to minimize the land acquisition so that least people are affected and no displacement of people; adequate design provisions for safety of project structures in general and the HRT in specific against seismological hazards. **Construction time** mitigation measures include; control of soil erosion, mass movement at excavation sites and muck disposal area; control of air, noise and water pollution as a result of various construction activities; good housekeeping practice at workers camp and close monitoring of any impact on water resources, houses and infrastructure facilities of the local villagers in the close proximity of tunneling and powerhouse construction. The effectiveness of these environmental considerations will, however, depend on appropriate inclusion of these in the work contracts. **Operation period** mitigation would involve good house keeping practice, wastewater disposal and maintenance/upbringing of green area/plantation. The operation unit will also be required to confirm, receipt of the construction period mitigation report and prepare a follow on timetable of actions.*

Mitigation Measures:

***Pre-construction** mitigation measures will include;*
***Compensation for Loss of Land:** For this project 9.604 ha of private agricultural land would be acquired. It is proposed to pay cash compensation to the concerned person as per government norms The compensation will have to be paid through Land and Revenue Department of Government of Uttarakhand. Compensation for standing crops, trees available on the proposed land shall be paid extra. The compensation should, however, not be less than the prevailing market rate of the land.*
***Compensatory Afforestation:** 49.28 ha of forest land will be lost due to location of project components. It is proposed to do compensatory afforestation over 120.68 hectare area in nearby degraded forest area. The objectives of the re-afforestation programme should be to develop natural areas in which ecological functions could be maintained on sustainable basis. Therefore planting of miscellaneous indigenous tree species should be applied. The afforestation work will be carried out through the Local Forest Department. The cost of compensatory afforestation @ Rs. 0.6732 Lac/ha works out to Rs. 81.24 lacs.*
***Preservation of Rare and Medicinally Important Species of Terrestrial Flora :** Some of the species of terrestrial flora which are either rare or have medicinal value shall be affected due to the project activities. Efforts will be made to preserve these species by including them in the plantation programs under reafforestation and CAT plan. It is also proposed to establish and maintain nursery specially for these species. The work will have to be carried out through the local forest department.*
***Sedimentation Control:** A comprehensive Catchment Area Treatment (CAT) plan has been presented, which would help in reducing the sedimentation load in the river. The project design, envisages removal of suspended particles of size greater than 0.20 mm from water entering the HRT through sedimentation tanks, which takes care of any possible damage to the turbine by suspended particles. Sedimentation tanks will be flushed out at regular interval to remove the accumulated sediments. The collected sediments will again be put into the river.*
***Minimum Sacrificial Flow:** A number of perennial streams having considerable flow join the river down stream of the proposed barrage. Neither water is drawn for any purpose nor any effluent is discharged in this critical length (between barrage and powerhouse) of the river. A minimum sacrificial flow of 4.3cumec has been provided to*

sustain the aquatic life and any other down stream use of the river water. Provision to maintain this flow shall be made in the barrage structure. A flowmeter is proposed to measure the sacrificial flow.

The construction period *mitigation would include the following measures:*
Soil Erosion Control: *Careful planning & selection of borrow pits, timing of cut and fill operations and re-vegetation are required to mitigate the soil erosion. A general guideline to control soil erosion shall be to stop all the earthwork activities during rainy season so that surfaces having loose earth are not exposed to rains. The cutting and filling area, on completion of the work shall be dressed well, compacted and covered with plantation.*
Muck Disposal: *The muck shall be filled in pre-selected areas in layers and compacted mechanically. Dumping sites on sloping ground shall be protected adequately against any possible slide/slope failure through engineering measures. The entire muck disposal area on completion of the filling operation shall be provided with a layer of good earth on the top, dressed neatly and covered with vegetation. A provision of Rs 18.75 lakhs towards development of muck disposal site as green patches has been made as estimated.*
Measures for Road Construction: *The clearing shall be kept minimum as per technical requirement of the road. The clearing area shall be demarcated to save trees and to keep tree cutting to minimum. The cut and fill shall be done at the same time to avoid large accumulation of earth/ soil. The slopes shall be stabilised and retaining wall shall be provided wherever required. Excavated material shall be stored properly for reuse/ refill for disposal and the diversion drains during construction shall be connected with natural drains.*
Side Slope Stabilization of Excavation and Quarry Sites: *The quarrying operation should be controlled and permitted in specified area earmarked for such purpose. Design of excavations i.e. side slope, benching depth of excavation shall be approved by the construction supervision engineer before starting the work. No unauthorized excavation should be allowed. Engineering measures like application of boulder crates at critical locations would be applied to stabilize the slope of excavation if needed. A provision of Rs 10 lakhs has been kept for this head.*
Measures to Control Indiscriminate Felling of Trees: *Efforts would be made to minimize the cutting of trees for various construction activities. An inventory of trees required to be cut shall be prepared showing the details of each tree to obtain necessary prior approval. Encroachment on nearby forest reserves and subsequent forest degradation can be avoided by arranging adequate supply of alternative fuels. Requirement of fuel for workers camp will have to be met through supply of fossil fuel to avoid encroachment on forest area during construction phase It is proposed to provide 50 % subsidy through the project proponent for compulsory provision of LPG in workers camp. The users and the contractor can share the balance cost. A provision of Rs. 67.5 lakhs has been kept for this head.*
Air Pollution Control: *Every day the haul road at the construction site shall be inspected and the debris left by the tractor - trolleys shall be removed as early as possible. As the vehicular movement may lead to fugitive dust in the area, hence provisions shall be made for sprinkling of water on the roads at least once a day during the entire construction period. Idling of delivery trucks / tractors and other construction equipment's shall not be permitted during the periods when they are unloaded or are not in active use. Stone crushers, which have installed pollution control device and have taken a certificate to that effect from the state pollution control board, shall only be allowed to operate. Concrete batching plant should be located at or near the project site so that the requirement of transit mixers/ delivery trucks is minimized. Operation time of each construction machinery should be optimized through modifications in the work schedule. As soon as the construction activity is over the surplus earth should be*

utilized to fill up the low-lying areas, if any. All stationary machines/DG sets emitting the pollutants shall be inspected weekly for maintenance and should be fitted with exhaust pollution control devices.

Noise Control: *Special acoustic enclosures shall be provided for individual noise generating construction equipment like DG sets. The Special acoustic enclosures may be provided by way of noise shields. For protection of construction workers, earplugs should be provided to those workers who will be working very close to noise generation source. Acoustic material and other protection device should conform to the user guidelines specified by MoEF. Noise control measures to be adopted for various construction machinery/sites shall be provided in the conditions of particular application of work contracts.*

Water Supply and Wastewater Treatment Facility for Workers Camps: *One community latrine could be provided per 20 people. The sewage from community latrine would be treated through septic tank and disposed off through soak pits. The drinking water facilities and sewage disposal sites should be located away from each other. About Rs 83 lakhs will be required for these facilities.*

Solid Waste Management for Labour Camps: *One garbage collection bins of about 20 litre capacity with handle and cover would be provided among eight workers every two and a half years, in addition four community bins at different locations would be provided for effective collection of the waste. The cost of these facilities including maintenance for 60months works out to about Rs.54.95 lakhs.*

Health Delivery System *Health centre facility would be provided for the workers during construction period. According to the criteria of Ministry of Health and World Health Organisation, two Health Centre (HC) with one doctor and minimum of five health personnel, (nurses, compounders etc.) for each HC would be required. Cost of the health facilities works out to Rs. 83.60 Lakhs.*

Precautions Towards Depletion of Water Resources in the Vicinity of Tunnel: *It is also proposed to measure the minimum discharge of the streams crossing the tunnel alignment and depth of ground water table in the villages near the tunnel before starting the tunnel excavation work. The observations will be used to see the impact of tunnelling on the water sources. In case, there is any indication of adverse impact on the water resources, the project authorities should take immediate action for alternative arrangement of water for the affected population.*

Safety Precautions in of Tunnel Construction*: Measures, which can provide guidelines for preparation of a comprehensive safety program achieving better safety performance for underground works are; deployment of a full time safety engineer, who will also prepare a safety program tailored to the project; emergency measures should include tunnel evacuation plan and procedures independent of the tunnel power supply; tunnel personnel should wear protective headgear, footwear and any other special garments that applicable code requires; specific working areas in underground construction can have their own unique risks that personnel should be made aware of; weatherproof first aid kits should be provided at appropriate locations; tunnels should be provided with mechanically induced reversible flow primary ventilation for all work areas and there should be detailed guidelines for handling and storage of explosives.*

Cultural Upliftment and Education Assistance*: The project will serve as a platform for cultural exchanges. The project will bring diverse cultural events and will lead to cultural upliftment of the area. To maintain the cultural heritage/events and promote awareness a provision of Rs.10 lakhs has been provided in the estimate to be appropriately utilised by cultural department of local administration.*

Training and Extension: *The training and extension programmes need to be conducted for Engineers of UJVNL officers. These programmes should also be extended for the local population for their active participation in the project implementation.*

Operation Period Mitigation *would include**:***

Deforestation (Mitigation): *There is local movement of residents of nearby villages, who collect the forest produce for domestic use and graze their cattle in nearby area. The requirements of fuel wood for heating and cooking can be replaced by cheap electricity generated by hydropower projects, ultimately reducing deforestation.*
Water Supply and Sanitation in Colony: *The surface water test results indicate that it needs preliminary treatment like chlorination and sedimentation before use. The wastewater from staff colony and office accommodation (about 0.058 mld) would be treated in aerated lagoon and secondary sedimentation tank to achieve the effluent standards for application on land. The effluent after treatment can be used for horticulture within the colony and powerhouse area.*
Refuse Disposal for colony: *The solid waste first needs to be collected in properly designed collection containers equipped with side handles to facilitate handling. The containers used for garbage storage should not exceed 50 litres capacity and should preferably be equipped with lockable cover. To avoid odour and accumulation of fly-supporting materials, garbage containers should be washed at frequent intervals. The solid waste could be finally converted to compost and reused for horticulture. Cost of these works shall make part of the engineering estimate.*

Dam Break Study and Disaster Management Plan: *MoEF committee observed that in event of a dam break of Vishnugad Pipalkoti HE project which is on upstream of the Bowala Nand Prayag HEP, the flood so generated could cause danger to proposed Bowala Nandprayag barrage. The committee observed that an examination of the dam break study of Vishnugad Pipalkoti (VP) project reveals the flood surge level as 1060.57 m at 15.8 km downstream of VP dam and also as BN project has a barrage as headworks the consequence of dam break upstream with water level expected to rise to 1044 m 18 km downstream of VP dam will endanger/destroy the barrage. In view of these observations, a review of Dam Break Analysis Report of Vishnugad Pipalkoti Project was carried out and since it covered a reach of only till about the proposed location of Bowala Nandprayag barrage, it was revised for downstream reach also with the help of additional river cross-sections taken during the course of study.*
In the revised Dam break study, Manning's coefficient has been considered varying between 0.055 to 0.080 replacing 0.4 used as manning's coefficient in VP dam break analysis. All other input parameters have been taken as same in the model setup those used in VP dam break analysis report. Based on latest corrected results, it can be observed that water levels with these corrected parameters at proposed Bowala barrage location downstream stretch remains below top of Bowala barrage i.e. 1034.0 m. Average river bed level at site is 1022 m. Hence in view of this modified modelling results, the flood waves doesn't pose any danger to this barrage and Bowala project would be safe functionally. In the event of dam break a disaster management plan has been prepared covering *Surveillance, Emergency Action Plan, Administrative and Procedural Aspects, Preventive Action, Communication System.*

7 CATCHMENT AREA TREATMENT PLAN

Catchment Scenario*: Alakhnanda River is one of the major tributaries of the river Ganga. Alakhnanda joins Bhagirathi at Devprayag to form the sacred river Ganges. The Alakhnanda originates at a height of 3641 meters below Balakun peak 16 km upstream from Badrinath form the two glaciers of Bhagirath Kharak and Satopanth. While moving from its source, the river flows in a narrow deep gorge between the mountain slopes of Alkapuri, from which it drives its name. All along its course, it drains its tributaries The total catchment area of river Alakhnanda at proposed barrage site is 5590 sq km as per DPR and 5549 sq km as per GIS study*
Catchment Area Treatment And Its Need: *Erosion observed in watershed area needs attention/mitigation. Soil erosion may be defined as detachment and transportation of*

soil. Various factors affecting erosion are soil characteristics, meteorological conditions such as total annual precipitation, snow fall, intensity of precipitation, wind velocity, exposure conditions such as extent and type of vegetation cover and the topography of the catchment. Controlling one or more factors responsible for erosion as mentioned above can control the process of soil erosion. Providing vegetation cover will have two fold effect in erosion control, the first is that it improves the soil matrix through reinforcing and second it reduces the intensity of run-off. Breaking of slopes through engineering measures like, check dams, contour bunds and retaining walls discontinue the slopes and prevent mass movement of soil.

Objectives:
Integrated watershed management aimed at minimizing the sedimentation and ecosystem conservation of the catchment area is the prime objective of the catchment area treatment.
***Approach and Methodology**: Catchment area map, Landuse classification map, soil map and slope map are used for the study. In the present study, 'Silt Yield Index' (SYI) method is used for determining erosivity of soil in a hydrological unit or watershed. In this method, the total catchment area is subdivided into various watersheds and the erodibility is determined on relative basis. SYI provides a comparative erodibility criteria of the catchment (low, moderate, high, etc.). The Silt Yield Index (SYI) model, considering sedimentation as a product of erosivity, erodibility and arial extent was conceptualized in the All India Soil and Land Use Survey (AISLUS) and is used to meet the requirements of prioritization of smaller hydrological units within river valley project catchment areas.*
***Catchment Area Treatment Measures**: Plantation works will be carried out in 350 ha forest area. Check dams would be constructed in some of the areas to promote growth of vegetation that will consequently lead to the stabilization of slopes/area and prevention of further deepening of gullies and erosion.*

***Cost Estimate and Phasing of Works**: Cost of the CAT works has been estimated to Rs. 3621.79lakhs. The cost of CAT works shall be borne by the project proponent and implemented through Forest Department of Uttarakhand Government The catchment area treatment works have been phased over five years duration, so as to complete them along with the project construction. The actual start time shall, however, depend upon the overall progress of the project including approvals and disbursement of funds for the CAT.*

8 ENVIRONMENTAL MONITORING PLAN

The environmental monitoring will be required during construction and operational phases for: Land Compensation and Social Welfare, Water Quality and Public Health, Catchment Area Treatment; and Air Quality and Noise quality.
***Establishment of Environmental Division:** UJVNL shall establish an Environment Division in the initial stage of the project itself. The division shall have an Environmental Engineer/Officer, a Technical Assistant (environment background) and two other assistants (miscellaneous works). The task of the division would be to supervise and co-ordinate studies, monitoring and implementation of environmental mitigation measures, and it shall report directly to the General Manager of the Project. An Environmental Advisor shall review progress of the division every year. The Environmental Advisor would be an experienced Ecologist or Environmentalist familiar with environmental planning of water resources projects. **Environmental Costs:** All costs involved in Environmental Mitigating measures and Management of Bowala Nand Prayag HEP works out to Rs. **5283.91**Lakhs.*

Chapter –1

Introduction

CHAPTER – 1
INTRODUCTION

1.1 POWER SCENARIO OF INDIA

Harnessed energy has become a symbol of growth and instrument for development. Electric power particularly the hydro is among the cleanest and renewable source of energy. It provides better economic activity, domestic and civic conveniences, climate control, communication and is pollution free. The Ministry of Power has set an objective of providing "Power for all by 2012". This will entail electrification of all villages by 2007 and of all households by 2012. There is a need for availability of assured and quality power at an affordable price. Adequate generation, transmission and distribution facilities form the core of the power sector.

Power generation in India began more than a century ago in 1898 when the first hydro power unit was set up at Darjeeling. The country had an installed capacity of 1,360 MW In 1947. The present installed generating capacity in the country is 1,57,229.48 MW. The share of hydro is about 36,863.40 MW (24.7%). Thermal accounts for maximum share of 64.6% with 100598.98 MW. It comprises of 82,343.38 MW from coal (53.3%), 17,055.85(10.5%) MW from Gas and 1,199.75 (0.9%) MW from Oil. The share of Nuclear is about 2.9% with 4340.00 MW while Renewable Energy Sources accounts for the balance 15,427.10 MW (7.7%).

The overall generation in the country has increased from 704.569BU during 2007-08 to 723.794 during the year 2008-09. Thermal generation has been improved by 5.57%, hydropower is improved by 8.38%, Bhutan Import is improved by 11.77% and there is declined in Nuclear power generation by 11.77%. The overall growth rate recorded in 2.74%.

The Indian power system requirement had been assessed to meet a hydro power and thermal/nuclear power mix in the ratio of 40:60 for flexibility in system operation depending on typical load pattern. The present ratio is 26:74 which needs to be corrected immediately to meet peak load requirements as well as system and frequency stability.

India is blessed with immense amount of hydro-electric potential and ranks 5th in terms of exploitable hydro-potential on global scenario. INDIA is endowed with economically exploitable and viable hydro potential assessed to be about 84,000 MW at 60% load factor (1,48,701 MW installed capacity). In addition, 6780 MW in terms of installed capacity from Small, Mini, and Micro Hydel schemes have been assessed. Also, 56 sites for pumped storage schemes with an aggregate installed capacity of 94,000 MW have been identified. However, only 19.9% of the potential has been harnessed so far. The Hydro Power has the following advantages.

- A renewable source of energy - saves scarce fuel reserves.
- Non-polluting and hence environment friendly.
- Long life - The first hydro project commissioned in 1897 is still in operation at Darjeeling.
- Cost of generation, operation and maintenance is lower than the other sources of energy.

- Ability to start, stop quickly and instantaneous load acceptance/rejection makes it suitable to meet peak demand for enhancing system reliability and stability.
- Has higher efficiency (over 90%) compared to thermal (35%) and gas (around 50%).
- Cost of generation is free from inflationary effects after the initial installation.
- Storage based hydro schemes often provide attendant benefits of irrigation, flood control, drinking water supply, navigation, recreation, tourism, pisciculture etc.
- Being located in remote regions leads to development of interior backward areas (education, medical, road communication, telecommunication etc.)

1.2 POWER SCENARIO IN UTTARAKHAND

Uttarakhand has a hydropower potential of the order of 25000 MW against which only about 3140 MW has been harnessed so far. which means that about 87.44% of its hydropower potential remains to be developed. Ganga and Yamuna are the main rivers of Uttarakhand. The major rivers in Ganga Valley including the Alakhnanda river have got considerable perennial flow and steep bed slopes. The nature of terrain also provides good storage sites without any considerable disturbance to the human settlements. As such the rivers of Uttarakhand can play a key role in the economic growth of this newly formed state.

Hydropower schemes are being planned and executed in the state of Uttarakhand ever since its inception to bridge the gap between the demand and supply. Identified Hydro Power Potential in Uttarakhand is reported in **Table 1.1**. Status of Hydro Power Projects in Uttarakhand is presented in **Table 1.2**. **Figure 1.1** shows various hydropower schemes (constructed, under construction and identified) in the State.

TABLE 1.1
IDENTIFIED HYDRO POWER POTENTIAL IN UTTARAKHAND

Range of Capacity (MW)	Nos & Capacity of Identified sites (Total)		OUT OF TOTAL							
			Capacity Under Operation		Capacity Under Construction		Capacity Under Development		Earmarked for further allocation to Various Developers	
	No	CAPACITY (MW)	No	CAPACITY (MW)	No	CAPACITY (MW)	No	CAPACITY (MW)	No	CAPACITY (MW)
Up to 1	32	17.6	18	8.2	0	0	1	0.3	13	9.1
1 to 5	52	149.75	10	24.6	5	14.2	26	81.6	11	29.35
5 to 25	38	439.4	2	29.7	5	33	21	239.7	11	137
25 to 100	27	1371	5	246	0	0	15	798	7	327
100 To 250	17	2900	5	822	0	0	11	1848	1	230
250 To 500	16	5620	2	680	5	1934	9	3006	0	0
Above 500	7	9680	1	1000	2	1600	3	2080	1	5000
Total	**189**	**20177.75**	**43**	**2810.5**	**16**	**3581.2**	**86**	**8053.6**	**44**	**5732.45**

FIGURE 1.1
HYDROPOWER SCHEMES IN UTTARAKHAND

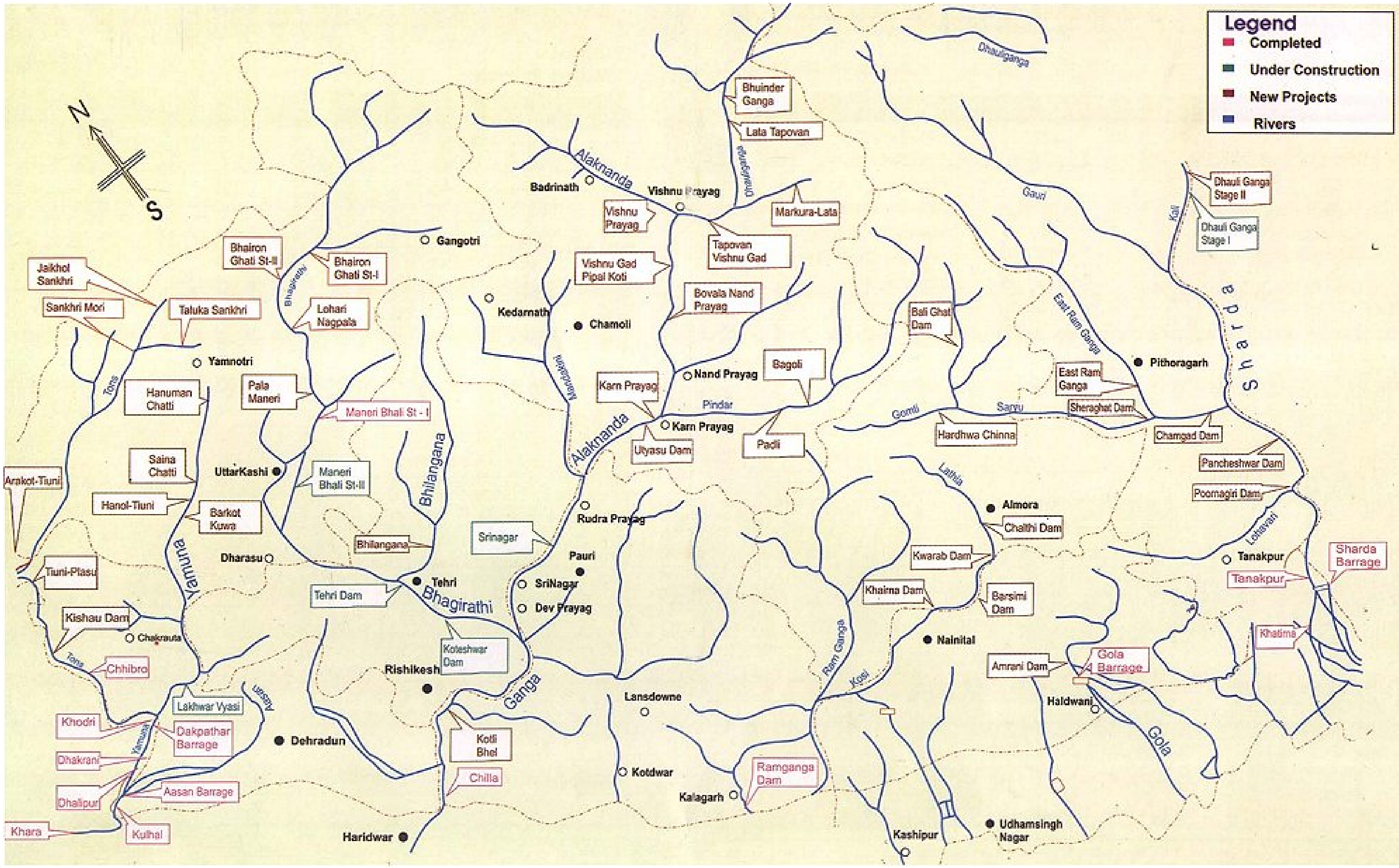


TABLE 1.2
STATUS OF HYDRO POWER PROJECTS IN UTTARAKHAND

S.No.	Projects Under	No. of Projects	Capacity (MW)
1	Operation	38	2808
2	Construction	16	3581
3	Development	85	8052
4	Planning	44	5733
	Total	**183**	**20174**

1.2.1 OTHER PROJECTS ON ALAKHNANDA RIVER

The Alaknanda River is a tributary of the Ganges River that begins at the confluence of the Satopanth and Bhagirath Kharak glaciers in Uttarakhand. It merges with the Bhagirathi river near Devprayag. About 15 hydropower projects are proposed on the river. Four hydropower projects are on upstream and ten projects are on downstream of Bowala Nand Prayag. Bowala Nand Prayag HEP is just downstream of confluence of river Alakhnanda and Birahi Ganga river. Projects on Alakhnanda and Birahi Ganga are presented in **Table 1.3.**

TABLE 1.3
PROEJCTS ON ALAKHNANDA AND BIRAHI

S.No.	Project (MW)	Developer	FRL (m)	TWL (M)	
				Max.	Min
Projects on Alakhnanda river					
1	Alakhnanda (300)	GMR Energy Ltd.	2922	2285.34	
2	Vishnuprayag (400)	Jaiprakash Power Ventures Ltd.	2276	1312.5	
3	Tapovan Vishnugad (520)	NTPC	1794	1267	
4	Vishnugad Pipalkoti (444)	THDC	1267	1030	1027.2
5	Bowala Nand Prayad (300)	UJVNL	1027	872	871.4
6	Nand Prayag Langasu (100)	UJVNL	857	779.51	
7	Utyasu-6 (70)		Between El 799.50 & 605.50		
8	Utyasu-5 (80)				
9	Utyasu-4(125)				
10	Utyasu-3 (195)				
11	Utyasu-2 (205)				
12	Utyasu-1 (70)				
13	Srinagar (330)	Alakhnanda Hydro Power Co. Ltd (GVK Group)	605.5	533.10	530.90
14	Kotli Bhel -1-B (320)	NHPC	521.0	463.2	455.91
15	Kotli Bhel -2 (530)	NHPC	458.5	410.83	403.03
Projects on Birahi Ganga river					
1	Birahi Ganga (4.8-7.28*)	Birahi Ganga Hydro Power Ltd.	1106.5	1047.76	1047.30
2	Birahi Ganga – I (24*)	PES Engineers Pvt. Ltd	1345.0	1130.0	1124.0
3	Birahi Ganga – II (24*)		1610.0	1456.0	1448.0

- Proposed for Capacity Enhancement

Uttarakhand Jal Vidyut Nigam Limited (UJVNL) has retained RITES Limited, a Government of India Enterprise in Ministry of Railways for carrying out the Environmental Impact Assessment (EIA) study for the Bowala Nand Pryag Project.

1.3 OBJECTIVES AND SCOPE OF STUDY

The main objective of the study is to carry out the comprehensive Environmental Impact Assessment (EIA) for the proposed Bowala Nand Pryag hydroelectric project to meet the environmental clearance criteria of Ministry of Environment and Forests, Government of India. The scope of study would be as outlined in the EIA guidelines of Ministry of Environmental and Forest for water resources/ river valley projects. This will facilitate the regulatory funding agency to decide that the project options are environmentally sound and sustainable on long-term basis. The scope of services are summarized in subsequent section.

1.3.1 Environmental Impact Assessment and Management Plan

- To develop baseline data of the project area from primary and secondary sources on physical and ecological environmental attributes, which would include collection and analysis of soil and water samples, air and noise quality monitoring and investigations for ecological parameters.

- Impact assessment during various phases of project cycle namely project location, construction and operation with a view to assess;

    - The change in land use pattern with special reference to loss of forestland and its type;
    - Impact on places/monuments of archaeological and historical importance and management plan if any required;
    - Impact on flora including the endangered species, which would possibly be affected by the project and suggest plans for their conservation;
    - The impact on terrestrial as well as aquatic fauna and measures proposed to counteract adverse effects;
    - Impact due to construction of infrastructure works such as roads, opening of new quarries etc.
    - Impact due to operation of the project.

- Preparation of environmental management plans to mitigate the negative/harmful impacts.
- Preparation of environmental monitoring plans for construction and operation phases.

1.3.2 Socio-Economic Studies

- Analysis of Census data for demographic profile (human population) including rate of growth, sex ratio, literacy rate, percentage of classified workers, SC/ST; residential houses, villages, towns etc in the study area.

- Identification of structures and persons affected by land to be submerged due to the project.

- Develop, review and appraisal of the existing situation of PAPs with regard to their socio-economic conditions. For this purpose random surveys to be conducted to evaluate social profile of PAPs. Opinion survey shall also be conducted regarding rehabilitation of the PAPs.

- Suggest locations and methods of rehabilitation of PAPs, if required.

- To assess the opinion of the public as observed in the public hearing, including the suggestions given by the public and the response of the project authorities.

1.3.3 Catchment Area Treatment (CAT) Plan

Based on land use/ cover category, soil characteristics, topography, climatic conditions etc., soil erosion intensity of the catchment area shall be worked out and classified. A comprehensive Catchment Area Treatment (CAT) plan, involving the social dimensions, shall be suggested to control soil erosion from the catchment. Physical and financial targets will be set for the same.

1.3.4 Environmental Cost Estimate

Cost of environmental mitigation and monitoring requirements shall be worked out. It shall also include the cost of catchment area treatment and the works of social commitments of the projects authorities including those suggested in the public hearing and agreed by the project authorities.

1.3.5 Statutory Requirements

The scope of work also includes assisting the project proponent in fulfilling statutory obligations such as;

- Conducting of Public Hearing for the project.

- Filling up of Questionnaire for Environmental Appraisal of Ministry of Environment and Forests (MoEF), GOI.

- Presentation of EIA report to the MoEF and compliance of the observations raised (if any) during the presentation

1.4 LEGAL, POLICY AND INSTITUTIONAL FRAMEWORK

The emerging environmental scenario calls for requisite attention on conservation and proper use of natural resources and also development without destruction. There is a need to integrate the environmental consequences of the development activities and for planning suitable mitigation measures in order to ensure sustainable development in the region. The environmental considerations in any development process have become a necessity for achieving sustainable development. To achieve these goals, the Ministry of

Environment and Forest, Government of India has enacted Acts, Legislations and Standards from time to time.

1.4.1 Important Environmental Legislations

The regulation of environmental acts, legislation, guidelines and standards is the responsibility of different government agencies. The principal environmental regulatory agency in India is the Ministry of Environment and Forests (MoEF), New Delhi. MoEF formulates environmental policies and accords environmental clearances for different projects. The important environmental legislations in India are given in **Table 1.4**.

TABLE 1.4
KEY ENVIRONMENTAL LEGISLATIONS

NAME	SCOPE AND OBJECTIVE	KEY AREAS	OPERATIONAL AGENCIES/KEY PLAYERS
Water (Prevention and Control of Pollution) Act, 1974,1988	To provide for the prevention and control of water pollution and enhancing the quality of water	Controls sewage and industrial effluent discharges	Central and State Pollution Control Boards
Air (Prevention and Control of Pollution) Act 1981,1987	To provide for the prevention and control of air pollution	Controls emissions of air pollutants	Central and State Pollution Control Boards
Forest conservation Act, 1980,1988	To consolidate acquisition of common property such as forests; halt India's rapid deforestation and resulting Environmental degradation	Regulates access to natural resources, state has a monopoly right over land; categories forests; Restriction on de-reservation and using forest for non-forest purpose	State government and Central government
Wildlife Protection Act, 1972, 1993	To protect wildlife	Creates protected areas (national parks/sanctuaries) categories of wildlife which are protected	Wildlife advisory boards; Central Zoo Authorities
Environment Protection Act, 1986	To provide for the protection and improvement of Environment	An umbrella legislation; supplements pollution laws	Central government nodal agency MoEF; can delegate powers to state department of Environment
National Policy on R&R	Resettlement and Rehabilitation of project affected people	Social issues	State Government
Environmental clearance Notification 1994,1997, 2006	Environmental Impact Assessment	Environmental Protection	Project Developer, State and Central government

Source: Government of India Publications

As per the EIA notification dated 14th September 2006, expansion or modernization of any activity shall not be undertaken in any part of India, unless it has been accorded environmental clearance. As per the procedure, anybody who desires to undertake any project in any part of the country or expansion or modernization of any existing project, a detailed project report, which shall inter alia include an Environmental Impact Assessment (EIA) report, needs to be submitted. Accordingly, this EIA report for Bowala Nand Pryag hydropower project has been prepared for the perusal of MoEF to assess environmental feasibility of the project. The MoEF as we know is vested with overall responsibility to set policy and standards for the protection of environment along with Central Pollution Control Board (CPCB). The air, noise and water quality standards are significant for preparation of Environmental Impact Assessment (EIA) Statement of any Developmental Project

1.4.2 Ambient Air Quality Standards

The Air (Prevention and Control of Pollution) Act, 1981 (also commonly known as the Air Act) including Rules 1982 and 1983 was enacted to prevent, control and reduce air and noise pollution. According to Section 21 of the Act, no person shall establish or operate any activity which can cause air pollution without obtaining Consent to Establish (CTE) as per the Air Act.

Ambient Air Quality Standards have been revise by the CPCB vide Gazette Notification dated 18th November 2009. These revised Standards include initiatives that have been developed in consonance with global best practices and in keeping with the latest advancements in technology and research. Some of the salient features include:

• Area classification based on land-use has been done away with so that industrial areas have to conform to the same standards as residential areas.

• The standards shall be applicable uniformly with the exception of stringent standards for NO_2 and SO_2 in the Ecologically Sensitive Areas.

• The previous standards for residential area have been uniformly applied for fine particulate matter (PM10), Carbon Monoxide and Ammonia. More stringent limits for Lead, SO_2 and NO_2 have been prescribed even for residential areas.

• Suspended particulate matter (SPM) as parameter has been replaced by fine particulate matter ($PM_{2.5}$) which is more relevant for public health.

• Other new parameters, such as, Ozone, Arsenic, Nickel, Benzene and Benzo(a)Pyrene (BaP) have been included for the first time under NAAQS based on CPCB/IIT research, World Health Organisation guidelines and EU limits and practices.

TABLE 1.5
NATIONAL AMBIENT AIR QUALITY STANDARDS

Pollutant	Time Weighted Average	Industrial, Residential, Rural & Other Area	Ecologically Sensitive Area (notified by Central Government
Sulphur Dioxide (SO_2), μm^3	Annual 24 Hours**	50 80	20 80
Nitrogen Dioxide as NO_2, μm^3	Annual 24 Hours**	40 80	30 80
Particulate Matter (size less than 10μm) or PM_{10} μm^3	Annual 24 Hours**	60 100	60 100
Particulate Matter (size less than 2.5 μm) or PM2.5 μm^3	Annual * 24 Hours**	40 60	40 60
Ozone (O3) μm^3	8 hours** 24 Hours**	100 180	100 180
Lead (Pb) μm^3	Annual * 24 Hours**	0.50 1.0	0.50 1.0
Carbon Monoxide (CO) mg/m^3	8 Hours** 1 Hour**	02 04	02 04
Ammonia (NH_3) μm^3	Annual * 24 Hours**	100 400	100 400
Benzene (C_6H_6) μm^3	Annual *	05	05
Benzo (a) pyrene (BaP)particulate phase only nm^3	Annual *	01	01
Arsenic (AS) nm^3	Annual *	06	06
Nickle (Ni) nm^3	Annual *	20	20

Source: Central Pollution Control Board Notification dated 18th November 2009

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

*** 24 hourly or 08 hourly or 01 hourly monitored values, as applicable, shall be complied with 98% of the time in a year. 2% of the time, they may exceed the limits but not on two consecutive days of monitoring.*

1.4.3 Ambient Noise Standards

Ambient Noise level standards have been notified by the MoEF vide Gazette Notification dated 26th December 1989 and also in the Schedule III of the Environmental (Protection) Rules 1986. It is based on the 'A' weighted equivalent noise level (L_{eq}). These are presented in **Table 1.6.**

TABLE 1.6
NATIONAL AMBIENT NOISE STANDARDS

CATEGORY OF ZONES	LEQ IN dB(A)	
	DAY *	NIGHT
Industrial	75	70
Commercial	65	55
Residential	55	45
Silence Zone **	50	40

Source: Central Pollution Control Board

* Day Time is from 6.00 AM to 9.00 PM.

** **Silence Zone** is defined as an area up to 100m around premises of Hospitals, Educational Institutions and Courts. Use of vehicle horn, loudspeaker and bursting of crackers is banned in these zones.

1.4.4 Effluent Discharge Standards

For the purpose of protecting and improving the quality of the environment and preventing and abating environmental pollution, the standards for discharge of environmental pollutants from the industries, operations or processes are stipulated under "Environmental Protection Rules (1993)". **Table 1.7** summarizes the general standards for discharge effluent in Indian Surface Water Bodies.

TABLE 1.7
EFFLUENT DISCHARGE STANDARDS (INLAND SURFACE WATER)

S. No.	Parameter	Unit	Standards
1	Colour & Odor	--	All efforts should be made to remove colour and unpleasant odor as far as practicable.
2	Suspended Solids, Max.	mg/l	100
3	Particle size of Suspended Solids	--	Shall pass 850 micron IS Sieve
4	pH value	--	5.5 to 9.0
5	Temperature, Max.	^{o}C	Shall not exceed 5°C above the receiving water temperature
6	Oil and grease, Max.	mg/l	10
7	Total residual Chlorine, Max.	mg/l	1.0
8	Ammonical Nitrogen (as N), Max.	mg/l	50
9	Total Kjeldah Nitrogen (as N), Max.	mg/l	100
10	Free Ammonia (as NH_3), Max.	mg/l	5
11	Biochemical Oxygen Demand (5 days at 20°C), Max.	mg/l	30
12	Chemical Oxygen Demand Max.	mg/l	250

S. No.	Parameter	Unit	Standards
13	Arsenic (as As), Max.	mg/l	0.2
14	Mercury (as Hg), Max.	mg/l	0.01
15	Lead (as Pb), Max.	mg/l	0.1
16	Cadmium (as Cd), Max.	mg/l	2.0
17	Hexavalent Chromium (as Cr^{+6}), Max.	mg/l	0.1
18	Total Chromium (as Cr) Max.	mg/l	2.0
19	Copper (as Cu), Max.	mg/l	3.0
20	Zinc (as Zn), Max.	mg/l	5.0
21	Selenium (as Se), Max.	mg/l	0.05
22	Nickel (as Ni), Max.	mg/l	3.0
23	Cyanide (as CN), Max.	mg/l	0.2
24	Fluorides (as F), Max.	mg/l	2.0
25	Dissolved phosphates (as P), Max.	mg/l	5.0
26	Sulphides (as S), Max.	mg/l	2.0
27	Phenolic compounds (as C_6H_5OH), Max.	mg/l	1.0
28	Radioactive Materials α Emitters, μcurie/ml, Max. β Emitters, μcurie/ml, Max.		 10^{-7} 10^{-6}
29	Bio-assay test	--	90% survival of fish after 96 hours in 100% effluent
30	Manganese (as Mn)	mg/l	2.0
31	Iron (as Fe)	mg/l	3.0
32	Vanadium (as V)	mg/l	0.2
33	Nitrate Nitrogen	mg/l	10.0

To ascertain and categorize the existing water quality, the results of the analysis of water quality need to be compared with the water quality standards given in **Table 1.8**.

TABLE 1.8
TOLERANCE LIMITS FOR INLAND SURFACE WATER QUALITY

Characteristic	Designated Use Class of Inland Waters				
	A	B	C	D	E
pH value	6.5 to 8.5	6.5 to 8.5	6.5 to 8.5	6.5 to 8.5	6.0 to 8.5
Dissolved Oxygen, mg/l, Min.	6	5	4	4	-
Biochemical Oxygen Demand (5 days at 20^0C), mg/l	2	3	3	-	-
Total coliform organisms, MPN/100 ml. Max.	50	500	5000	-	-
Colour Hazen units	10	300	300	-	-
Chlorides (as Cl), mg/l Max.	250	-	600	-	600
Sodium Adsorption ratio Max.	-	-	-	-	26
Boron (as B), mg/l. Max.	-	-	-	-	2
Sulphates (as SO_4), mg/ l	400	-	400	-	1000
Nitrates (as NO), mg/l Max.	20	-	50	-	-

Characteristic	Designated Use Class of Inland Waters				
	A	B	C	D	E
Free Ammonia (as NH_3), mg/l	-	-	-	1.2	-
Conductivity at 25^o C microhm / cm Max.	-	-	-	1000	2250
Arsenic (as As), mg/l. Max.	0.05	0.2	0.2	-	-
Iron (as Fe), mg/l	0.3	-	50	-	-
Fluorides (as F), mg/l	1.5	1.5	1.5	-	-
Lead (as Pb), mg/l. Max.	0.1	-	0.1	-	-
Copper (as Cu), mg/l	1.5	-	1.5	-	-
Zinc (as Zn) mg/l/ Max.	1.5	-	1.5	-	-
Manganese (as Mn), mg/l	0.5	-	-	-	-
Total Dissolved Solids, mg/l	500	-	1500	-	2100
Total Hardness ($CaCO_3$), mg/l	300	-	-	-	-
Magnesium (as Mg), mg/l	100	-	-	-	-
Chlorides (as Cl), mg/l	250	600	-	-	600
Cyanides (as CN), mg/l	0.05	0.05	0.05	-	-

A: Drinking Water Source without conventional treatment but after disinfections;
B: Outdoor bathing organized;
C: drinking water source with conventional treatment followed by disinfections;
D: propagation of wildlife and fisheries;
E: irrigation, industrial cooling, controlled waste disposal.

1.5 REPORT LAYOUT

Chapter-1 of the report is on Introduction. It gives an overview of energy scenario in the country and the hydropower schemes in the state. The legal/ policy frameworks along with environmental standard are also summarized in this chapter. In **Chapter-2**, a concise documentation is given on the proposed project activities and facilities including site selection, project features, construction schedule and cost estimates. **Chapter-3** summarizes environmental baseline data on physical and ecological parameters as obtained prior to the commencement of the project. **Chpater-4** is on socio-economic aspects, which presents the socio-economic profile of the project-affected people. It also includes the points raised about the project in public hearing vis-à-vis the reply of these points by the project proponent. **Chapter – 5** highlights anticipated potential positive and adverse environmental impacts of the project. An environmental strategy to offset/mitigate the probable adverse impacts have been outlined in **Chapter-6** under Environmental Management Plan. Catchment Area Treatment (CAT) plan of the project is presented in **Chapter-7**. Environmental monitoring programme and environmental costs are elucidated **in Chapter-8**. Findings, recommendations and conclusions are presented in **Chapter –9**.

Chapter –2

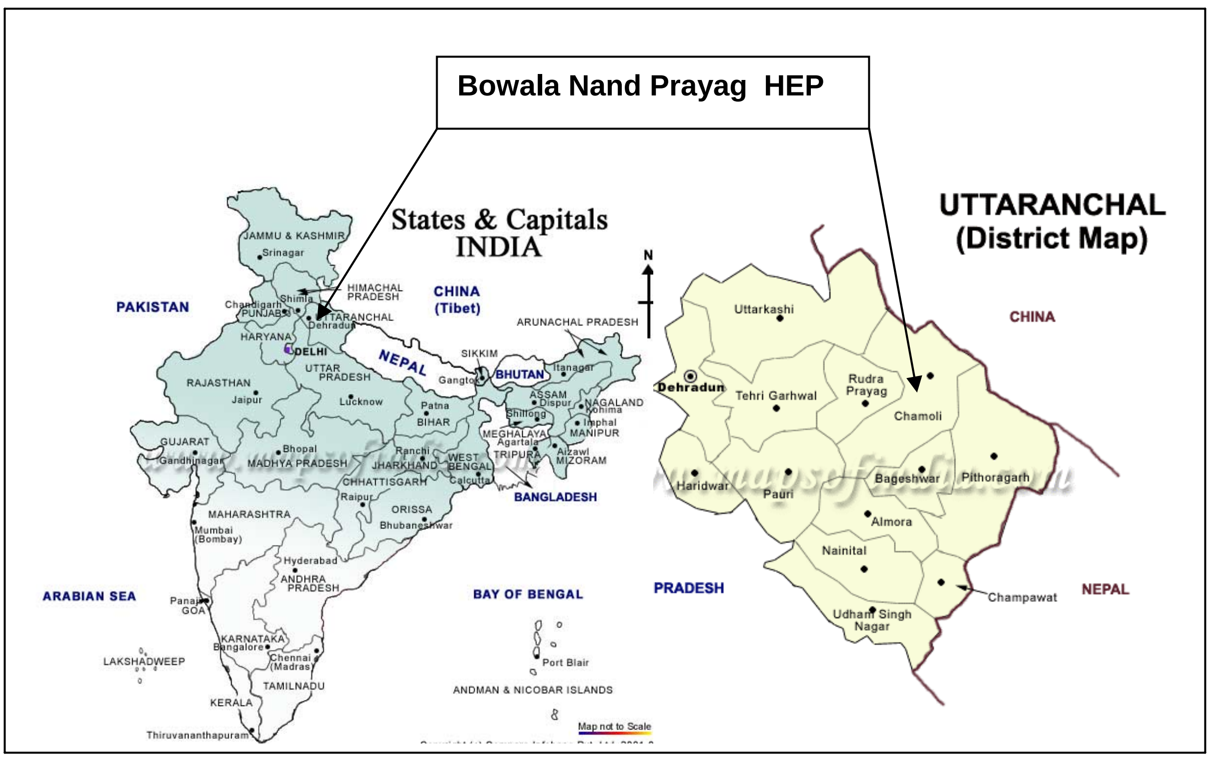
Project Description

CHAPTER - 2
PROJECT DESCRIPTION

2.1 THE PROJECT AND ITS LOCATION

Bowala Nand Prayag Hydro-Electric Project is a run of the river scheme on river Alakhnanda which is a tributary of the Ganga. The Bowala Nand Prayag hydroelectric power project envisages an installed capacity of 300 MW and a total average annual energy production of 1069 GWh or Million Units for 90% dependable year and 1351 for 50% dependable year (DPR - September 2007). The plant will comprising a concrete barrage, an intake structure, desilting basin, a headrace tunnel, a restricted orifice type surge tank, pressure shaft, underground penstocks, a surfaced powerhouse. The design discharge is 239.4 m^3/s (cumec). The proposed Bowala Nand Prayag Power project is located on the Alakhnanda River in Chamoli District of Uttarakhand State. The Alakhnanda is a major tributary of the Ganga river, which is the main river of the State of Uttarakhand. The location of the project is shown in **Figure 2.1.**

FIGURE-2.1
PROJECT LOCATION



Intake of this scheme is located near Birahi village on Rishekesh Badrinath road at a distance of 208 km from Rishikesh. The nearest airport is at Dehradun and the nearest railhead is Rishikesh. Longitude and Latitude of the project area are 79^o 22' 40" E to 30^o 24' 30" N respectively.

2.2 NEED OF THE PROJECT

There is acute shortage of electricity in the state and the gap between generation and demand is increasing day by day because of setting up of new industries, tube-wells, pumping sets, commissioning of new irrigation schemes and rising standard of living. It is, therefore, very necessary that quick maturing schemes requiring low investment should be taken up for execution. The electricity generation from hydro is cheaper than nuclear and thermal. Today the hydro and thermal ratio is 26:74. The fuel for thermal power generation is coal and oil. These are increasing air pollution problem in the country at local and regional level from thermal power plants. In order to achieve economic balance the hydro-thermal ratio need to be increased to 40:60.

The proposed Bowala Nand Prayag hydroelectric project is an ambitious scheme of the Uttarakhand Government. This would not only fulfill the power requirements of the state but would also become an important means of revenue generation. Given the topography and hydrology of the proposed site the project would prove to be a quick maturing and comparatively low investment scheme. There would be considerable saving in time and construction expenditure being closer to the road. The road from Rishikesh to Badrinath has been declared as National Highway and is being upgraded.

2.3 SITE SELECTION AND ALTERNATIVES

A master plan for development of hydroelectric power potential in river Ganga was prepared in 1960-61. The Bowala Nand Prayag Hydel Scheme forms a part of the phased development of the Ganga-Alakhnanda Valley. Earlier in 1960-61, the investigation for these schemes was taken up and the Geological Survey of India was approached for preliminary examination of general feasibility. Since then, the investigations on this scheme have been in progress. There was a set back to these investigations due to the unprecedented floods in the Alaknanda river and in the Birahi Ganga due to the bursting of the Gohna Lake and heavy precipitation. In the year 1960-61, a dam had been suggested near Bowala but this was given up on further geological investigations and a barrage was decided to be adopted.

Three alternatives for the headrace tunnel were considered for the project. First layout (Alternative-1) for the head race tunnel has 250m vertical cover near Pol Nala and the total length of the head race tunnel was approximately 9,300m. In the second alternative (Alternative -2) the tunnel crosses Pol Nala some 600m west of the previous alignment. At this location the cover at Pol Nala would be about 100m. The total length of HRT increases to 1167m but the overall tunnel length (HRT plus adit) is reduced by 283m. Third alignment (Alternative -3) comprises re-aligning of tunnel so that it crosses Pol Nala some 1,200m west of original alignment. The construction adit would be replaced by an access road to the crossing site. The length of HRT will increase to 10,053m but deleting the Adit. The overall length of tunnel excavation (HRT+Adit) is reduced by about 1,000m. Time benefit is calculated which shows that Alternative-2 would be completed 2.5 months earlier and Alternative-3 would be completed 10 months earlier than the Alternative-1. Cost comparison shows a benefit of Rs 1672 lakhs and Rs 7134 lakhs for the Alternative -2 and alternative -3 compared to Alternative-1. The third alternative is selected as it is most beneficial because it will enable the project to be commissioned about 10 months earlier and also shows financial advantage. The present site for the barrage has been finalized because of following reasons:

- No submergence of land behind diversion weir,
- Minimum land requirement (private) for the project,
- No displacement of people due to land acquisition, minimum ecological disturbance, and
- No significant tree cutting is anticipated.

Given the topography and hydrology of the proposed site the project would prove to be a quick maturing and cost effective scheme. There would be considerable saving in time and construction expenditure, as the approach road level exists right upto the project site from the nearest railhead at Rishikesh. Further the road exists on the same side on which various facilities of the Hydel project are proposed. This would facilitate movement of heavy vehicles carrying construction equipment and machinery for the project.

2.4 HYDROLOGY

The proposed barrage site is situated on river Alakhnanda at Bowala, which is approximately 208km from Rishikesh. River Alakhnanda, which along with Bhagirathi and other tributaries constitute river Ganga, originate in glacial region of the Himalayas in the extreme northern part of District Chamoli of Uttarakhand.

2.4.1 Catchment Area

The Catchment area of river Alakhnanda at Bowala is 5,590 sq km out of which the snow bound area is 2,700 sq km and rain fed area is 2,850 sq km. The Catchment of River Alakhnanda upto the intake site for Bowala Nand Prayag extends from latitude 30^{O}24'N to 31^{O}02'N and longitude 79^{O}12'E to 80^{O}15'E. It is generally mountainous and about 50% is snow covered. The highest altitude in the Catchment is over 7,800m m.a.s.l. (the peak of Nanda Devi) and the lowest point near the intake site is at 1,025m.

2.5 PROJECT SALIENT FEATURES

The proposed Bowala Nand Prayag HEP is a run of the river scheme with an installed capacity of 300 MW. The water will be diverted through sedimentation tank to penstock. The proposed layout of project components is given in **Figure 2.2.** Salient features of the project are described in subsequent paragraphs and a summary of the salient features is given in **Table 2.1**.

FIGURE 2.2
LAYOUT OF PROJECT COMPONENTS

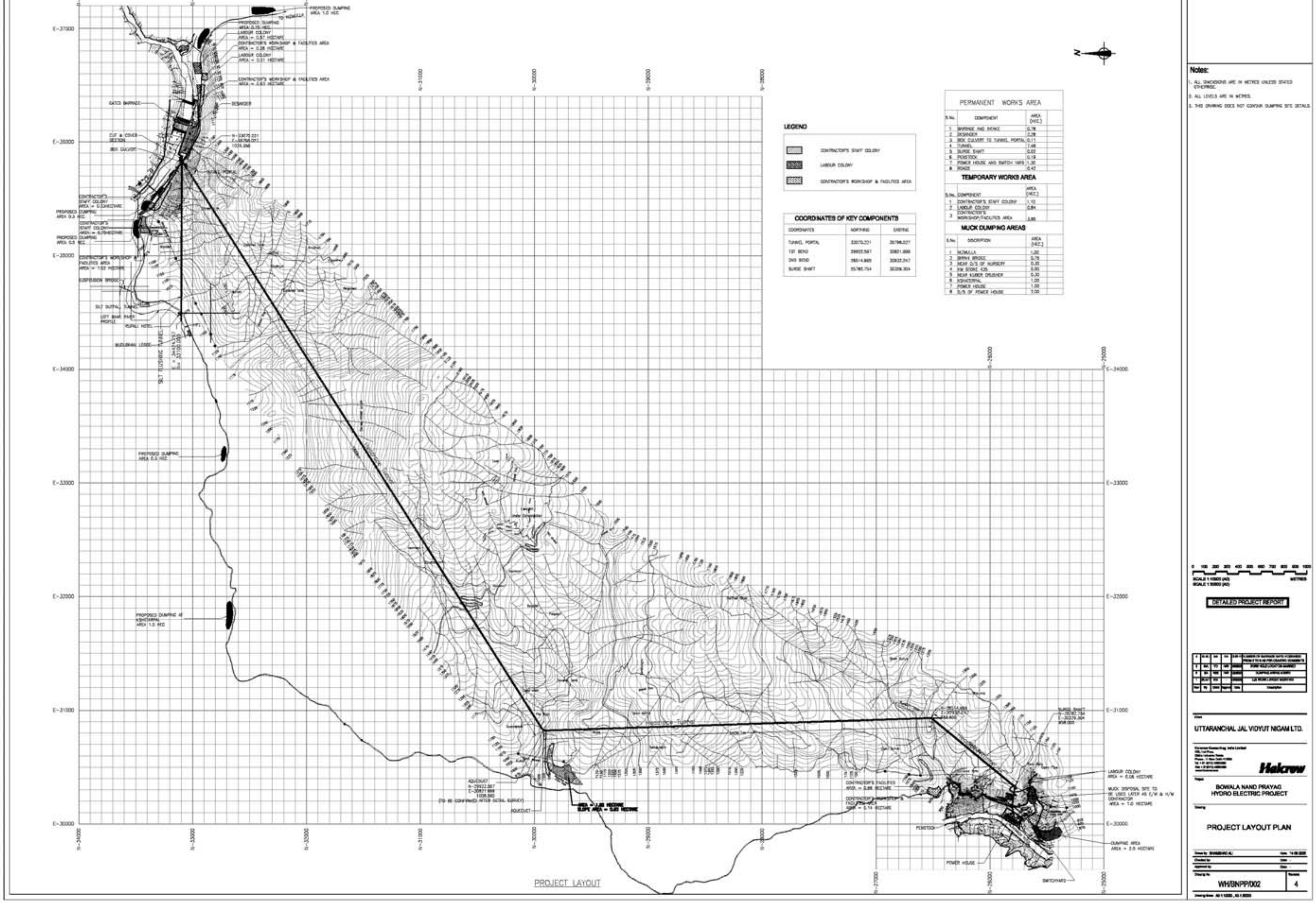


TABLE 2.1
SALIENT FEATURES

1.	**PROJECT LOCATION:**	
a)	Location	Intake near Birahi village and power house site near Nand Prayag
b)	Tehsil	Chamoli
c)	District	Chamoli
d)	State	Uttarakhand
e)	Name of river	Alakhnanda
2.	**HYDROLOGY:**	
a)	Catchment area at Intake site	5,590 km^2
b)	Snow Catchment	2,890 km^2
c)	1 in 100 year flood	8710 m^3/s
d)	Standard Project flood (SPF)	9,790 m^3/s
3.	**DIVERSION BARRAGE AND HEAD POND**	
a)	Type	Gated Barrage
b)	Design Flood level	+1031.4m
c)	Full Supply Level (FSL)	+1027.0m
d)	MOL	+1025.5m
e)	Average river bed level at axis	± 1022m
f)	Crest length of barrage	123 m
g)	No. of Gates	9 gates 11m x 14m
h)	Sill Level	1022.0m
i)	Design Discharge	8710 m^3/s (1 in 100 yr flood)
4.	**INTAKE STRUCTURE**	
a)	Width of intake	82m
b)	No. of bays	4
c)	Width of each bay	15.5m
d)	Orientation w.r.t to barrage axis	0^O
e)	Regulating gates	8 Nos. vertical lift fixed wheel type, 7.75m X 9.0m
f)	Design discharge	293m^3 (incl. 20% for flushing de-silting basin)
5.	**DESILTING ARRANGEMENT**	
a)	No. and size of desilting basins	4 Nos., each 21m x 12m x 250m
b)	Particle size to be excluded	0.20mm and above
c)	Flow through velocity	0.30m/s
d)	Gates at d/s end of desilting basin	8 Nos., 8.75 X 3.1m
6.	**HEAD RACE TUNNEL**	
a)	Size and type	Concrete lined horseshoe section, 9.3m dia
b)	Velocity	3.36 m/s
c)	Length	10.375 km including 120m of cut and cover crossing at Pol Nala
d)	Design discharge	239.4 m^3/s
e)	Slope	Inlet to Pol Nala 1: 2000 Pol Nala to Surge shaft 1:86
7.	**SURGE SHAFT**	

a)	Type	Underground, restricted type
b)	Diameter	27m
c)	Height	80m
d)	Orifice Diameter	6m
e)	Top level	+1070.0m
f)	Bottom level	+990m
g)	Maximum upsurge	+1059.2m
h)	Minimum down surge	+998.7m
8.	**PENSTOCK**	
a)	Main penstock	1 No. Underground, 7.0m diameter, 226m long
b)	Branches	4 No. 3.0m diameter
c)	Type & thickness of steel liner	IS: 2002, Grade-3 or Equivalent. Thickness varying from 36mm to 60mm
9.	**POWER HOUSE**	
a)	Type	Surface
b)	Installed capacity	300 MW
c)	Size of power house	120m long X 22.2m wide X 44m high
d)	Gross head	154.5m
e)	Net head	136.6m
f)	Machine Axis	+870m
g)	Service bay level	+888.0m
h)	Crane beam level (Top of rail)	+898.48m
i)	Minimum TWL	+871.0m
j)	Draft tube gates	1 No. each turbine vertical lift fixed wheel type 4.35m X 4.1m
k)	Highest Flood level at outlet	+885m
10.	**TURBINES**	
a)	No. and Type	4 Nos., vertical shaft Francis
b)	Rated power	76.5 MW each
c)	Rated net head	136.6m
d)	Max./Min net head	152.9/136.2m
e)	Rated discharge	61.0 m^3/s each
f)	Speed	250 rpm
g)	Specific speed	172 m-KW
11.	**MAIN INLET VALVE**	
a)	Type	Butterfly
b)	Diameter	3.0 m
c)	Location	In Machine Hall
12	**GENERATOR**	
a)	Type	Vertical shaft Synchronous Machine
b)	Number	4
c)	Rated Capacity	83.33
d)	Speed	250 rpm
e)	No. of phases	3 phase/5pairs of poles per phase
f)	Frequency	50 Hz
g)	Power Factor	0.90 (lagging)
h)	Rated Terminal voltage	13.2 kV

i)	Excitation System	Static
13	**GENERATOR STEP UP TRANSFORMER**	
a)	Location	Transformer bays behind Power House
b)	No.	4
c)	Rated	84 MVA
d)	Voltage Ratio	13.2/220kV
e)	Frequency	50 HZ
f)	Type of cooling	Oil immersed, forced oil circulation, water cooled
14	**POWER BENEFITS**	
a)	90% dependable year	1069 GWh
15.	TARRIFF (at September 2006 PL)	
	First Year	Rs 3.34
	Levelised	Rs 2.24
15.	**CONSTRUCTION PERIOD**	**60 months (Main Works)**

Source: Bowala Nand Prayag Hydroelectric Project Report- 2007

It is propose to construct a barrage, intake, sedimentation tank, Head race tunnel, surge shaft, penstock, powerhouse, etc. These are briefly discussed in subsequent sections. The following structures are proposed for the project.

2.5.1 Temporary River Diversion & Cofferdam

A temporary river diversion will be required during the construction of the barrage and its approach and downstream channels. This would be achieved by providing a concrete lined diversion channel on the left bank 20m wide x 4m deep x 600m long. The diversion works are designed to pass a flood discharge of $400m^3/s$.

2.5.2 Barrage

The barrage will have 9 gated opening and each opening shall be controlled by a radial gate 11m wide by 14m high. The opening deck of the barrage will provide sufficient freeboard to pass a flood of 500-year return period, with one gate out of operation.

2.5.3 Intake

The power intake consists of a fore bay on the left bank of the river, just upstream of the barrage, leading to a gated intake structure with 4 intakes to deliver water to each of the four desilting basins. Water level at the intake is controlled by a weir with a crest level at elevation 1024.5 m. This is 1.0 m above the invert level of the approach channel at the barrage to prevent bed-load material from entering the intakes. Deposits in front of the weir can be periodically flushed by opening the left side gate in the barrage. During floods, the left hand gate should always be opened first, and closed last, to keep the intake clear of deposits.

A trash rack cleaning machine is to be provided. The geometry of the upstream surface of the intake structure is designed to facilitate the smooth operation for trash cleaning machine.

2.5.4 Sedimentation Tank

In order to safeguard the water conductor system and the runner blades of the turbine, sediment of 0.2mm and above have to be removed. Sedimentation tank is designed to exclude above particle size. The desilting facilities comprise of four parallel surface desilting basins with central silt channel located on the left bank of the river. Three silt flushing outlets are provided in each basin at the third points and at the downstream end. For removing particle of 0.2mm and above size, with flow through velocity as 0.3 m/sec sedimentation tanks of 21m x 12m x 250m will be appropriate.

2.5.5 Headrace Tunnel (HRT)

Water from desilting chamber would be carried upto the proposed powerhouse at Nand Prayag through a 10.375km Headrace Tunnel having a horse shoe section of 9.3 m diameter. It is located on the left side of the Alakhnanda River. Velocity for design discharge of 244.0m^3/s is 3.36 m/sec.

2.5.6 Surge Shaft

At the tail end of the head race tunnel, a restricted orifice type surge shaft has been provided for dampening the water hammer effect. The ground level at the proposed location of the surge shaft will be 27m, with a top elevation of 1085.0m and a bottom level of 990m. It will be connected to HRT by a throttle of 6m diameter, 25m long. The final lining will be in situ plain concrete, 500mm thick.

2.5.7 Penstocks

Water from down stream end of power tunnel i.e. junction with the surge tank to the turbine for generation of power will be carried first through a main 266m long penstock of 7.0m diameter. The steel lined penstock will be 282m long with an internal diameter of 7m. The penstock will have four branch pipes of 3m diameter leading to the 4 generating units.

2.5.8 Powerhouse

The power house will be on surface of 300MW installed capacity. The power house is 120m long, 22.2m wide and 44m high.

2.5.9 Turbines and Generators

4 Nos vertical shaft turbines of rated power of 76.5 MW each will be provided. Transformer will be four number vertical shaft type with a rate capacity of 83.33 MVA.

2.6 POWER POTENTIAL

The power potential has been studied for installed capacities in the range of 132MW (to match the original scheme capacity) up to 350MW. This represents a range of design discharges of between 123m^3/s to 287m^3/s which in turn represent a range of exceedence probabilities of between 44% and 25% on the long term flow duration curves for the scheme. This range was considered sufficient to encompass the likely optimized capacity. The analysis has been carried out for both the 50% and 90% dependable years.

The optimum installed capacity has been selected by considering various financial indicators such as benefit, cost ratio, cost of incremental energy and levelised tariff. The design energy for financial evaluation of the project is for the 90% dependable year with 95% plant availability according to CERC guidelines.

2.7 CONSTRUCTION MATERIAL

For completion of the various items of works of the project, following materials will be required. Arrangement for their procurement and safe storage will be made. The requirement of materials is given in **Table 2.2** along with quantities.

TABLE 2.2
REQUIREMENT OF CONSTRUCTION MATERIAL

S.No.	Material	Unit	Quantities
1.	Cement	MT	295000
2.	Stone	CUM	17000
3.	Sand	Cum	285000
4.	Coarse aggregate	Cum	550000
5.	Steel	MT	18693

2.8 CONSTRUCTION PROGRAMME

The project has been planned for completion in 60 months period including commissioning. It has been observed that Head Race Tunnel is the most critical item of the project. To facilitate the timely completion of HRT, one intermediate phase shall be opened at Pol Nala. This will provide four working phases for construction of HRT for the purpose of excavation and lining thereafter. During first year all approach road shall be completed during first six months of the start of works. During this period the river diversion works of Barrage and start of excavation of HRT shall be initiated. The construction of all other components of the project shall start during second year. The works of the project shall be completed in 56 months period and the project is scheduled for completion in 60 months. The detailed construction schedule is shown in **Figure 2.3.**

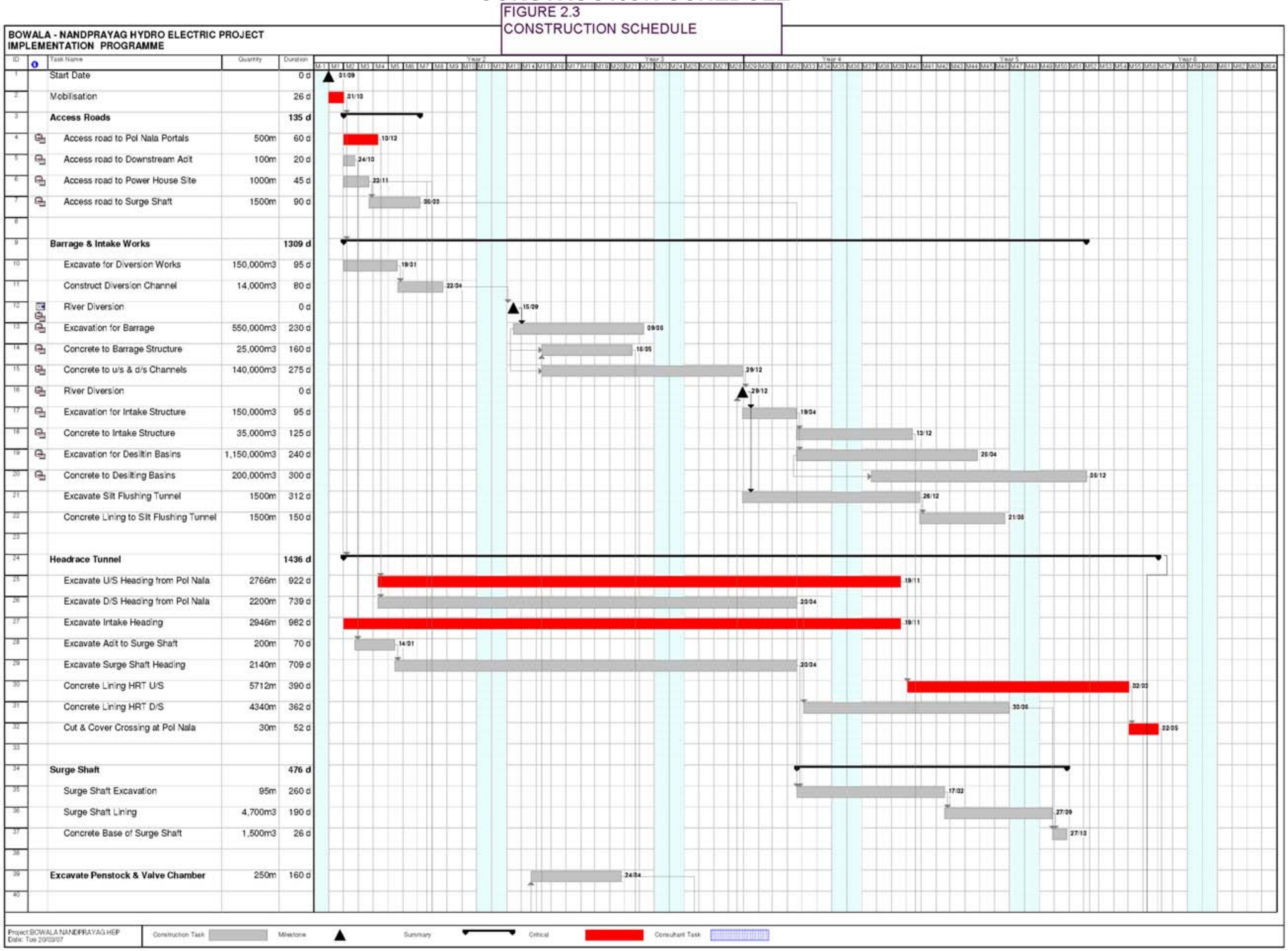
2.9 ESTIMATE OF COSTS

The cost estimate for Bowala Nand Prayag Hydel Scheme as per DPR 2007 is Rs. 1862.17 Crores (at September 2006 PL). Abstract of Cost is presented in **Table 2.3.**

TABLE 2.3
ABSTRACT OF COST

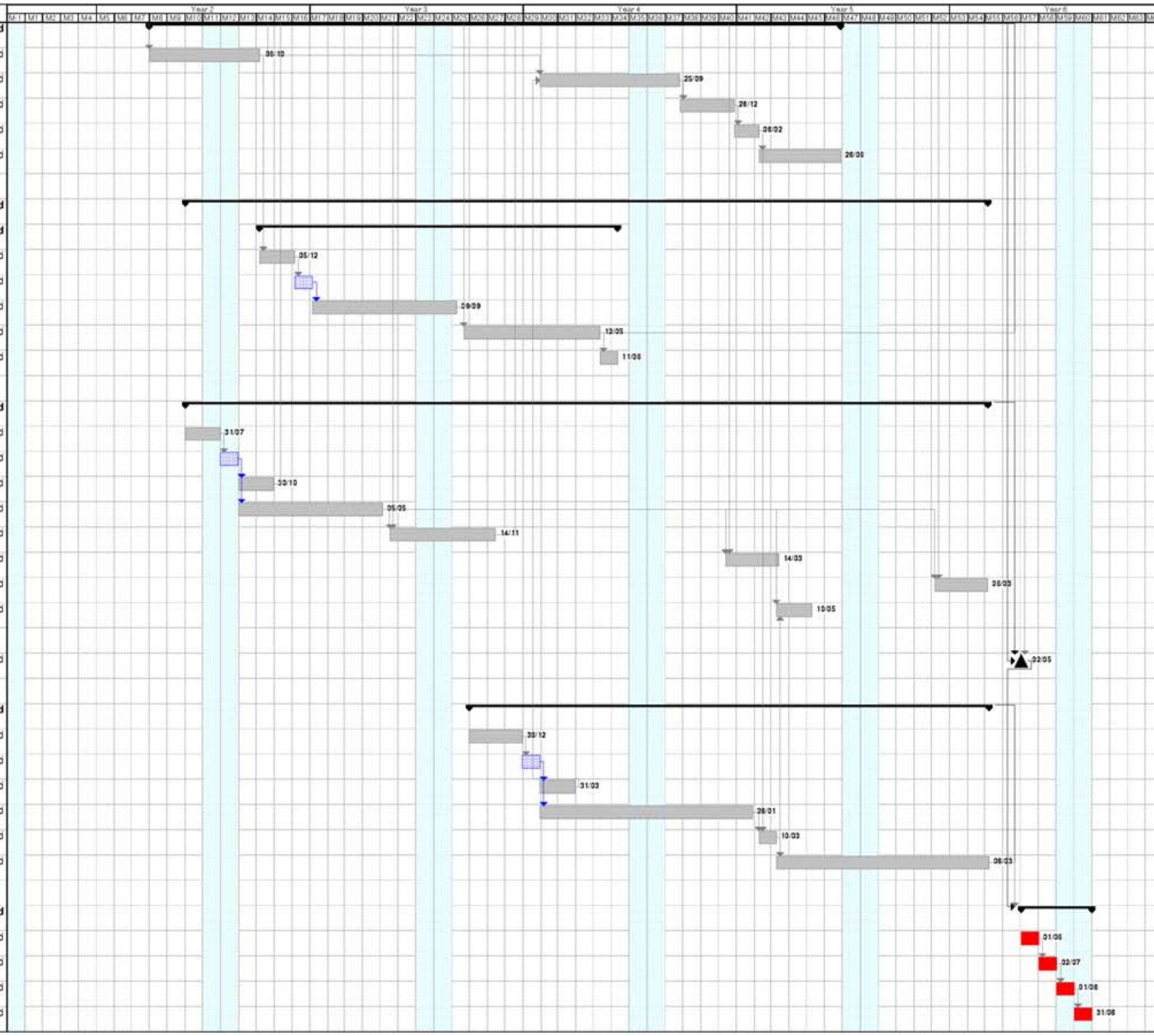
S. No.	Description	Amount (In crores)
A	Basic Cost	1391.32
B	Escalation during construction	470.85
	Total Cost	**1862.17**

FIGURE 2.3.
CONSTRUCTION SCHEDULE



BOWALA - NANDPRAYAG HYDRO ELECTRIC PROJECT
IMPLEMENTATION PROGRAMME

ID	Task Name	Quantity	Duration
41	**Power House**		**1015 d**
42	Excavation	67,000m3	84 d
43	Substructure Concrete	30,000m3	126 d
44	Walls, Columns and Crane Beam	2,800m3	80 d
45	Roof		36 d
46	Internal Walls & Finishes		120 d
47			
48	**Hydromechanical Works**		**1178 d**
49	**Steel Lining to Penstock**		**526 d**
50	Detailed Design & Shop Drawings		52 d
51	Drawing Approvals		26 d
52	Fabrication & Delivery		212 d
53	Steel Lining Erection	250m	200 d
54	Install Penstock Valve		26 d
55			
56	**Gates & Screens**		**1178 d**
57	Detailed Design & Shop Drawings		52 d
58	Drawing Approvals		26 d
59	Delivery of Embedded Items		52 d
60	Fabrication & Delivery		212 d
61	Erection (Barrage)		156 d
62	Erection (Intake Structure)		78 d
63	Erection (Desilting Basins)		78 d
64	Erection (Power House)		52 d
65			
66	**Water Available**		0 d
67			
68	**E&M Works**		**763 d**
69	Detailed Design & Shop Drawings		78 d
70	Drawing Approvals		26 d
71	Delivery of Embedded Items		52 d
72	Fabrication & Delivery		312 d
73	OHT Crane Erection & Commissioning		26 d
74	E&M Installation		312 d
75			
76	**Tests on Completion**		**104 d**
77	Unit 1		26 d
78	Unit 2		26 d
79	Unit 3		26 d
80	Unit 4		26 d



Project: BOWALA NANDPRAYAG HEP
Date: Tue 20/03/07

Construction Task | Milestone | Summary | Critical | Consultant Task

Chapter –3

Environmental Baseline Data

CHAPTER – 3
ENVIRONMENTAL BASELINE DATA

3.1 GENERAL

The objective of Environmental Impact Assessment (EIA) is to ascertain the baseline environmental conditions and then assess the impacts as a result of the proposed hydroelectric power project during various phases of the project cycle. Identification of environmental parameters, data collection and impact predictions form the core of Environmental Assessment process. A Scoping matrix has been formulated to identify the attributes likely to be affected due to proposed project. The Matrix for Bowala Nand Prayag Hydro Electric project is available in **Table 3.1.** The environmental baseline includes inventory of physical, ecological and socio-economic parameters. The data has been compiled for:

- Land Environment (land use, geology, seismology and soils);
- Water Environment (water resources, water use, water quality, hydrology);
- Air Environment (air quality);
- Noise Environment (noise levels);
- Ecological Environment (terrestrial and aquatic ecology); and
- Socio-Economic Environment (demography, socio-economic, public health)

Based on environmental scoping matrix and project settings the attributes likely to be affected are identified for baseline data generation. The information presented in this chapter has been collected from various sources. Majority of data have been collected from field studies. Field studies have been carried out in three different seasons e.g. winter, summer and post-monsoon to generate primary data on water, noise, soil, air quality, ecology and socio-economics at the project site. Formal and informal discussions were held with the local people, project affected people and local government/non-government organizations. These have provided very useful information, which have been integrated while preparing this report. Information on project facilities, size, magnitude and cost of the construction activities, geology and, seismology of the project site have been taken from the DPR.

Landuse/ landcover of project study (10 km radius) area has been generated from latest cloud free satellite imageries of the area. Landuse/ landcover, slope map and other information have been further utilized in the preparation of catchment area treatment plan. Study of Survey of India (SOI) toposheets, literature, books, maps and reports has also provided useful secondary data on the project. The methodology adopted for data collection is highlighted wherever necessary and the frequency adopted for data collection for environmental attributes is summarized in **Table 3.2**.

This chapter deals with the description of existing environmental setting in the study area as per MoEF guidelines for water resources projects.

TABLE 3.1
SCOPING MATRIX FOR THE PROJECT

ASPECT OF ENVIRONMENT	LIKELY IMPACTS
A. LAND ENVIRONMENT	
Construction Phase	- Increase in soil erosion - Pollution by construction spoils - Use of land for labour colonies - Problems due to muck disposal - Solid waste from labour camps - Acquisition of land for various project appurtenances
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	- Disruption of hydraulic regime - Sedimentation and siltation risks
C. AQUATIC ECOLOGY	
Construction Phase	- Increased pressure on aquatic ecology as a result of indiscrimate fishing. - Reduced productivity due to increase in turbidity
Operation Phase	- Impacts on migratory fish species - Impacts on spawning and breeding grounds - Degradation of riverine ecology
D. TERRESTRIAL ECOLOGY	
Construction Phase	- Increased pressure on nearby forests due to labour force to meet their fuel wood and timber requirements - Adverse impacts due to migration of labour population - Loss of forest - Impacts on nature reserves due to various project appurtenances - Impacts on wildlife movement - Impacts on wildlife habitats - Impacts on diversity and productivity of flora - Impacts on economically/ genetically/ biologically important plant species
E. SOCIO-ECONOMICS	
Construction Phase	- Acquisition of land and private properties - Impacts on archaeological & cultural monuments - Impacts on mineral reserves - Improved employment potential during project construction phase - Development of allied sectors leading to greater employment. - Pressure on existing infrastructure facilities - Friction between guest and host community
Operation Phase	- Increased revenue from power generation
F. AIR POLLUTION	
Construction Phase	- Impacts due to emissions generated by crushers and other equipment - Impacts due to increased vehicular movement - Fugitive emissions from various sources.
G. NOISE POLLUTION	
Construction Phase	- Noise due to operation of various equipment - Noise due to increased vehicular movement - Noise due to blasting activities
H. PUBLIC HEALTH	
Construction Phase	- Increased incidence of water related diseases - Transmission of diseases by immigrant labour population

ASPECT OF ENVIRONMENT	LIKELY IMPACTS
Operation Phase	- Increased incidences of vector borne diseases

TABLE 3.2
ENVIRONMENTAL ATTRIBUTES AND FREQUENCY OF MONITORING

S. NO	ATTRIBUTE	PARAMETER	FREQUENCY	SOURCE
LAND ENVIRONMENT				
1	Land Use	Land use pattern	---	Latest cloud free satellite Imageries procured from NRSA
2	Soil	Soil Characteristics	Three different seasons	Field studies
3	Geology	Geological Status	---	DPR
4	Seismology	Seismic Hazard	---	DPR and Literature
WATER ENVIRONMENT				
5	Water Resources	Catchment Area, Flow, Design	---	DPR
6	Water Quality	Physical, Chemical and Biological parameters	Three different seasons	Field studies
7	Hydrology	Drainage area and pattern	---	DPR and SOI toposheets
AIR, NOISE AND METEOROLOGY				
8	Ambient Air Quality	SPM, SO_2 and NO_x	Three different seasons	Field Studies
9	Meteorology	Temperature, Relative humidity, Rainfall	Data	DPR, India Meteorological Department
10	Noise	Noise levels in dB (A)	Three different seasons	Field monitoring
ECOLOGY ENVIRONMENT				
11	Ecology	Flora & Fauna Diversity	Field Studies	Field Studies Satellite Imageries Information from Forest department and Literature Study
12	Aquatic Ecology	Density & diversity of aquatic species	Field studies in the river	Field study, Fisheries Department, Literature review
SCIO-ECONOMIC				
13	Socio-economic aspects	Socio-economic characteristic of the affected area	Socio-economic	Field Studies, Literature review.

3.2 LAND ENVIRONMENT

The project is located near village Bowala on Rishikesh Badrinath road in district Chamoli of Uttarakhand state. The head works are located near village Bowala on river Alakhnanda about 750m downstream of the confluence of Biraehi Ganga with river Alaknanda at a height of about 1,022 m above MSL. Parameters involved in land environment are physiography, geology, minerals, soils, land use pattern and seismicity. These are discussed in the following paragraphs.

3.2.1 Land Use Pattern of District and Affected Villages

Land use and land cover patterns are important in environment impact assessment study. The land use describes its use such as agriculture, settlement, etc and land cover, describes the material on it such as forest, vegetation, rocks or building etc. The land use pattern of Chamoli district presented in **Table 3.3** indicates that forests is spread over 68.17% of the district area and barren land suitable for cultivation cover 3.22% while other barren land not suitable for cultivation is 16.12%. Land other than for agriculture use is 1.75% and pastures, gardens, orchards and shrubs comprises of 10.74%.

TABLE 3.3
LAND USE PATTERN OF CHAMOLI DISTRICT

S. NO.	LAND USE	AREA (ha)	%
1.	Forest	4,38,982	68.17
2.	Barren land suitable for cultivation	20,767	3.22
3.	Barren land	57	0.01
4.	Other Barren land	1,006	0.16
5.	Barren land not suitable for cultivation	1,02,716	15.95
6.	Land other than for agriculture use	11,269	1.75
7.	Pasutres	13,593	2.11
8.	Garden, orchards and shurbs	22,023	3.42
9.	Net cultivable area	33,544	5.21
		6,43,957	**100**

Source: Statistical Handbook of Chamoli district 1999-2000

3.2.2 Landuse/Landcover of 10 Km Radius Study Area

Landuse/Landcover of the 10 km radius study area with reference to the barrage site has been derived using latest cloud free satellite imageries. The data has been generated from Indian Remote Sensing (IRS) Satellite 1D/P6, LISS III sensor procured from National Remote Sensing Agency. The data from LISS III sensor is of 23.5 m resolution. The data has been geo-referenced using Survey of India (SOI) 1:50,000 scale and 1:25,000 scale topographical sheets with the help of standard data preparation techniques in image ERDAS IMAGINE software. Interpretation of the geo-referenced data has been done using standard enhancement techniques and ground truthing. Satellite image of the 10 km radius study area isgiven in **Figure 3.1**, whereas the Landuse/Landcover map of the same has been presented as **Figure 3.2**.

Details of Landuse/Landcover of the study area of 10 km radius is indicated in **Table 3.4.** About 83% is forest land, 13.4% is agricultural and 0.7% settlements. Landuse classification for river catchment at barrage site clubbed with study area of 10 km radius with reference to barrage axis is indicated in **Table 3.5.** It is observed that 61% of catchment area is under snow cover, 28% is under forest and balance is other uses. Landuse classification for directly draining catchment is indicated in **Table 3.6.** From the analysis of landuse data it could be concluded that catchment forest area is similar to project area. However the cover is reducing.

FIGURE 3.1
SATELLITE IMAGE OF 10 KM RADIUS AREA

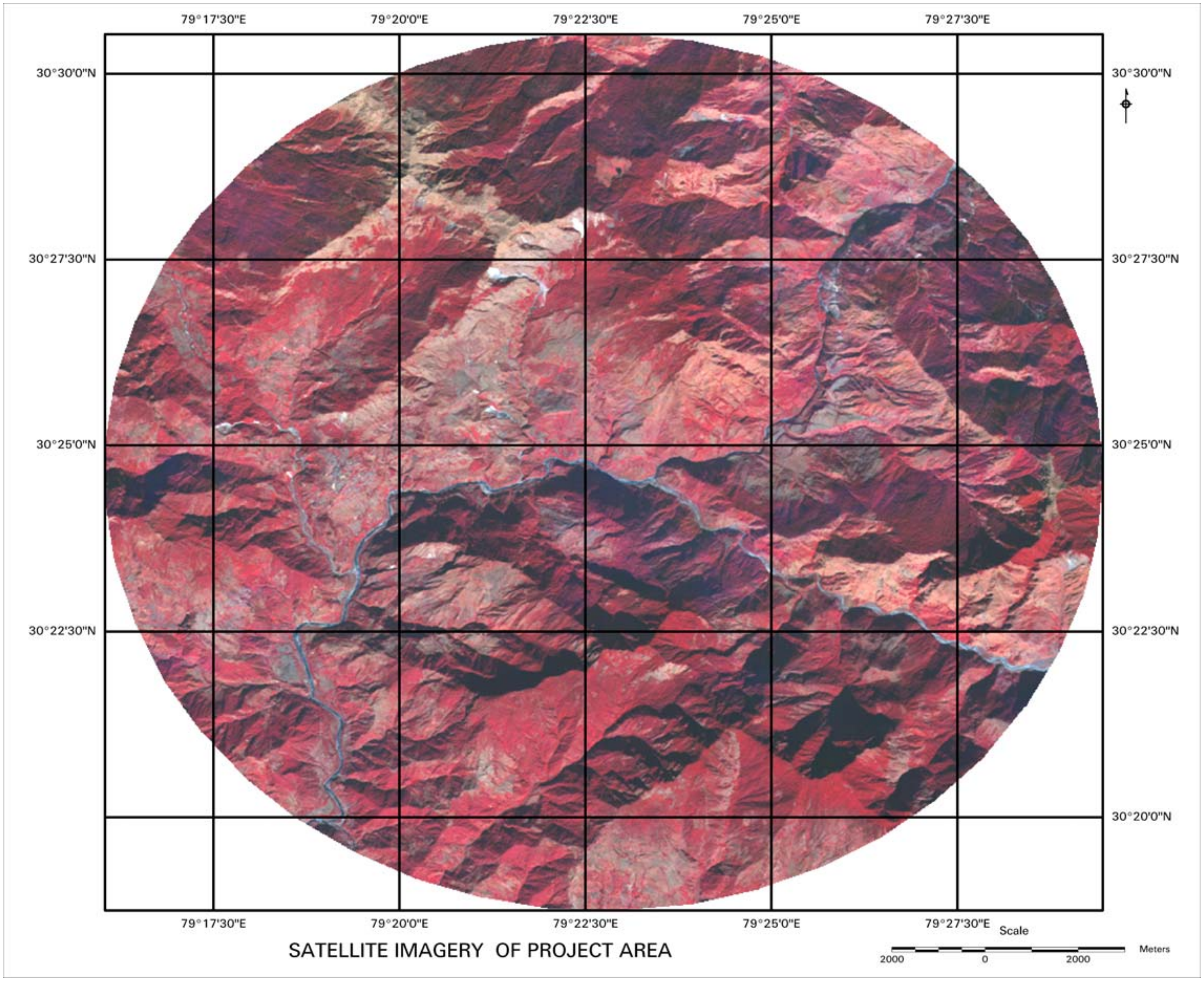


FIGURE 3.2
LAND USE/LANDCOVER MAP 10 KM RADIUS STUDY AREA

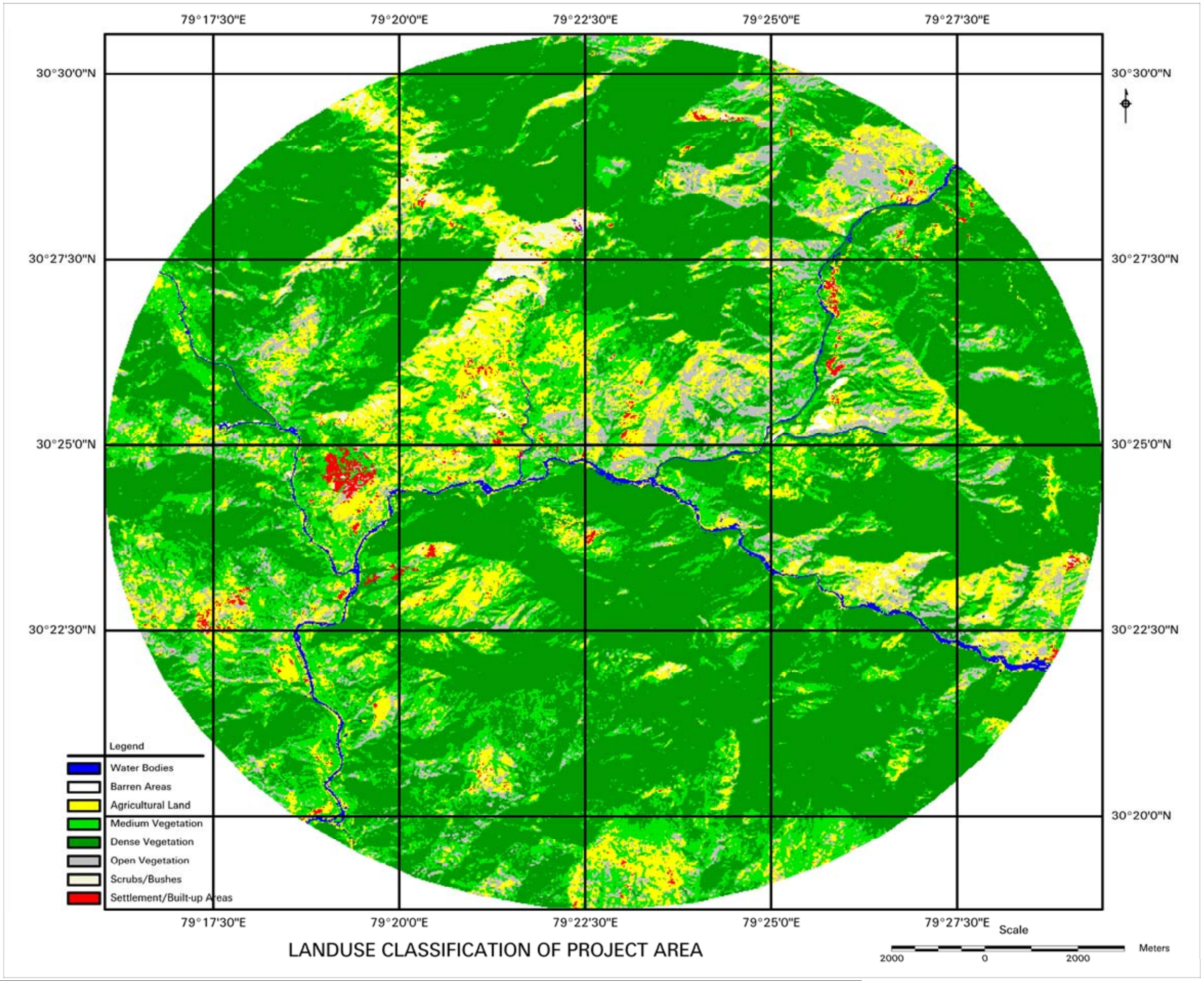


TABLE 3.4
LAND USE OF 10 km RADIUS STUDY AREA

S.NO.	LAND COVER CATEGORY	AREA (ha)	AREA (%)
1	Dense Vegetation (Crown cover density >40%)	17,020	54.18
2	Medium Vegetation (Crown cover density 10 - 40%)	7,102	22.61
3	Light Vegetation (Crown cover density <10%)	2,047	6.52
4	Agricultural land	4,201	13.37
5	Scrubs/Bushes	461	1.47
6	Barren area	68	0.22
7	Water body	288	0.92
8	Settlement/Built-up	229	0.71
9	Snow covered area	-	-
	TOTAL	**31,416**	**100.00**

TABLE 3.5
LAND USE CLASSIFICATION FOR RIVER CATCHMENT AT BARRAGE SITE CLUBBED WITH STUDY AREA OF 10 km RADIUS WITH REFERENCE TO BARRAGE AXIS

S.NO.	LAND COVER CATEGORY	AREA (ha)	AREA (%)
1	Dense Vegetation (Crown cover density >40%)	835.57	15.1
2	Medium Vegetation (Crown cover density 10 - 40%)	320.8	5.8
3	Light Vegetation (Crown cover density <10%)	416.84	7.5
4	Agricultural land	106.87	1.9
5	Scrubs/Bushes	147.73	2.7
6	Barren area	308.38	5.55
7	Water body	5.34	0.1
8	Settlement/Built-up	6.75	0.1
9	Snow covered area	3400.72	61.25
	TOTAL	**5549**	**100.00**

TABLE 3.6
LAND USE CLASSIFICATION FOR DIRECTLY DRAINING CATCHMENT

S.NO.	LAND COVER CATEGORY	AREA (ha)	AREA (%)
1	Dense Vegetation (Crown cover density >40%)	2118.1	48.35
2	Medium Vegetation (Crown cover density 10 - 40%)	986.3	22.50
3	Light Vegetation (Crown cover density <10%)	521.8	11.90
4	Agricultural land	632.3	14.41
5	Scrubs/Bushes	7.3	0.2
6	Barren area	35.4	0.8
7	Water body	63.8	1.46
8	Settlement/Built-up	16.0	0.38
	TOTAL	**4381**	**100.00**

3.2.3 Physiography

Situated in the Himalyas, the district which is nearly half the size of its parent district, Garhwal, is broad in the north and narrow toward the south and is somewhat cup shaped, its length from north to south being about 129 km and its breadth form west to east about 117 km. To its north lies Tibet and to the northwest the district of Uttarkashi. On the east it is bounded by the Pithoragarh, on the south and south-east by the Almora, on the south west by the Garhwal and on the west by the Tehri Garhwal districts. Perched in the breadth taking loveliness of upper Himalayas divided by the ranges as venerable as the Pyramid, the district of Chamoli stretches across the snow free valleys to the sky crapping peaks the perpetual snow and glaciers. The terrain consists of the ridges of Nanda Devi range and Badrinath range which are the dominant features and leaves only the narrow and precipitous valleys such as on the banks of Alakhnanda and at Lohta Plateau. The adjacent ridges of the valley are the homes of dense forests. Between the dense fringe of the forest occur the scarcely populated tracts, the inhabitants of which subsisting on terrace cultivation. Chamoli district is criss-crossed by several important rivers and their tributaries. Alaknanda, traversing a distance of 229 kms. before it confluence with Bhagirathi at Devprayag and constituting the Ganga, is the major river. The Alaknanda originates at a height of 3641 meters below Balakun peak 16 km. upstream from Badrinath form the two glaciers of Bhagirath Kharak and Satopanth. The two glaciers rise from the eastern slopes of Chaukhamba (7140 Meters) peak, Badrinath peak and its satellite peaks. These peaks separates the Gangotri group of glaciers in the west. The major portion of the Alaknanda basin falls in Chamoli district. From its source upto Hallang (58 Km),the valley is treated as upper Alaknanda valley. The remaining part of the area is known as lower Alanknanda valley. While moving from its source, the river flows in a narrow deep gorge between the mountain slopes of Alkapuri Geographical area of district is 7,691 sq. km

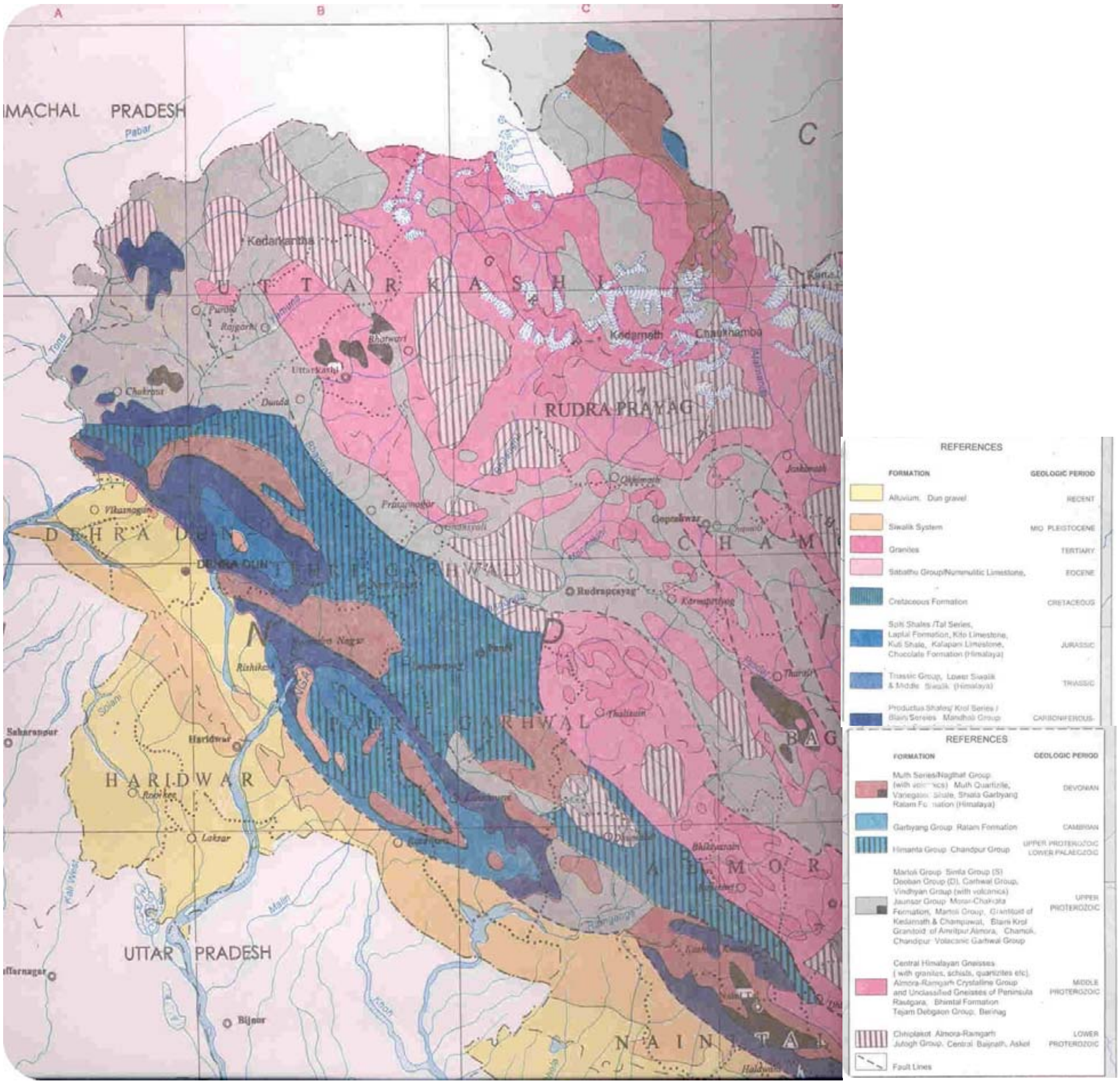
The Physical map of Uttarakhand showing project location is given as **Figure 3.3.**

FIGURE 3.3
PHYSICAL MAP OF THE PROJECT AREA

3.2.4 Geology

Geological map of a portion of Uttarakhand is given in **Figure 3.4**, which shows the general geology of the project area. Uttarakhand Himalayas occurring in the central part of the Himalayan folded belt has the rock type varying in age from Proterozoic to Late Tertiary period, disposed in four major tectonic belts designates as Foothill Siwalik belt, Lesser Himalayan belt, Central Crystalline and Tethyan belt. Two heterogeneous tectonic divisions, one representing the epigeosynclinal orogeny and the other indicating an epiplatform or extra geosynclinal orogeny are possibly juxtaposed. Various geologists have studied the magnitude of the crystalline thrust sheets of Kumaon Himalaya and introduced the concept of large scale overthrusting to explain structural disposition of parts of Himalayan belt.

FIGURE 3.4
GEOLOGICAL MAP OF THE PROJECT AREA



The foothills consist entirely of a narrow belt of Lower Siwalik sediments consisting of sandstone, siltstone, shales and conglomerates. Middle and upper Siwaliks are subordinate with contact often marked by strike faults. The individual Siwalik sections are mostly normal and are demarcated on the north by an important geotectonic feature named as the Main boundary fault/thrust.

The lesser Himalayan belt consists of a vast stretch of unfossiliferous zone in Garhwal and Kumaon regions bounded by the Main Boundary Fault (MBF) to the south and the Main Crystalline Thrust (MCT) in the north and is geologically very intricate. This could be demarcated into several important tectonic units demarcated by faults and thrusts. This belt comprises the Krol belt, a group of argillaceous, calcareous, arenaceous sedimentary rocks of Pre-Cambrian to tertiary age. Doubly plunging synforms named Mussorie synform, Garhwal synform and Nainital synform form a part of this belt. This belt includes rocks designated as Mandhalis, Chandpurs, Nagthat overlain by Blaini, Infra Krol, Krol, Tal and paleogene Nummulitics in the ascending order. The other belt in Almora-Dudatoli crystalline belt consisting of pelitic, psamitic and semi-pelitic schists and quatzites intercalated with bends of migmatites, granitic gneisses and non-foliated granitic rocks occurring in asymmetric synform. The other belts are the Ramgarh, Eastern Kumaon, smaller crystalline belts, also in Kumaon area. The other important rock group is the northern sedimentary belt, a vast unfossilferous group referred as Garhwal group. This belt laterally stretches from Uttarkashi in the northwest to Kali river in the south east, where it extends into Nepal and they are represented by Ortho quartzite-carbonate sequence with minor argillaceous component.

The main Central Crystalline belt consists of a complex of mylonite gneisses, phyllite, garnetiferous schist and kyanite bearing schist, calc silicate rock and quartzite with associated, migmatite syntectonic granite gneisses and late to post – tectonic tourmaline bearing granite including the famous Badrinath and Gangotri granite.

Gannser (1964) indicated that a normal sequence of decreasing metamorphism is noticeable in the upper part in the Central crystalline belt grading in to Martoli Garbyang formation. This belt is subjected to poly phase deformation and ply metamorphism with isoclinal and reclined fold plunging toward NNE. Keta – zonal assemblages, poly metamorphism three or four fold symmetries characterize this belt. The long belt of Central Crystalline is marked at many places by mica schist and gneisses with sills of amphibolites of the gabbroid to dioritic composition. Lower most gneisses show upward increase of the content of plagioclase feldspar. Overlaying rocks are psammitic gneisses with the preponderance of garnet, staurolite, kyanite etc. within the overall biotite gneisses or migmatites zone. In Garhwal Himalaya enormous thickness of quartzite is developed with short strike extension. Linear intrusion of tourmaline granite is seen towards the upper most part of Garhwal Himalaya.

The Tethyan belt consists of a great succession of marine fossilferous sediment mostly from Martoli and Garbayne formation with no sharp geological discontinuity except for Dar-Martoli fault. The northern belt of Tethyan belt is marked by a thrust of major tectonic significance near Kailash region where slightly metamorphic south dipping flysch zone with intercalated amphibolites and some exotic blocks is thrust along south dipping tectonic contact over the thick and horizontally bedded Kailash conglomerate (Gannser 1964) and this thrust probably divides the Himalaya from the Trans-Himalaya and marks the northern limit o the Tethyan Himalaya.

The main structural discontinuities running through the entire length of Uttarakhand are the Main Central Thrust (MCT), North Almorah Thrust (NAT), which in its western part is referred to as Srinagar thrust and the Main Boundary Thrust (MBT). The MCT has brought the Central Crystalline in juxtaposition with rock of the low-grade complexes (Lesser Himalayan belt of rock) and in a sense marks the southern boundary of higher Himalaya. The surface trace of this north-dipping plane is sinuous and at places offset by transverse fault. The MCT at the base of Central Crystalline is a low angle feature when discernible and in a regional way does not present persistently linear traces. The North Almorah thrust (NAT) southerly to sub vertically dipping discontinuity separates the Garhwal group from Morar - Chakarata –Tehri formation in Garhwal Himalaya (Kumar et al. 1989). The most distinct developed thrust is the MBT separating the Pre-Tertiaries from the Tertiaries. Apart from the regional thrust following the Himalayan trend a number of faults of transverse disposition dissect and displaces the rock units.

3.2.4.1 Geology of the project area

The project is located in the rocks Berinag Formation of Garhwal Group. The formation comprises fine to medium grained white quartzite with or without penecontemporaneous mafic volcanics, minor amounts of chlorite phyllite and biotite-chlorite phyllite. These rocks are exposed around Chamoli in the northern limb of Maithana Syncline and between Sunla and Nandpryag in the southern limb, locally referred to as the Patroli quartzite.

The rocks are mostly covered with debris and fluvioglacial material and are exposed in the river section, road cutting, and foot tracks. The rocks are moderately to closely jointed.

Major portion of the barrage site is occupied by glacial and fluvioglacial material. The outcrops are scanty and isolated. Outcrops exposed in the river bed and on the bank about 450m down stream of the barrage axis. The rocks exposed are biotite gneiss and schist with intrusions of basic rock. The gneiss is generally of dark grey colour, medium to fine grained and contains micaceous and chloritic layers along foliation plane. Large boulders upto 3m size of gneiss and small sub rounded boulders of quartzite, gneiss, limestone and amphibolite occur on the surface at desilting basin location. The ground level around the proposed intake portal location is around 1026.36m and mainly consist of talus and fluvio-glacial deposits down to the riverbed level. The major portion of the excavation will be through gluvio-glacial material. The predominant rocks expected to be encountered in the H.R.T. are gneiss, guartzite and metabasic rock. The bedrock at penstock are undifferentiated gneiss, quartzite and metabasic rock. Along the penstock alignment the rock is weathered and gravitiational glide cracks (slump joints) are noticed. The alignment is mostly covered with slope debris. The rocks exposed at he site of powerhouse are, gneiss, schist with basic intrusive (undifferentiated). The outcrops are sparse with intervening river borne material.

3.2.5 Soils and Minerals

Mainly mountain soil occurs in district Chamoli. The nature and type of soil is quite inconsistent. Mild hill slopes are covered with a layer of fragmented rocks and gravel mixed with soil, whereas top-cover has scoured from steeper slopes. The soils in the valley are alluvial of red and brown colour, being thin on the hillsides. The soil on the shady side of a hill, especially if it is bordered by forests, retains moisture better than if it has a southern aspect and is usually thicker and richer. At places the quality of the soil, if it is not alluvial, is determined by the kind of rocks in the sub-soil. **Figure 3.5** compares the soil characteristics of the project area with that of the rest of the region (a portion of Uttarakhand)

3.2.5.1 Soil Characteristics

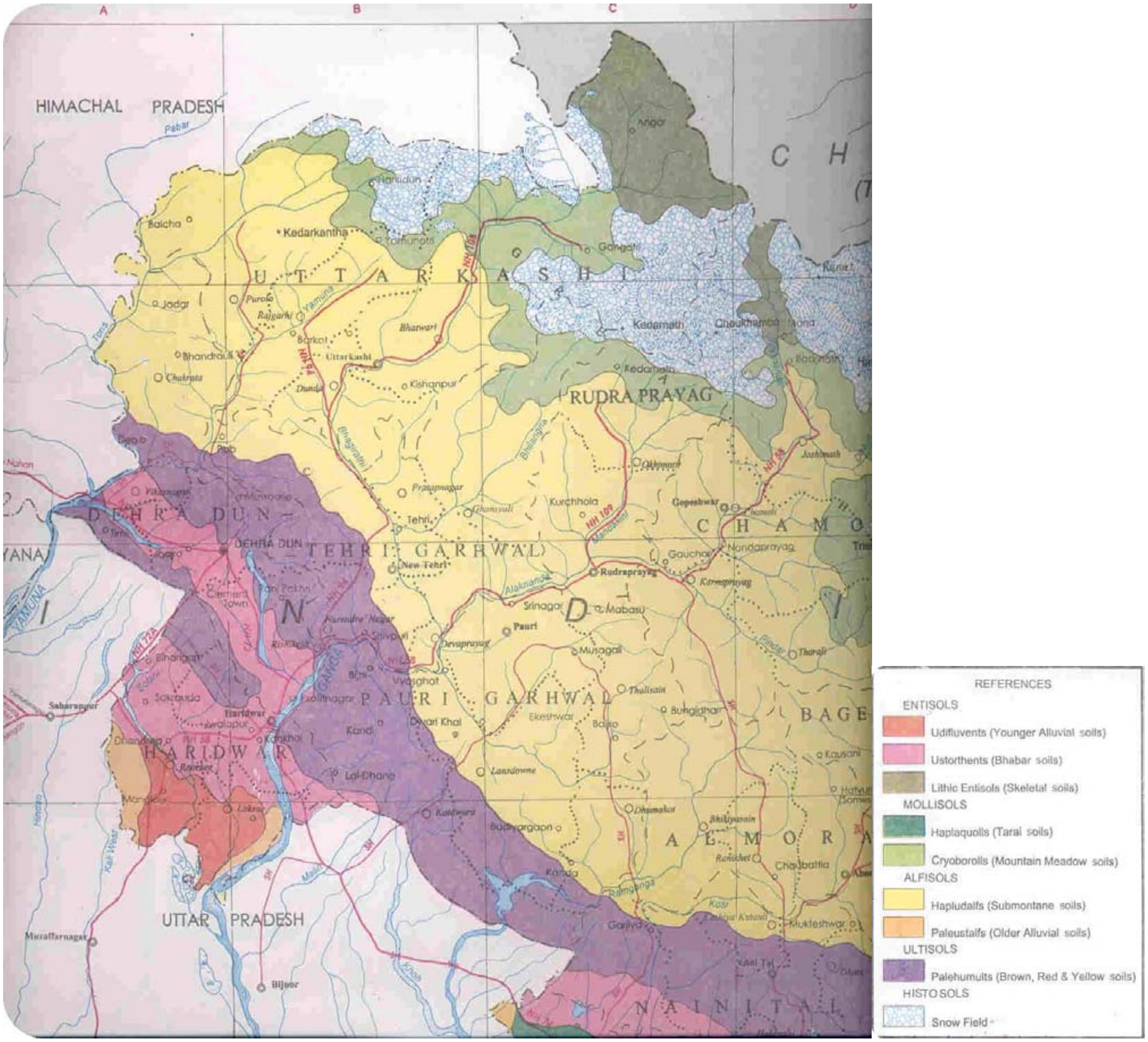
Soil samples were collected from four different locations, one each at barrage site, power house site, Chamoli and Nandpryag The soil samples were collected in three different seasons and were analysed for NPK, organic matter, pH value, Calcium, and Magnesium content. Soil test results presented at **Table 3.7** indicate that soil in the project area is sandy. Low organic content and the levels of NPK indicate that productivity of soil is moderate. It does not indicate extensive use of fertilizers. The sodium levels do not indicate any potential for soil salinization or adverse impact on soil productivity. In general the pH value is around 7, which indicates neutral characteristics of the soil.

TABLE 3.7
PHYSIO-CHEMICAL CHARACTERISTICS OF SOILS

PARAMETER	Barrage Site			Chamoli			Power House site			Nand Pryag		
	I	II	III	I	II	III	I	II	III	I	II	III
pH value	7.06	8.21	7.04	7.15	8.04	7.32	5.56	6.32	5.75	7.61	7.74	7.35
Organic Matter	0.15	6.88	4.09	4.56	7.36	1.93	0.85	0.56	0.55	5.28	1.75	4.05
Sodium Content (Meq/100gm)	1.13	2.99	0.65	0.96	3.07	0.91	0.82	0.93	0.61	2.3	1.95	0.56
Potassium Content (Meq/100gm)	0.45	1.56	0.26	0.65	1.5	0.15	0.56	0.66	0.15	1.53	0.82	0.35
Calcium Content (Meq/100gm)	3.19	5.6	6.97	5.75	5.57	7.18	3.24	2.24	1.76	19.35	9.17	14.72
Magnesium Content (Meq/100gm)	2.42	1.05	3.01	1.56	2.42	1.21	2.36	1.82	1.2	11.5	0.48	2.4
Phosphate (as P_20_5) (Kg/hectare)	430.52	123	436.79	417	337.4	1139.26	220	240.42	610.18	22.16	27.13	979.76
Nitrogen Content (Kg/hectare)	532	895.23	2770.8	2086	1966.46	2547.63	736	895.26	813.76	4705.39	1740	4601
Texture:												
Sand (%)	85.6	81.93	81.09	76.54	76.66	76.08	87.63	81.58	77.36	88	94.32	88.57
Silt	3.3	8.87	12.35	14.56	12.22	17.01	9.54	10.36	15.26	4.05	2.44	9
Clay	11.1	9.2	6.56	8.96	11.12	6.91	5.36	7.36	7.38	7.95	3.24	2.43

I- First Season Study (Summer)
II- Second Season Study (Post Monsoon)
III- Third Season Study (Winter)

FIGURE 3.5
SOIL MAP OF PROJECT AREA



3.2.5.2 Minerals

The minerals that are found in the district are Asbestos, magnestic, Soapstone or Steatite, copper, iron, graphite, gold, gypsum, lead, slate, limestone, building stone, sulphur and bitumen. Asbestos is of the amosite variety, Magnestic is of an average quality is crystalline in nature, and is found associated with crystalline dolomites and sometimes with soapstone. The Magnesium carbonate found here is also of average quality and its mineralisation has also been reported to occur in the district. Soapstone or Steatite is white saponaceous stone resembling pipe clay is obtained in as lenticular body and is associated with mineral pyrites, which adds a color to it, and in places with magnesite. It can be mined for use as filler in soap and in the cosmetic industries. In the past various utensils were made of it which, when polished, had the appearance of marble.The copper mines in the district are extensive and of reputed during the period of Hindus and The Gorkhas rules. All the rich mines have since being exhausted and at present they do not offer a fair field for the employment of capital. Small and sporadic occurrence of iron are known to occur in several parts of district but are of hardly any economic important. Iron ore, rich in haematite, and magnetic ore, with haematite and siderite, also occur in the district. In the past Graphite, also known as plumbago, found mostly in patti Lohba, was used as a dye but no large deposits have been noticed for a long time. Although no gold mines has been discovered in the district, the sands of Alaknanda and the Pinddar are said to be auriferous to a limited extent. Gypsum is found on the bank of some river and was used in the past for the manufacture of saucers and bowls . Lead Deposits were fairly numerous in the past but it is found in somewhat inaccessible places and has long since ceased to be worked. There are two distinct ranges of lime stone hills in the district, the first, north of the Alaknanda in Nagpur, the second, running from Lohba patti to the Pinddar and again to the Alaknanda in patti Bacchansyun in district Garhwal. Reserves of dolomite exists in the district and tufaceous deposits are also found near several Nallahs. Sand stone is found in abundance in the lower hills. Gneiss and chlorite schists which are available throughout the district are frequently used for building purposes. Sulphur also known as brimstone is found in the district as green sulphate of iron. Sulphur springs also occur in many parts in the district. The brownish white natural sulphate of alumina known as Shilajit is found in rocks at a fairly high altitude and occur in small lumps which generally have an admixture of red sand and micaceous stone embedded in them. It is used in Ayurvedic medicine and during the season when there is an influx of pilgrims, it fetches good income to those who deal in it. Some other minerals found in the district are Antimony, Arsenic, Lignite or Brown Marble, Mica and Silver.

3.2.6 Seismicity

Based on the tectonic features and records of earthquake, Seismic Zoning map of the country has been developed by Bureau of Indian Standard. Seismic Zoning Map of India is placed as **Figure 3.6.** The project area falls in zone-IV of this map.

3.2.6.1 Tectonic Setting

The Himalayan mountain range, an outcome of the compressional processes ensued by the India-Asia collision (70-40 Ma), has been undergoing extensive crustal shortening along the entire 2400-km-long northern edge of the Indian plate. A series of thrust planes is known to have formed as a result of these processes. Three principal thrust planes in the Himalayan region are the Main Central Thrust (MCT), the Main Boundary Thrust (MBT) and the Main Frontal Thrust (MFT).

The MCT is believed to have developed by an intra-crustal thrust that brought up the mid-crustal level rocks of the Higher Himalayan Crystallines to the Lesser Himalaya. Tectonically, it represents a ductile shear zone at depth, comprising a duplex zone with three distinct sub-thrusts: MCT I, MCT II and MCT III from south to north. Of these, MCT-I, the southernmost and the youngest, appears to be seismically more active. Several barrageaging earthquakes have occurred along these thrust faults, and there are continuing debates on the current seismogenic potential of these fault systems. The M6.5 Uttarkashi earthquake of 1991, centered about 70 km north-west of Chamoli town, is considered to be associated with this fault. The 1999 Chamoli earthquake also appears to be associated with the same fault.

The Lesser Himalayan sequence lying between the MCT and the MBT shows stacking of various groups of rocks characterized by south-vergent thrusts, which were later folded into major scale synforms and antiforms. The geological maps of the area indicate presence of anticlinal structure very close to Chamoli. In the studies conducted after 1999 earthquake, some signatures of recent deformation, associated with this anticline, were observed. A sharp contact of MCT-I with recent/sub-recent deposits is identified near Chamoli on the southern flanks of the anticline along the Alaknanda river. Thick deposits of colluvium (boulders and pebbles intercalated with coarse sand) occur at the foot of the steeper limb of the fold. The colluvium may have been remobilized on an incipient slope due to the development of the growing fold. This contact is interpreted to be the surface expression of an active fold.

3.2.6.2 Historic and Current Seismicity

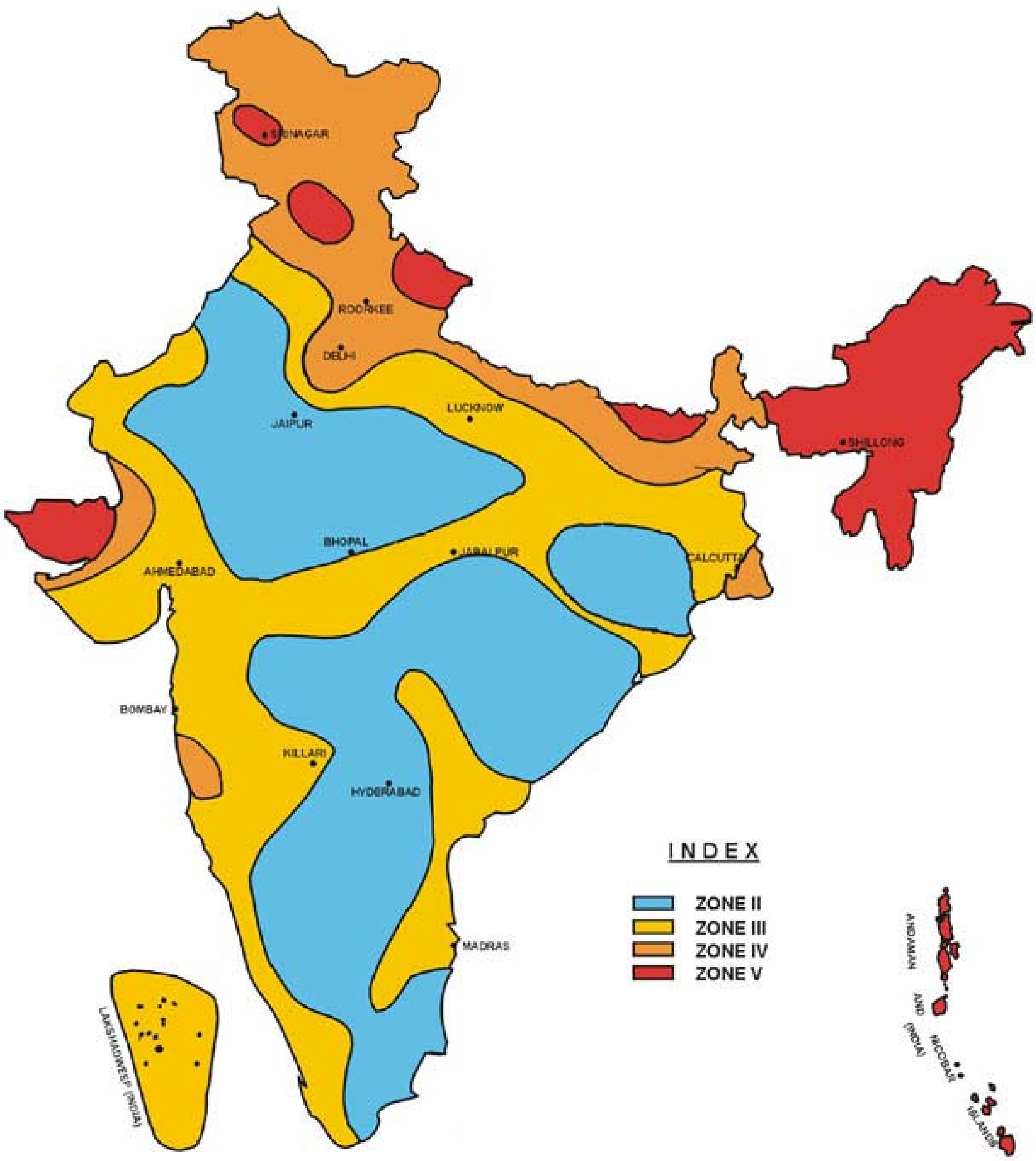
Historic and instrument data suggest fewer large earthquakes in the region compared to the rest of the Himalaya. One earthquake, probably of M >7, is reported to have occurred in this region on 1 September 1803. Several villages are reported to have been buried by the rockfalls and landslides caused by that earthquake. The Badrinath temple located 40 km north of Chamoli was severely barrageaged during that earthquake.

In 29 March 1999 the earthquake occurred at 00:35:13.59 hours (local time) near the town of Chamoli in the erstwhile state of Uttar Pradesh in northern India. The earthquake magnitude was mb 6.3, MS 6.6 as per USGS, and it was mb 6.8, MS 6.5 as per India Meteorological Department (IMD). The preliminary location of epicenters by different agencies was somewhat inconsistent; 30°49.2′N, 79°28.8′E as per USGS, and 30°17.82′N, 79°33.84′E as per IMD. Location of aftershocks recorded and the barrageage pattern suggest that the zone of activity may be close to Chamoli town; this region also showed a maximum intensity of VIII on MSK scale. USGS estimate of the focal depth is 12 km.

During the post-earthquake survey of the 1999 Chamoli earthquake, two temples, one at Gopeshwar and the other at Makkumath, built during 7-12th century were examined. These show evidences of severe barrageage during the 1803 event. Many parts of these two temples have been reconstructed as indicated by the inscriptions on their wall stones. Both these temples suffered only minor vertical cracks during the current earthquake, in spite of them being located in the meizoseismal area. This indicates that magnitude of the 1803 event may have been much larger.

FIGURE 3.6

SEISMIC ZONING MAP



3.3 WATER ENVIRONMENT

Water environment consists of water resources such as streams, lakes, estuaries, water use, and quality. Understanding the water quality is essential in preparation of EIA and to identify critical issues with a view to suggest appropriate mitigation measures for implementation. Water quality parameters of the surface water, which is the main source of water in the project area, have been studied for assessing the water environment and to evaluate its suitability for drinking purpose along with anticipated impacts of the proposed project on water environment.

3.3.1 Water Resources

The water regimes of Uttarakhand comprise mainly three basins. The first type of water basin includes the rivers originating from glacial regions of the Higher Himalayas like the Ganga, Yamuna and Kali rivers. The second and third regimes are the non-glacial rivers originating from ground water sources in lesser Himalayas like Ramganga, Kosi etc. and the seasonal rivers in the Siwaliks. Chamoli district is criss-crossed by several important rivers and their tributaries. Alaknanda, traversing a distance of 229 kms. before it confluence with Bhagirathi at Devprayag and constituting the Ganga, is the major river.

The proposed barrage is on river Alaknanda near Bowala on Rishikesh - Badrinath road (208 km from Rishikesh). The catchment area of river Alaknanda at Bowala Nand Prayag is 5,549 sq. km. out of which the snow bound area is 3400 sq. km.

3.3.2 Water Use

The major uses of water are for agriculture, drinking and domestic purpose. The main sources of water are rivers and nallahs. These are used to meet the requirements in project as well as in study area. The water is conveyed to the consumer through open channels. The area has rainfed agriculture. Rainwater and snow are absorbed within the soil; this water percolates through the soil and reappears in the form of springs. These springs are also used for water consumption. The flow of these springs increases during rainy season and decreases during winter and summer.

3.3.3 Ground Water

Groundwater regimes in Uttarakhand from Gangeatic planes to Higher Himalayas are governed by varied meteorological and ground water hydrology. Sources include recharge from rainfall, snowmelt in Lesser Himalayas, snow, ice and glacial melts in Greater Himalayas. On an average percolation of 15 to 25% of the precipitation into the ground is expected, while the remaining water flows overland depending upon slopes, nature of soil, vegetation and anthropogenic activities. The interconnectivity of the porosity patterns allows water to migrate from a few meters to many kilometers in depth in the direction of gravity and rock inclinations. The percolating water tends to be trapped or accumulated in natural reservoirs or aquifers and may flow along fractures, joints, cleavage, schistose and dislocating planes in rocks.

3.3.4 Water Quality

Water quality can be expressed in terms of physical, chemical and biological characterization of water. Essential characteristics like pH, total hardness, Iron and Chlorides are covered in physical analysis. Dissolved solids, Calcium, Magnesium, Sulphates, Nitrate and Fluoride are chemical parameters to be analysed as per BIS. In order to collect baseline data on the existing water quality, raw water samples were collected from 3 different locations on the river and analyzed as per the procedure specified in standard methods for examination of water and wastewater published by American Public Health Association and the Bureau of Indian Standards (APHA/BIS). The results of the physio-chemical analysis are summarized in the **Table 3.8**

The test results when compared with **Table 1.7** "Tolerance Limits for Inland Surface Water Quality" show that water in the river is suitable for all kinds of its designated use namely; (A): drinking water source without conventional treatment but after disinfection, (B): outdoor bathing, (C): drinking water source with conventional treatment followed by disinfection, (D): propagation of wildlife and fisheries and (E): irrigation, industrial cooling and controlled waste disposal.

TABLE 3.8
WATER QUALITY IN PROJECT AREA

Parameter	Barrage site			Chamoli			NandPrayag		
	I	II	III	I	II	III	I	II	III
pH Value	7.45	7.78	7.1	7.07	7.85	7.74	7.32	7.94	7.73
Chlorides (as Cl) (mg/l)	7.99	3	8	8	2	3.99	8	2	3.99
Sulphates (as SO_4) (mg/l)	31.84	14.03	10.15	8.36	10.75	21.62	6.57	11.94	5.41
Phosphates (as PO_4) (mg/l)	<0.003	ND	ND	ND	ND	<0.003	ND	ND	<0.003
Total Iron (as Fe) (mg/l)	0.078	4.2	2.02	2.08	3.24	1.2	0.46	3.44	0.078
Dissolved Oxygen (mg/l)	7.7	5.2	7.4	7.3	5.8	7.2	7.5	5.4	7.6
Total Suspended Solids (mg/l)	1.6	15.2	69.8	73.4	18.2	60.99	13.6	21.8	0.3
Total Dissolved Solids (mg/l)	248.18	89.31	75.52	77.97	77.72	123.98	105.1	76.72	117.42
Calcium (as Ca) (mg/l)	131.87	47.95	47.95	47.95	35.96	59.94	59.94	35.96	59.44
Magnesium (as Mg) (mg/l)	31.97	27.97	19.98	19.98	23.98	27.97	23.99	23.98	19.98
Total Alkalinity (mg/l)	119.88	59.94	51.95	55.94	31.97	55.94	83.92	31.97	107.89
Nitrates (as NO_3) (mg/l)	3.11	1.23	1.95	2	1.56	1.4	1.65	1.08	1.47
BOD 3 days at 27°C (mg/l)	<2	<2	ND	ND	<2	<2	ND	ND	<2
Fluorides (as F) (mg/l)	1.23	0.16	0.33	0.28	0.05	0.28	0.45	0.05	0.22

I. First Season Study (Summer)
II. Second Season Study (Post Monsoon)
III. Third Season Study (Winter)

It is observed from the test results that BOD of all the samples is well within permissible limits of drinking water, which indicates the absence of organic pollution loading. This is maily due to low poluplation density, low agrochemical dosing, and absence of industries in the area. The iron content of most of the samples is above the permissible limits (i.e. 0.3 mg/l). This may be due to the soils rich in iron or dissolution of ferrous minerals. The higher presence of DO is due to the cascading effect of the river and less polluting organic matter. From the above results it could be concluded that surface water at the site is fit for human consumption after preliminary treatment like chlorination and sedimentation.

3.3.5 Sedimetation

The proposed project being a diversion scheme, silting up of reservoir is not of much importance. However it is essential to remove sediments as these are very much injurious to the runner blades of the turbine and also to the water condutor system. In maneri Bhali Stage – I scheme some Barrageage to the turbine has been observed due to high velocity of the flow and suspended particulate matter. According to Creager and Justine, the silt particles upto 0.05mm size are not injurious to the blades where as Emil Mosonyl indicates that the particles of size 0.2 to 0.5 mm is usually objectionable for medium head plants.according to Sokolov, sharp edged sediment with a particle size as small as 0.25mm may seriously injure the tubine. Thus to prevent the tubines and tunnel lining sedimentation tank is designed to exclude particle size 0.2mm and above.

3.4 METEOROLOGY AND AIR ENVIRONMENT

Meteorology is an important parameter in environmental impact assessment exercise. It is responsible for the movement of air and air pollutants. The main parameters are: temperature, humidity, rainfall, winds and cloud cover. The meteorology and air environment of the area are discussed in subsequent sections.

3.4.1 Meteorology

As the elevation of the district ranges from 800 mts. to 8000 mts above sea level the climate of the district very largely depends on altitude. The winter season is from about mid November to March. As most of the region is situated on the southern slopes of the outer Himalayas, monsoon currents can enter through the valley, the rainfall being heaviest in the monsoon from June to September.

Temperature: The nearest Indian Meteorological Department (IMD) observatory is at Joshimath which is approximately 30km from the Intake Site at an elevation of 1875m. January is the coldest month after which the temperature begin to rise till June or July. Temperature vary with elevation. During the winter cold waves in the wake of western disturbances may cause temperature to fall appreciably. Snow accumulation in valleys is considerable. The lowest temperature at Joshimath of -15^{O}C was recorded in the month of January 1974 and the highest temperature at Joshimath was 34^{O}C recorded in the month of June 1978. A graph showing mean monthly maximum and minimum temperatures at Joshimath is shown in **Figure 3.7**

Rainfall: Most of the rainfall occur during the period June to September. About 70 to 80 percent of the annual precipitation is accounted for in the southern half of the district and 55 to 65 percent in the northern half. The effectiveness of the rains is, among others, related to low temperature which means less evapo-transpiration and forest or vegetation cover. However, the effectiveness is neither uniform nor even positive in areas where either the vegetational cover is poor or / and has steep slops or the soils have been so denuded that their moisture absorption capacity has become marginal. There are several rain gauging stations established in the upper part of the catchment area, however, due to difficulty of access the records from these stations are generally incomplete, particularly during the winter months. The rain guage at Joshimath provides a rainfall record from 1958 to 2003 which is more or less complete, and which, due to its central location in the catchment, gives an indication of the annual rainfall distribution. The mean annual rainfall in the catchment estimated from isohyetal map of IMD is 1050mm. A graph showing annual rainfall distribution at Joshimath is given in **Figure 3.8**.

Humidity: The relative humidity is high during monsoon season, generally exceeding 70% on the average. The driest part of the year is the pre monsoon period when the humidity may drop to 35% during the afternoon. During the winter months humidity increases toward the afternoon at certain high stations

Cloud cover: Skies are heavily clouded during the monsoon months and for short spells when the region is affected by the passage of western disturbances. During the rest of the year the skies are generally clear to lightly clouded

3.4.2 Wind Speed and Wind Direction

Data for wind speed and direction were collected to prepare wind rose diagram of winter, summer autumn and rainy season. Annual wind rose diagram has also been drawn to get the annual average result of wind speed and wind direction. The wind rose diagram has been drawn for 8:30 hours and 17:30 hours time. These diagrams have been placed at **Annexure 3.1**. Wind direction during morning and evening hours have been drawn out from these diagrams which indicates that wind direction prevailing in the morning hours is northeast and that in the evening time is southwest.

3.4.3 Air Quality

Sampling Stations; The ambient air quality within the study area of 10 Kms radius from the barrage site forms the baseline information. The study area is rural in nature and there is no industry or urban settlements. The primary sources of air pollution in the area are vehicular emissions, domestic fuel burning and dust from roads/ fields. The prime objective of collecting baseline air quality data is to assess the air quality of the area during pre-project conditions. The ambient air quality for suspended particulate matter (SPM); oxides of nitrogen (NO_x), carbon monoxide (CO) and hydrocarbon (HC) have been assessed. Two Ambient Air Quality Monitoring (AAQM) stations at following locations were selected for sampling. These locations have been shown on plan in **Figure 3.9.** and site photographs of air quality monitoring have been placed as **Figure 3.10 and Figure 3.11.**

- Near Barrage site at Birehi
- Powerhouse site at Pursari

FIGURE 3.7
MEAN MONTHLY MAXIMUM AND MINIMUM TEMPERATURES AT JOSHIMATH

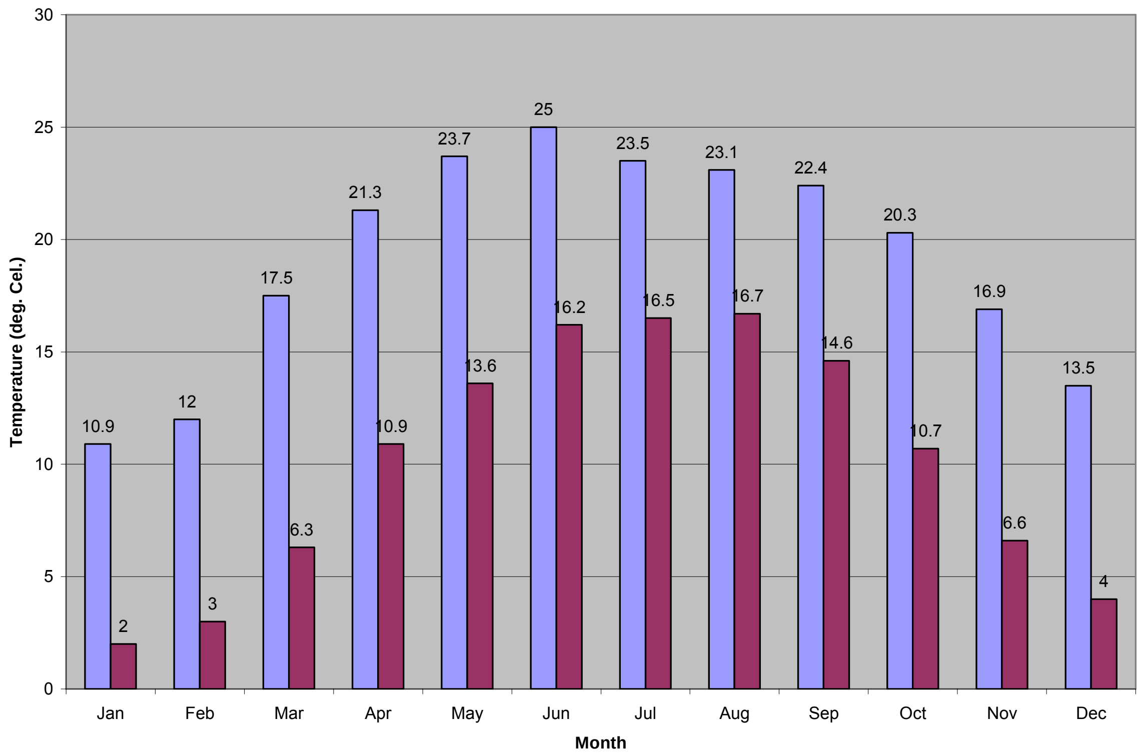


FIGURE 3.8
RAINFALL DISTRIBUTION AT JOSHIMATH

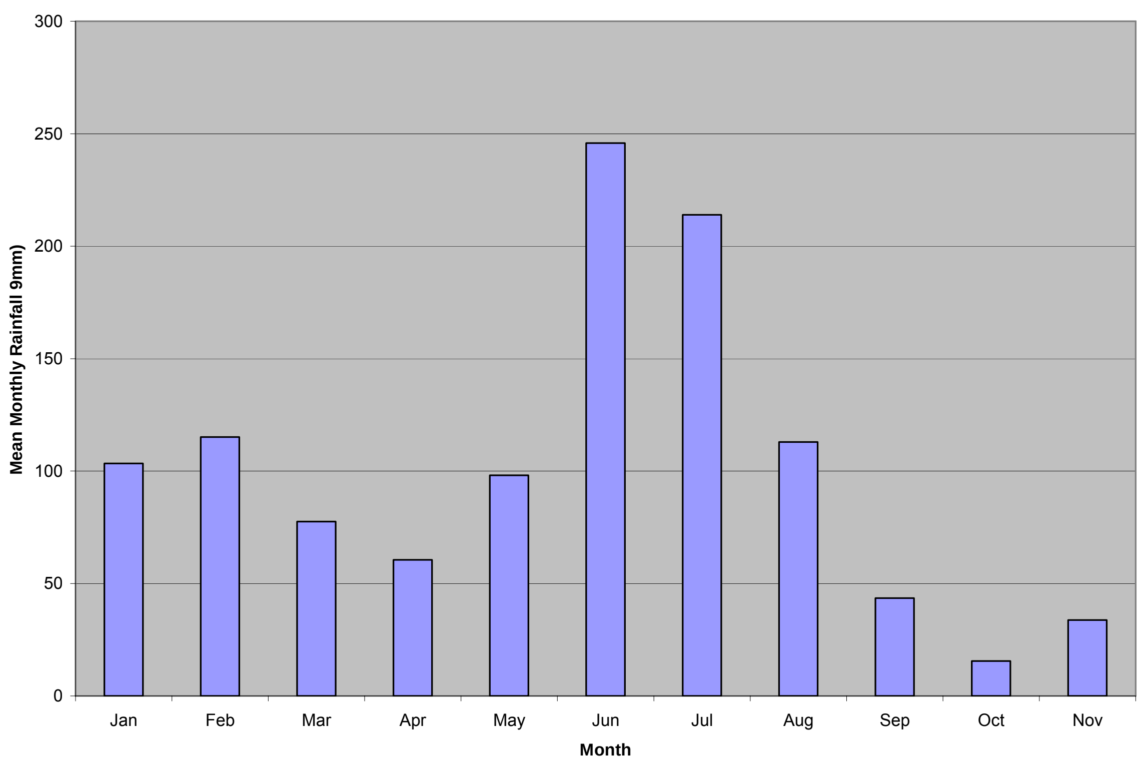


FIGURE 3.9
AIR QUALITY MONITORING STATIONS

★ Air Monitoring Stations

Frequency; The ambient air quality monitoring has been carried out for three seasons namely; summer, winter and post-monsoon season.

Methodology; Methodology and equipment used for measuring the parameters are based on Indian standards. The methodology adopted and equipment used are discussed in following sections:

a) Suspended Particulate Matter (SPM): Atmospheric air was drawn through High Volume Sampler (HVS) of ENVIROTECH make; by means of high –flow-rate blower at the flow rate of 1.00 to 1.20 m^3/min for 24 hourly samples twice a week. Particles within the range of 100 to 0.1μm were collected on pre–weighted conditioned GF/A glass micro fiber paper. The mass concentration in μg/m^3 of suspended particulate in ambient air was computed gravimetrically by measuring the mass of collected particulate and the volume of air sampled as per IS:5182 (Part – IV)

b) Nitrogen Oxides (NO_2): Nitrogen Oxides as Nitrogen dioxides from the air was absorbed in 0.1N NaOH-Na_2AsO_2 solution by bubbling the air into absorbing solvent by meant of low volume sampler assembly attached with HVS, at a flow rate of 0.5 litre/min. The No_2 ion, thus produced during sampling was allowed to react with phosphoric acid, sulphanilamide & N-1 (napthyl) ethlenediamine dihydrochloride (NEDA) to form a coloured complex, intensity of which was measured by VISIBLE Spectornmeter at a wavelength of 40 nm. Level of nitrogen oxide as NO_2 in atmospheric air was quantified by computing the concentration of NO2 in absorbing solution and the volume of air sampled as per IS:5182 (pt IV).

c) Carbon Monoxide (CO): Carbon monoxide were collected in bladders and samples were analyzed by CO ANALYSER model CO 11M make environment .s.a. France based on NDIR technique & reported as CO, mg/m^3 as per IS:5182 (Pt-X).

d) Total Hydrocarbon (HC):Air sample were collected in bladders and samples were analysed by TOTAL HYDROCARBON ANALYSER model THM 411 make DANI, Italy & reported as CH_4 ppm as per IS: 5182.

Results; The results of the monitoring are tabulated in **Table 3.9** and summary of results in **Table 3.10**. The air quality monitoring results show that concentration of any of the four pollutant, at any of the two locations, during any time (among three different seasons) have not exceeded the concentration limits of these pollutants specified by CPCB for residential area. Further the presence of gaseous pollutants is either below detectable limits or very low which shows existence of very good quality air in the project area.

TABLE 3.9
AIR QUALITY MONITORING

Season	BIREHI				PURSARI			
	SPM	NO_2	CO	HC	SPM	NO_2	CO	HC
Summer	44	11	0.5	3.8	68	15	0.7	3.7
	18	8	0.2	3.1	30	11	0.3	3.4
	73	12	0.4	3.5	98	19	0.5	4.0
Average	45	10.3	0.4	3.5	65.3	15.0	0.5	3.7
Post Manson	75	12	<0.1	2.8	124	20	<0.1	3
	47	7	<0.1	2.6	85	30	<0.1	3.2
	19	7	<0.1	2.5	37	20	<0.1	2.9
Average	47	8.6		2.5	82.0	23.4		3.0
Winter	35	23	0.1	2.2	88	17	0.3	2.8
	29	20	0.3	2.3	74	9	0.2	2.6
	12	12	0.2	2.4	102	12	0.4	3.2
Average	25.3	18.3	0.2	2.3	88	12.5	0.3	2.9

TABLE 3.10
SUMMARY OF AMBIENT AIR QUALITY(ug/m^3)

STATION	AVERAGE	MAXIMUM	MINIMUM
SPM			
BIREHI	39.11	75.00	12.00
PURSARI	78.44	124.00	30.00
NOX			
BIREHI	12.44	23.00	7.00
PURSARI	17.00	30.00	9.00
CO			
BIREHI	0.28	0.50	0.10
PURSARI	0.40	0.70	0.20
HC			
BIREHI	2.80	3.80	2.20
PURSARI	3.20	4.00	2.60

FIGURE 3.10
AIR QUALITY MONITORING AT BIREHI VILLAGE

FIGURE 3.11
AIR QUALITY MONITORING AT PURSARI VILLAGE

3.5 NOISE ENVIRONMENT

Noise levels have been measured at barrage site and powerhouse site during three different seasons. The observations were recorded in the morning (8:00hrs to 10:00 hrs), afternoon (12:00 hrs to 14:00hrs), evening (16:00 hrs to 18:00 hrs) and Night (12:00 hrs to 02:00 hrs). The results of observations are summarized in **Table 3.11** indicate that noise levels at both the sites exceeded the limit prescribed for residential area (55 dBA) the reason being the monitoring sites are close to the river. Site photograph of noise monitoring has been placed as **Figure 3.12**

During site visits it is noticed that the main source of noise in the project area (10 km radius) is due to the flow of water in the river and the noise level at any point in the area is inversely proportional to its distance from the river. The other secondary sources of noise are occasional movement of vehicle on the road along the riverside and wind blowing. The area is otherwise calm and quite.

FIGURE 3.12
NOISE MONITORING AT VILLAGE PURSARI

TABLE 3.11
NOISE MONITORING RESULTS
TABLE 3.11
NOISE LEVELS IN PROJECT AREA IN dB(A)

TIME (Hrs)	L_{eq}						L_{10}						L_{50}						L_{90}					
	I Season		II Season		III Season		I Season		II Season		III Season		I Season		II Season		III Season		I Season		II Season		III Season	
	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B
8:00-9:00	66.0	59.4	68.4	59.7	55.4	58.2	68.2	72.3	68.8	61.1	55.2	59.8	59.4	61.4	65.6	52.5	48.8	56.0	57.1	51.7	54.3	47.3	48.0	54.6
9:00-10:00	66.6	59.8	68.7	53.0	55.0	59.1	68.8	71.4	69.6	55.2	53.6	61.4	60.0	59.7	65.9	50.6	48.8	56.6	57.8	51.5	54.8	48.0	48.0	54.8
12:00-13:00	65.3	61.4	63.7	64.1	55.0	61.3	69.9	70.6	66.6	67.8	57.9	63.8	60.4	58.7	60.7	61.9	50.8	58.5	58.1	51.6	57.9	59.2	48.3	56.4
13:00-14:00	64.2	60.3	64.0	63.3	50.3	60.5	69.1	69.9	66.3	67.1	51.7	62.8	59.4	58.7	61.0	61.8	49.6	58.1	57.7	51.7	58.0	58.0	48.9	56.2
16:00-17:00	63.0	71.3	63.9	60.3	50.0	62.2	67.6	75.3	66.3	60.9	51.1	63.9	62.0	70.9	60.7	59.2	49.6	61.0	57.5	64.9	56.2	57.6	49.1	58.8
17:00-18:00	66.0	69.8	63.2	61.1	50.8	60.4	68.1	74.2	66.0	63.0	51.8	62.1	62.3	66.2	59.6	59.5	50.6	59.4	57.9	61.4	54.0	58.3	49.4	58.8
Average	**65.2**	**63.7**	**65.3**	**60.3**	**52.7**	**60.3**	**68.6**	**72.3**	**67.3**	**62.5**	**53.5**	**62.3**	**60.6**	**62.6**	**62.3**	**57.6**	**49.5**	**58.3**	**57.7**	**55.5**	**55.9**	**54.7**	**48.6**	**56.5**
Minimum	**63.0**	**59.4**	**63.2**	**53.0**	**50.0**	**58.2**	**67.6**	**69.9**	**66.0**	**55.2**	**51.1**	**59.8**	**59.4**	**58.7**	**59.6**	**50.6**	**48.8**	**56.0**	**57.1**	**51.5**	**54.0**	**47.3**	**48.0**	**54.6**
Maximum	**66.6**	**71.3**	**68.7**	**64.1**	**55.4**	**62.2**	**69.9**	**75.3**	**69.6**	**67.8**	**57.9**	**63.9**	**62.3**	**70.9**	**65.9**	**61.9**	**50.8**	**61.0**	**58.1**	**64.9**	**58.0**	**59.2**	**49.4**	**58.8**
00:00-01:00	58.5	58.5	57.8	53.5	44.6	52.1	59.4	73.9	58.7	57.0	46.0	55.0	58.6	64.3	57.6	53.2	44.4	61.6	57.9	59.1	56.3	41.5	43.8	51.1
01:00-02:00	57.8	58.2	57.4	54.7	44.4	52.8	58.6	73.3	58.4	56.5	45.9	55.2	58.0	52.2	57.1	54.9	44.2	52.0	57.6	58.4	56.2	41.7	43.7	51.3
Average	**58.2**	**58.4**	**57.6**	**54.1**	**44.5**	**52.5**	**59.0**	**73.6**	**58.6**	**568**	**45.9**	**55.1**	**58.3**	**63.3**	**57.4**	**54.1**	**44.3**	**51.8**	**57.8**	**58.8**	**56.3**	**41.6**	**43.7**	**51.2**
Minimum	**57.8**	**58.2**	**57.4**	**53.5**	**44.4**	**52.1**	**58.6**	**73.3**	**58.4**	**56.5**	**45.9**	**55.0**	**58.0**	**62.2**	**57.1**	**53.2**	**44.2**	**51.6**	**57.6**	**58.4**	**56.2**	**41.5**	**43.7**	**51.1**
Maximum	**58.5**	**58.5**	**57.8**	**54.7**	**44.6**	**52.8**	**59.4**	**73.9**	**58.7**	**57.0**	**46.0**	**55.2**	**58.6**	**64.3**	**57.6**	**54.9**	**44.4**	**52.0**	**57.9**	**59.1**	**56.3**	**41.7**	**43.8**	**51.3**

A-Barrage Site Birehi B- Power House site Pursari

Leq: Equivalent sound pressure level- the steady sound level that, over a specified period of time, would produce the same energy equivalence as the fluctuating sound level actually occurring.

L90: The level of noise exceeded for 90% of the time. The bottom 10% of the sample is the L90 noise level expressed in units of dB (A).

L50: The sound pressure level that is exceeded for 50% of the time for which the given sound is measured.

L10: The sound pressure level that is exceeded for 10% of the time for which the given sound is measured.

I represents summer season
II represents post monsoon season and
III represents winter season

3.6 ECOLOGICAL ENVIRONMENT

An ecological study of the ecosystem is essential to understand the impact due to project development activities on the existing flora and fauna of the area. The present study was undertaken to predict change as a result of the project activities and to suggest measures for maintaining the conditions. This section describes the ecology of the are base on information collected from field studies and from secondary data available for the study/project area. Three sampling sites (S_1, S_2 and S_3) were identified in the project area keeping in view the various points: the area to be adversely affected by the activities of submergence; area directly draining into reservoir; area within 10 km from reservoir periphery; the land to be acquired for power house; and the site of dumping of excavated tunnel materials. The sampling site S_1 was identified in the submergence area near Birahi village at the bank of Alaknanda river (1,042m above m.s.l.) 1.5 km upstream dam site near the confluence of Alaknanda and Birahi rivers, while the S_2 site was identified near Bowala village (1,032 m above m.s.l.) close to the site of dam. The sampling site S_3 (892 m above m.s.l.) was identified near Pursari village; 9.3 km downstream from the dam site (S_2) and close the site of power house.

3.6.1 Terrestrial Ecology

Additional study on the terrestrial ecology of the project area was conducted. The objective of the study of terrestrial ecosystem was to prepare an inventory of flora, listing of rare, endangered of economically important and medicinal plant species and to determine frequency, density and abundance of different vegetation components. Voucher specimens for all RET and endemic plants with GPS readings were also collected. Considering the difficult terrain, quadrate method was used for sampling of the vegetation. Taking into consideration, the size of the vegetation patches, 25 random quadrates of 10m x 10m size were laid to study the trees and shrubs, and 25 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) 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 ($\overline{H}$) = $-\sum_{i-1}^{s}\left(\frac{n_i}{N}\right)\log_2\left(\frac{n_i}{N}\right)$

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.

3.6.2 Aquatic Ecology

Aquatic ecological analysis of Alaknanda river was made following the methods outlined in Wetzel and Likens (1991) and APHA (1998). Periphyton 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:

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

Primary productivity of periphyton-phytoplankton of Alaknanda 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 Alaknanda 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.

3.6.3 RESULTS AND ANALYSES

The terrestrial ecological survey for various aspects of the project area was conducted. The altitude in the project area of Bowala-Nandprayag HEP ranges from 850 m to 1,100 m above m.s.l. The major forest type of the project area is a sub-montane forest. A total number of 127 plant species were recorded during the floristic survey in the project area. Plant diversity of the project area encompasses 27 species of trees, 40 species of shrubs, 41 species of herbs, 4 species of climbers and 5 species of grasses in addition to 3 species of Pteridophytes, 3 species of Bryophytes, 3 species of Lichens and 1 species of fungi. An inventory of plant species, their local names, ecological status and economic values have been presented in **Annexure 3.2**. An inventory for all RET and endemic plants with GPS readings along with their voucher specimen's number has been presented in **Table 3.12**

Sampling Site S_1: The sampling site S_1 was located in the submergence area near the confluence of Alaknanda and Birahi rivers (1042m above m.s.l.). The left bank of the Alaknanda river is dominated by the shrubs of *Artimesia*, *Sapium* and *Colebrookia* species along the National Highway-58. The higher reaches of the left bank above the highway is having steep slopes dominated by the trees of *Pinus roxburghii*. The right bank side of the Alaknanda river in the submergence area was dominated by the young trees of *Pinus roxburghii* and bushes of *Blumia, Parthenium*, *Artimesia*, and *Eupatorium* species along with the herbs of *Desmodium*, *Arabidopsis* and *Ageratum* species. The submergence area at the right bank side of Alaknanda river has mostly young trees. However, the higher reaches of right bank side have old trees of *Pinus roxburghii, Cedrus deodara* and *Sapium insigne.* Overall, the trees were few in number and scattered at this sampling site.

The frequency, density, abundance, basal area and importance value index (IVI) of the trees, herbs and shrubs at S_1 have been presented in **Annexure 3.3**. A perusal of the data on the ecological analysis revealed that the most dominant tree species were *Pinus roxburghii* (IVI: 235.87) and *Sapium insigne* (IVI 64.13). The shrubs were dominantly represented by the species of *Blumia spp* (IVI: 43.73) followed by *Parthenium hysterophorus* (IVI 40.85) and *Eupatorium adscendensce* (IVI: 40.02). The dominant herbs were the species of *Aribidopsis thaliana* (IVI: 35.84), *Ageratum conyazoides* (IVI: 34.25) and *Bidens pilosa* (IVI: 29.10).
.

Sampling Site S_2: The sampling site S_2 is close to the barrage site, near Bowala village (1,032 m above m.s.l.). The right bank of the site has few young pine trees in addition to the bushes of *Artimicia scorpia* and, *Eupatorium* and *Colebrookia* species. The left bank at site S_2 is dominated by the tree species of *Pinus roxburghii.* However, *Sapium insigne* was also present in between the pine trees. The upper reaches are having very steep slope dominated by the trees of *Pinus roxburghii*.

The frequency, density, abundance, basal area and importance value index (IVI) of the trees, herbs and shrubs at S_2 have been presented in **Annexure 3.4** 4. A perusal of data revealed that the sampling site S_2 is dominated by the tree species of *Pinus roxburghii* (IVI: 213.59) and *Sapium insigne* (IVI: 65.33). However, the shrubs were dominated by Eupatorium *adscendensce* (IVI: 46.03), *Parthenium hysterophorus* (IVI: 44.42) and *Colebrookia oppositifolia* (IVI: 33.01). The herbs were dominantly represented by the species of *Cassia tora* (IVI: 39.66), *Ageratum conyzoides* (IVI: 38.89) and *Arabidopsis thaliana* (IVI: 37.96).

Sampling Site S_3: The sampling site S_3 is close to the site of Power House (892 m above m.s.l.) which is represented by bushes and herbs on the left bank. However, the right bank is dominated by the species of *Pinus roxburghii*. National Highway 58 runs along the left bank of Alaknanda river in the Project area. Entire strip of 200 m width between National Highway 58 and the Alaknanda river is dominated by bushes and shrubs. A few trees of *Holoptelia integrifolia* and *Mallotus phillipinnenses* were found to occur at the left bank of the Alaknanda river at site S_3. Most of the tree species of *Pinus roxburghii* were having the girth ranged from 1.5-2.5m at the right bank.

The frequency, density, abundance, basal area and importance value index (IVI) of the trees, herbs and shrubs at S_3 have been presented in **Annexure 3.5**. A perusal of data revealed that the sampling site is dominated by the tree species of *Pinus roxburghii* (IVI: 147.57) and *Mallotus phillipinenses* (IVI: 53.49) and *Sapium insigne* (IVI: 50.79). The shrubs at the sampling site S_3 were dominated by the species of *Parthenium hysterophorus* (IVI: 43.75) and *Eupatorium adscendense* (IVI: 43.58). The dominant herbs present at site S_3 were *Ageratum conyzoidus* (IVI: 42.28), *Euphorbia hirta* (IVI: 39.05) and *Euphorbia prolifera* (IVI: 37.04).

Diversity Indices: Species diversity index can be considered as a measure of environmental quality and indicates the well being of any ecosystem. The species diversity indices (Shannon-Weiner) of plants at sampling site S_1 have been presented in **Annexure 3.3** Diversity indices of sampling site S_1 were computed to be 0.794 for trees, 3.114 for shrubs and 3.483 for herbs. The values for all the three components of plants indicate poor tree diversity at S_1.

The species diversity indices (Shannon-Wiener) of plants at sampling site S_2 have been presented in **Annexure 3.4**. Diversity index of sampling site S_2 was found to be 1.241 for trees, 3.076 for shrubs and 3.236 for herbs. This indicates that the sampling site S_2, the site of barrage, is rich in terms of biodiversity.

The species diversity indices (Shannon-Wiener) of plants at sampling site S_3 have been presented in **Annexure 3.5**. Diversity indices of sampling site S_3 were found to be 0.717 for trees, 3.011 for shrubs and 3.211 for herbs. The values for all the three components of plants indicate very poor tree diversity. However, it has good diversity of herbaceous components of plants.

Threatened Status of Plants and Environmental Management Plan: Out of 27 trees species present in the project area of Bowala-Nandprayag HEP, Chir pine (*Pinus roxburghii*) is a common and economically important species used for timber and resin. *Cinnamomum tamala*, *Delbergia sericea, Ficus species* and *Sapium insigne* were present in the area, which are used for timber, medicine and fodder. Among 40 species of shrubs collected from the area, one species was found to be an endangered or threatened. **This RET species was *Berberis aristata* DC (voucher specimen no. GUH 17220)** Only 20 species were found to be of medicinal value, a few fodder species and some fiber yielding species and a few were having edible fruits. Among the 41 herbaceous species**, three species, *Asparagus adscendens* Buch. Ham. (voucher specimen no. GUH 17221), *Centella asiatica* L. (voucher specimen no. 17216) and *Gloriosa superba* L. (voucher specimen no. 17228) were found to be of rare and threatened category.** Most of the herb species were having the medicinal value. But these herbaceous species are common in the other areas adjacent to the project area. Keeping in view of their common presence in the periphery of the project area, the loss of these species from the submergence area is not very substantial. There was no species endemic to the project area. All these species reported here have their presence in other parts of Uttarakhand. Overall four species of climbers were present in the project area. Out of these, two were common and the two species of climbers are of the rare category. **The voucher specimens of *Dioscorea bulbifera* L (GUH 17225) and *Cissampelos pareira* L. (GUH**

17222) are deposited in the Garhwal University Herbarium. The details of the site of presence of these specimens along with the GPS readings are given in **Table 3.12**.

TABLE 3.12
INVENTORY OF ALL RET PLANT SPECIES AND THEIR VOUCHER SPECIMEN NUMBERS WITH GPS READINGS

S.N	Voucher Specimen no.	Botanical Name	Local Name	Status	GPS readings
		Shrubs			
1.	GUH 17220	*Berberis aristata* (DC)	Kingor	Rare	Lat: 30^{0}40' 82.4" N Long: 79^{0}38' 63.0" E, Altitude :1042 m above m.s.l.
		Herbs			
1.	GUH 17221	*Asparagus adscendens* (Buch. Ham)	Jhirni	Rare	Lat: 30^{0}40' 29.8" N , Long: 79^{0}31' 80.9" E, Altitude :892 m above m.s.l.
2.	GUH 17216	*Centella asiatica* (L.)	Brahmi buti	Rare	Lat: 30^{0}40' 29.8" N , Long: 79^{0}31' 80.9" E, Altitude :892 m above m.s.l.
3.	GUH 17228	*Gloriosa superba* (L.)	Kalihari	Rare	Lat: 30^{0}40' 82.4" N Long: 79^{0}38' 63.0" E, Altitude: 1042 m above m.s.l. Lat: 30^{0}40' 29.8" N , Long: 79^{0}31' 80.9" E, Altitude : 892 m above m.s.l.
		Climbers			
1.	GUH 17225	*Dioscorea bulbifera* (L)	Genthi	Rare	Lat: 30^{0}40' 29.8" N , Long: 79^{0}31' 80.9" E, Altitude : 892 m above m.s.l.
2.	GUH 17222	*Cissampelos pareira* (L.)	Pahre	Rare	Lat: 30^{0}40' 29.8" N , Long: 79^{0}31' 80.9" E, Altitude : 892 m above m.s.l.

Wood Loss in the Project Area: The estimated wood loss (volume) due to the execution of Bowala-Nandprayag HEP has been presented in **Table 3.13.** Overall, the wood loss in the project area is not of very high magnitude. However, a loss of wood (118.68 m^3. ha^{-1}) has been estimated for the submergence area (S_1). A substantive wood loss of 292.47m^3.ha^{-1}) has been estimated for the site S_2. However, a wood loss of 150.35 m^3 ha^{-1} at S_3, the site of outlet of tunnel and the site of power house was calculated. Overall, the affected area is very small; therefore, the net wood loss at this site will be very low.

TABLE 3.13
WOOD LOSS (m^3ha^{-1})

Site	Tree species	Wood loss (volume) $m^3. ha^{-1}$
S_1	*Pinus roxburghii*	**118.68**
S_2	*Pinus roxburghii*	257.24
	Delbergia sisoo	35.23
	Sub-total	**292.47**
S_3	*Pinus roxburghii*	**150.35**
	Grand Total	**561.50**

Terrestrial Fauna On the basis of enquiry from local inhabitants, personal survey and the survey of secondary data, it was revealed that 05 species of mammals, 10 species of birds and three species of reptiles were found to occur in the project area. However, two bird species Himalayan Dove (*Streptopelia orentalis*) and Cheer Pheasant (*Catreus wallichii*) were encountered during the ecological survey. Among reptiles, the common rock lizard (*Agama tuberculata*) was frequently seen in the area (**Annexure 3.6**).

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3.6.4 AQUATIC ECOLOGY

The aquatic analyses of Alaknanda river were conducted for one season only at all the three sampling sites (S_1, S_2 and S_3) during the month of September 2005. 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.

Periphyton and Phytoplankton: The Alaknanda river, a metarhithronic stretch of the river is represented by rapids and pools in the stretch of the project area. Dominance of periphyton were present in the rapids, while, phytoplankton were present in the pools. Periphyton were represented by 23 species of the family of Bacillariophyceae, Chlorophyceae and Myxophyceae. However, only 15 species of phytoplankton were represented by the family of Bacillariophyceae, Chlorophyceae and Myxophyceae. The data on frequency, density, abundance and diversity indices of periphyton dwelling in Alaknanda river have been presented in **Annexure 3.7** through **3.9**. The total density of periphyton ranged from 2,876 ind. m^{-2} to 2,964 ind. m^{-2}, which was dominated by the members of Bacillariophyceae. Diversity indices (Shannon-Weiner) of periphyton ranged from 3.944 to 3.995 indicating good quality of river water. It was maximum at S_3 and minimum at S_1.

The data on frequency, density, abundance and diversity index (Shannon-Weiner) of phytoplankton of the river Alaknanda have been presented in **Annexure 3.10-3.12**. The population of phytoplankton fluctuated from 148-165.6 ind. l^{-1} at the sampling sites. The diversity indices of phytoplankton ranged from 2.842–2.886 showing a moderate diversity of phytoplankton.

Zooplankton: Zooplankton population in the metarhithronic stretch of Alaknanda river was very low (Table **Annexure 3.13** to **Annexure 3.15**). Only 6 species of zooplankton were found to occur in the river. Density of zooplankton was present in the range of 28.8 – 36.0 ind. l^{-1}. The diversity index was in the range of 1.797 –1.865 at all the sites. It indicates the poor diversity of zooplankton in the Alaknanda river.

Macrozoobenthos: Macrozoobenthos of the Alaknanda river were represented by the species of Ephemeropterans (09), Trichopterans (03), Dipterans (02) and Coleopterns (01).

Ephemeropterans contribution was highest to the total macrozoobenthos. The density of macrozoobenthos was present in the range of 1,512 – 1,784 ind. m^{-2}. A maximum density of macrozoobenthos was observed at S_3. The diversity index of macrozoobenthos ranged from 3.805 to 3.891 in the stretch of the Alaknanda river of the project area (**Annexure 3.16-3.18**). It confirms the rich diversity of aquatic insects and good environmental quality of aquatic ecosystem of Alaknanda.

Primary Production: Primary production of Alaknanda river 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 **Annexure 3.19** to **Annexure 3.20**. 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 September 2005 was 12 hours.

The gross primary productivity (P_g) was in the range from 0.637 to 0.661 g C m^{-3} hr^{-1}. The net primary productivity (P_n) of the river Alaknanda was estimated to be in the range from 0.038 to 0.048 g C m^{-3} hr^{-1}. The monthly (September 2005) gross primary productivity (P_g) ranged from 229.382 to 237.828 g C m^{-3} $month^{-1}$. However, the net primary productivity (P_n) was recorded in range from 13.513 to 17.229 g C m^{-3} $month^{-1}$.

Trophic Status of Alaknanda river: The P/R ratio of Alaknanda river was estimated to be in the range from 1.060 to 1.079. 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 (1.079) is the clear indication of better trophic status present at the sampling site S_3.

Aquatic Macrophytes: Only a few aquatic macrophytes were recorded along the bank of the river Alaknanda. These macrophytes were identified as *Equisetum spp., Adiantum* and *Selaginella spp.* Aquatic macrophytes were present in the wet area of riparian zone of the Alaknanda river.

Fish: Experimental fishing was undertaken in the Project area at all the sampling sites. Most of the individuals caught under the experimental fishery were of Snow trout, *Schizothorax richardsonii*. Snow trout contributes more than 65% of the total fish catch in the area. On the basis of enquiry from the local fishermen and published literature, 15 fish species were found to occur in the Alaknanda river in the stretch of Bowala-Nandprayag HEP. An inventory of fish species along with their local names has been given in **Annexure 3.21**. Photographs of the ecological study is shown in **Figure 3.13- Figure 3.18.**

Fig. 3.13 Laying of quadrate for herbaceous components at S_1

Fig. 3.14 Aquatic ecological analysis at sampling site S_1

Fig. 3.15. Laying of quadrates at S_2

Fig. 3.16 Measurement of DBH of a pine tree

Fig. 3.17 Experimental fishing in the area

Fig. 3.18 Experimental fish catch from the area

Fig. 3.19 Aquatic ecological analysis at sampling site S3

Fig. 3.20.Measurement of diameter of herbs in the project area

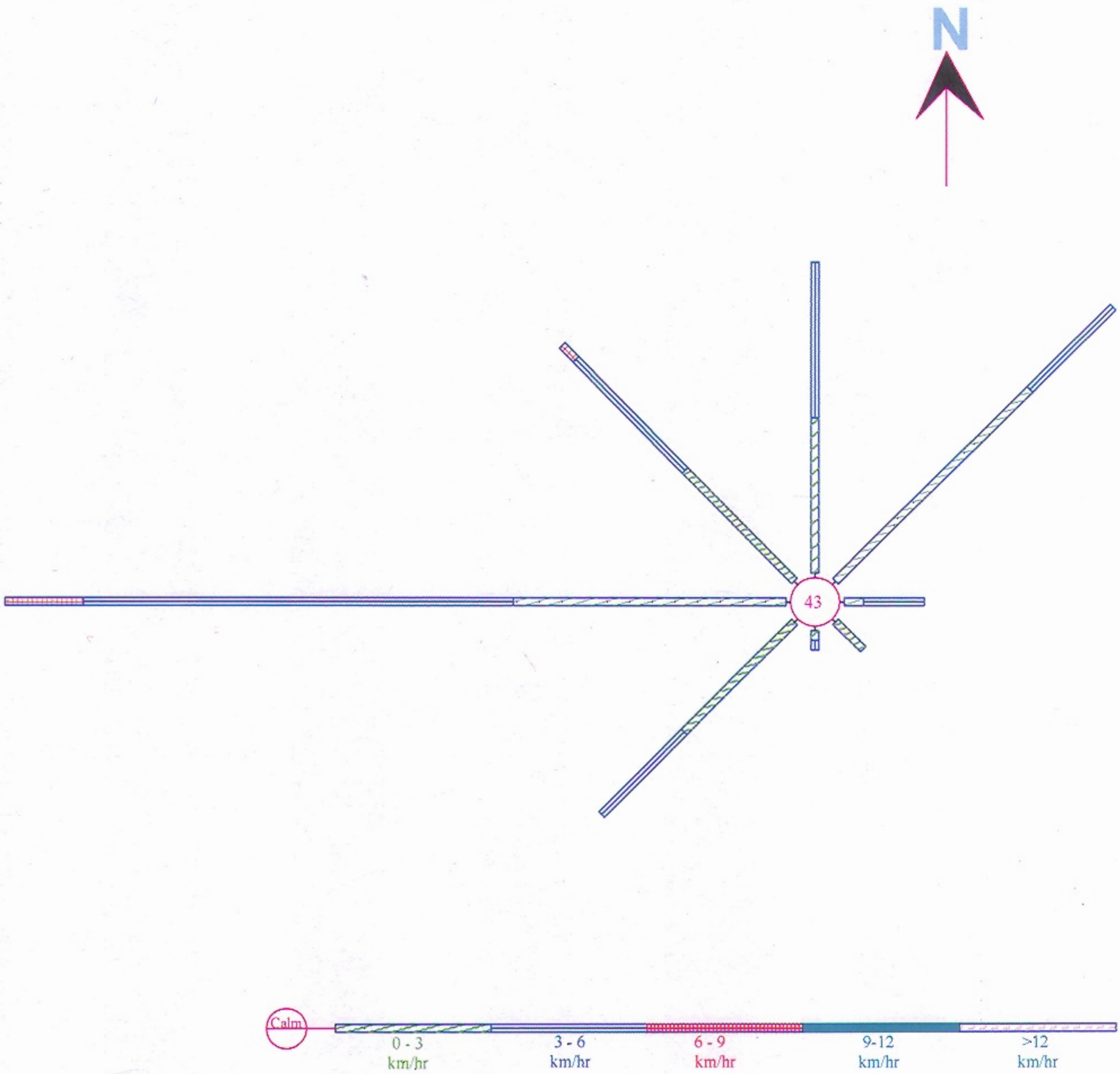
Annexure 3.1

Wind Rose Diagrams

ANNEXURE 3.1

FIGURE NO. 1

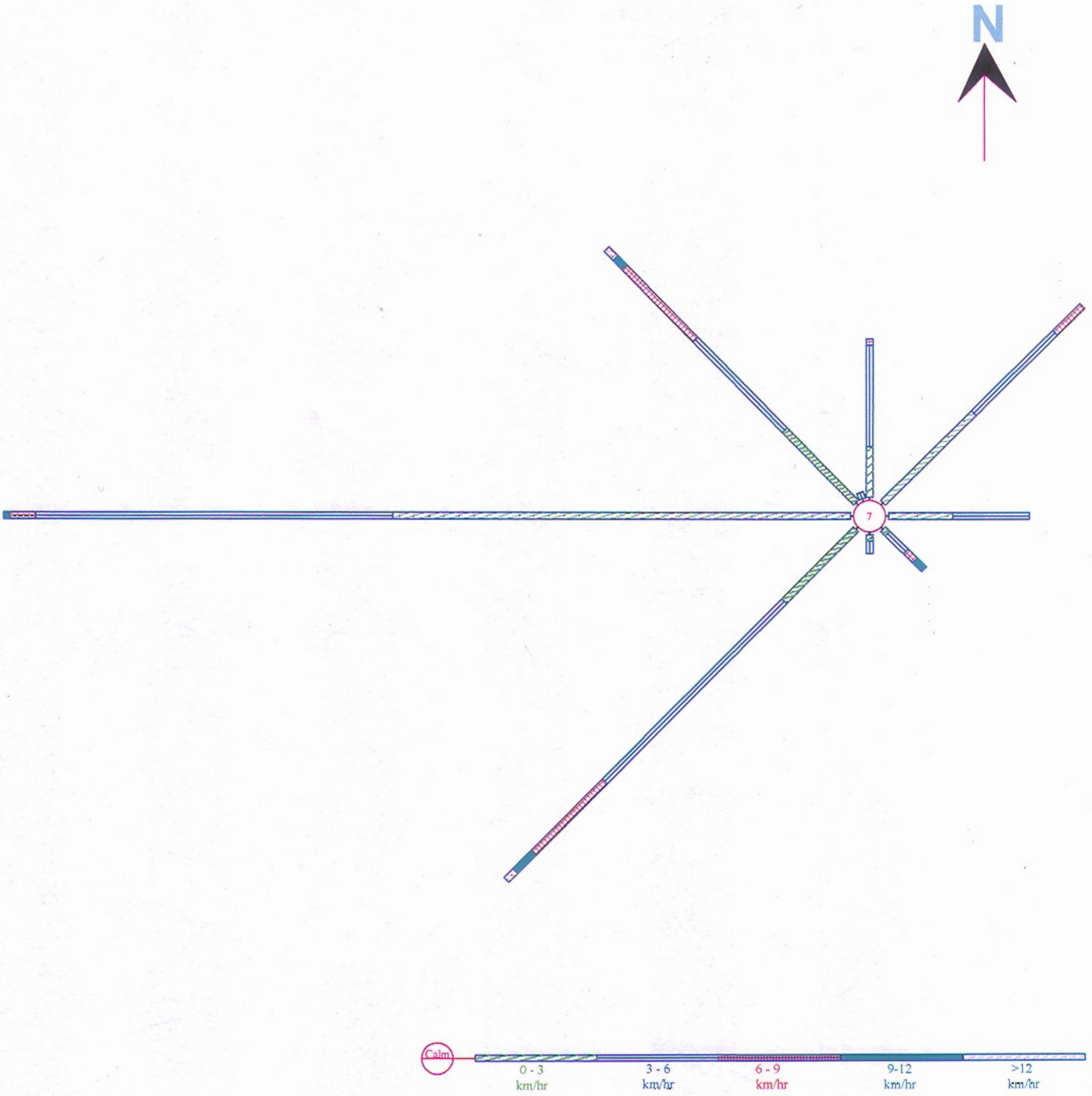
ANNUAL : - 8.30 Hrs.



ANNEXURE 3.1

FIGURE NO. 2

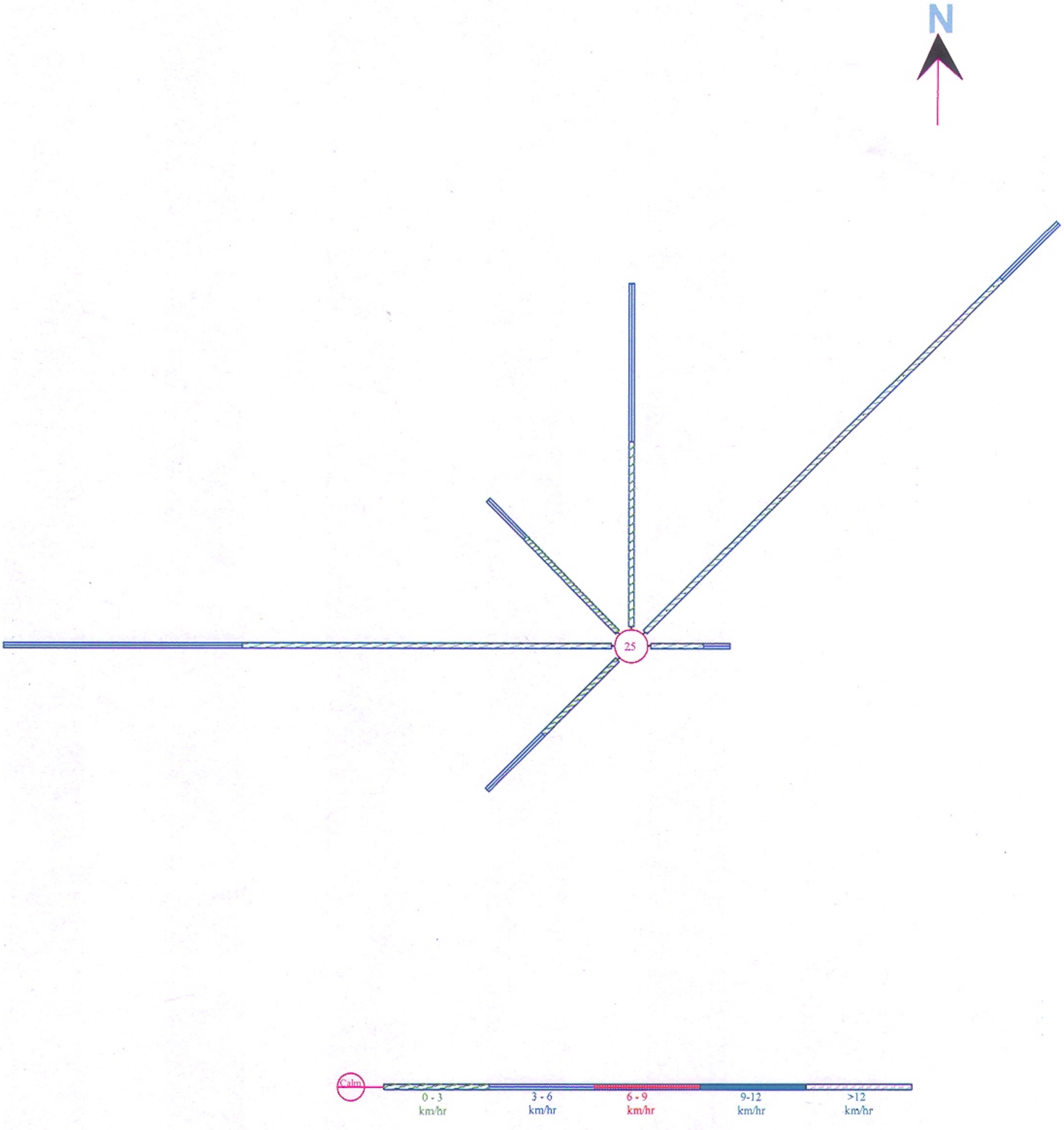
ANNUAL : - 17.30 Hrs.



ANNEXURE 3.1

FIGURE NO. 3

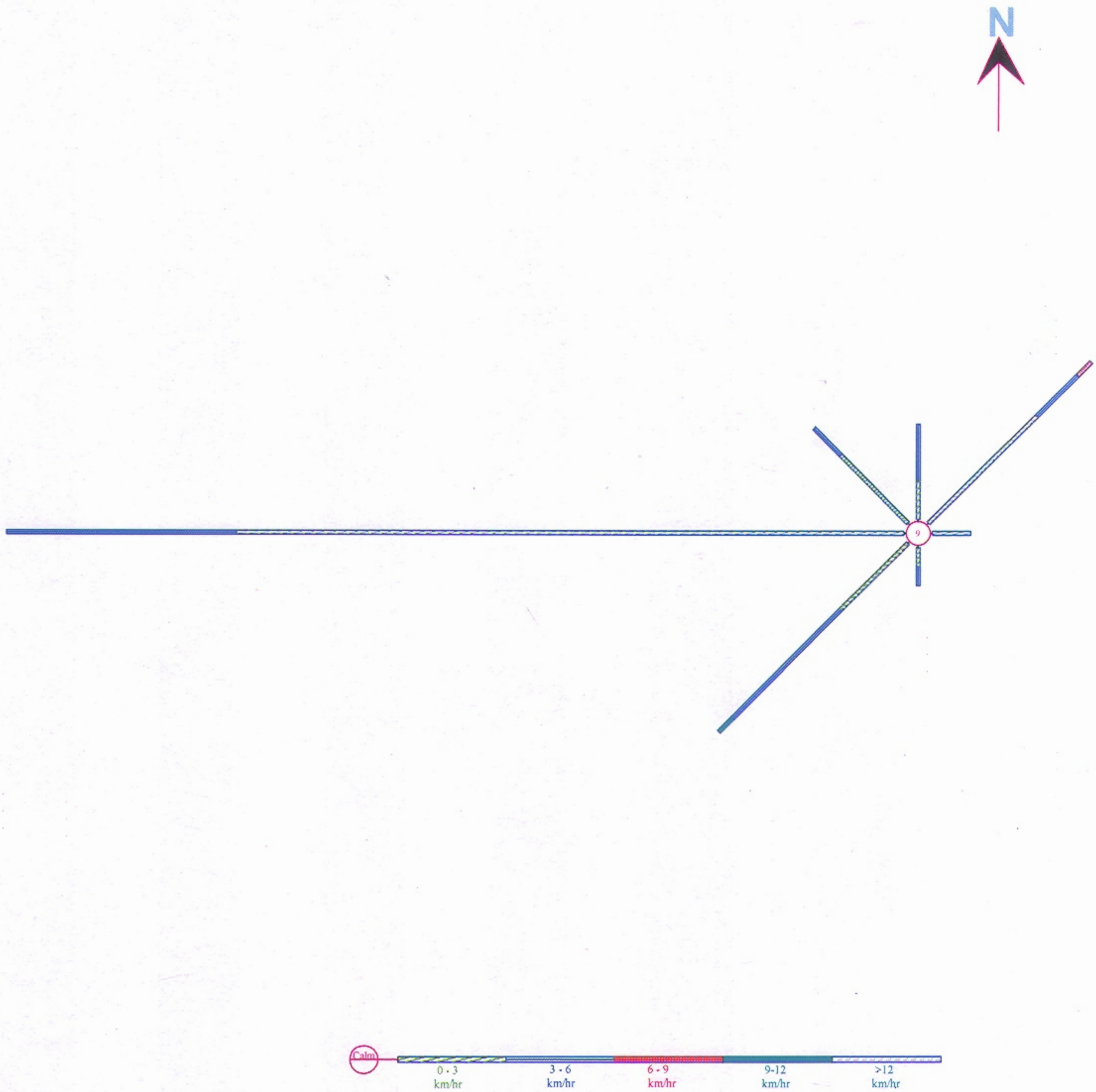
WINTER : - 8.30 Hrs.



ANNEXURE 3.1

FIGURE NO. 4

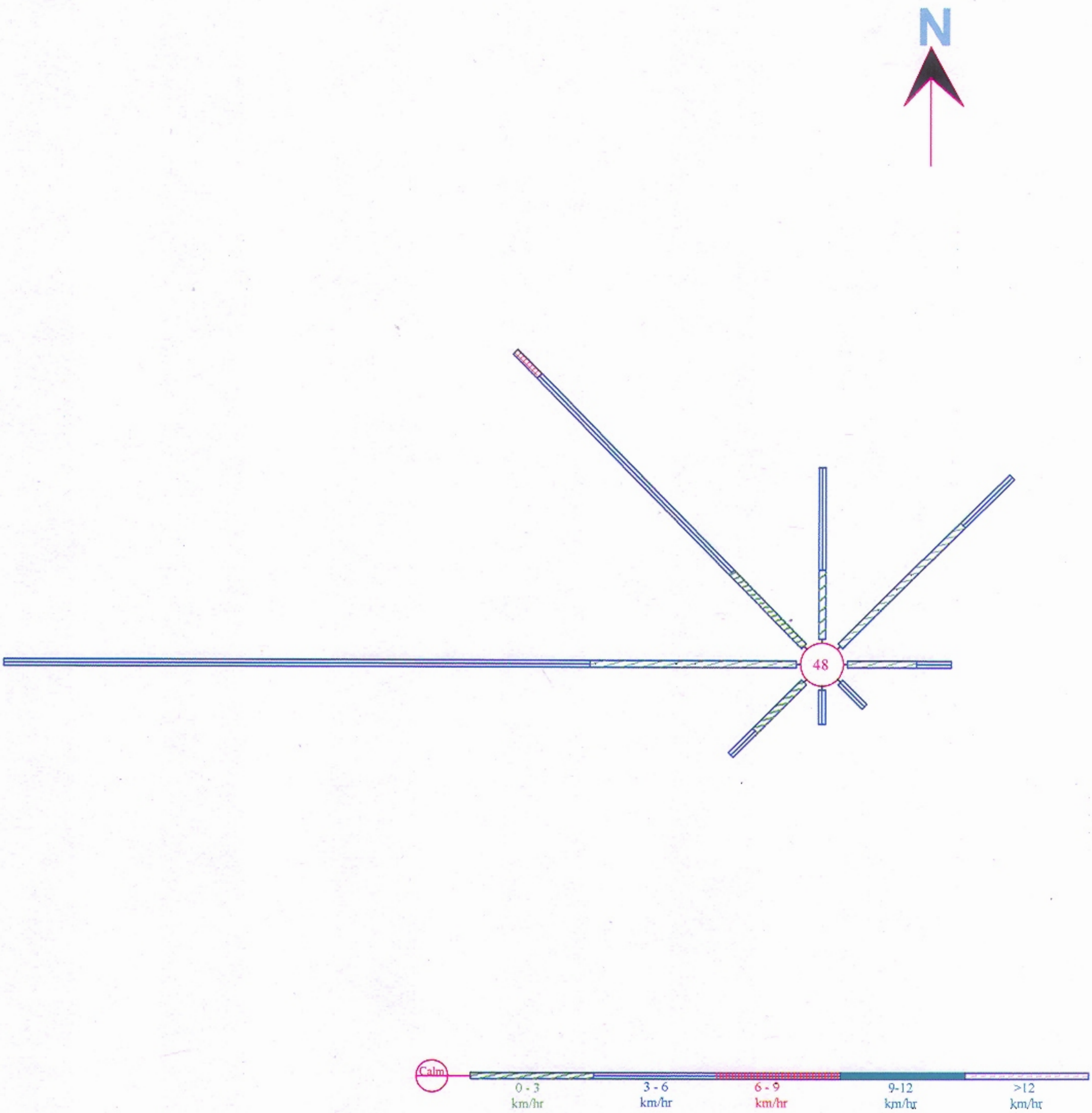
WINTER : - 17.30 Hrs.



ANNEXURE 3.1

FIGURE NO. 5

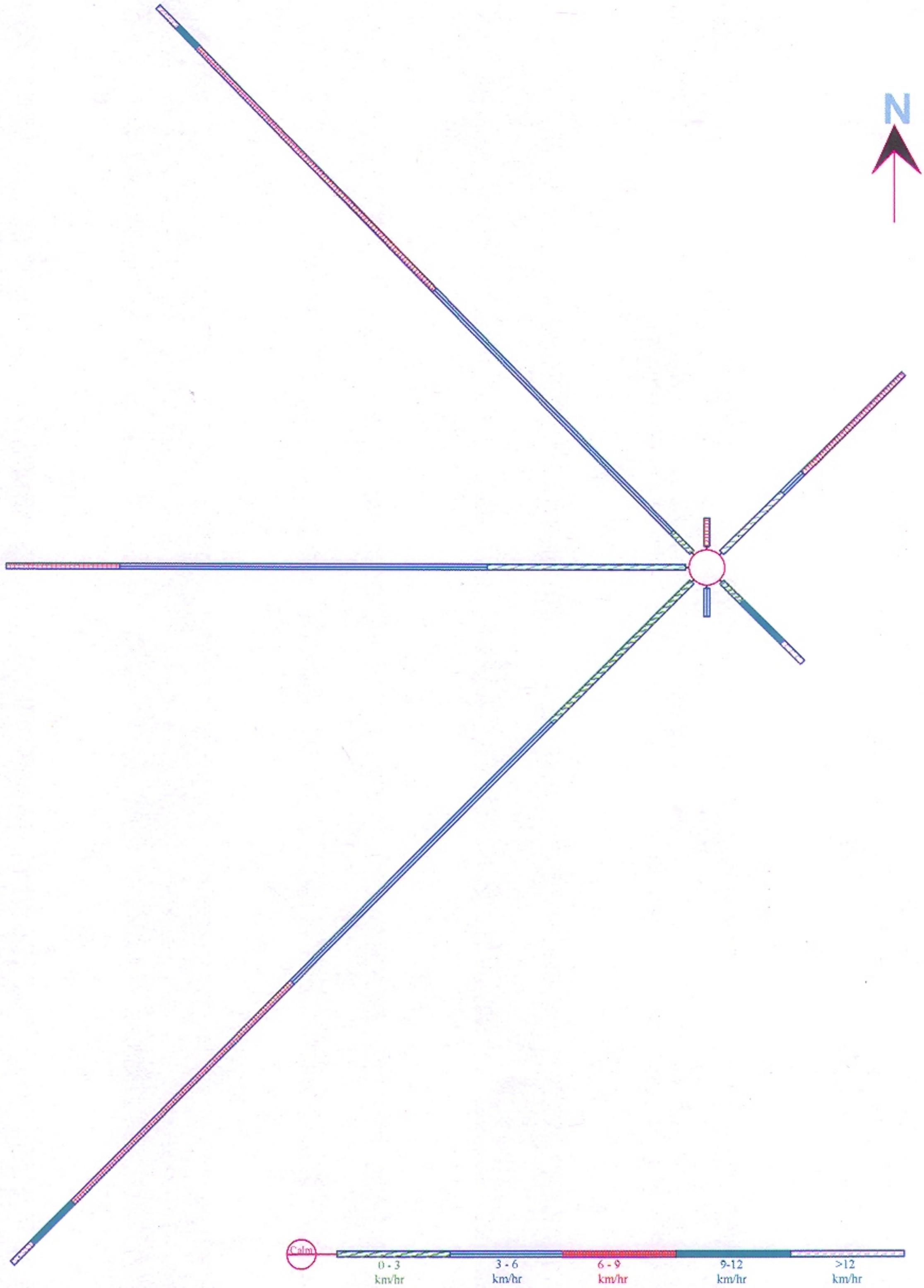
SPRING : - 8.30 Hrs.



ANNEXURE 3.1

FIGURE NO. 6

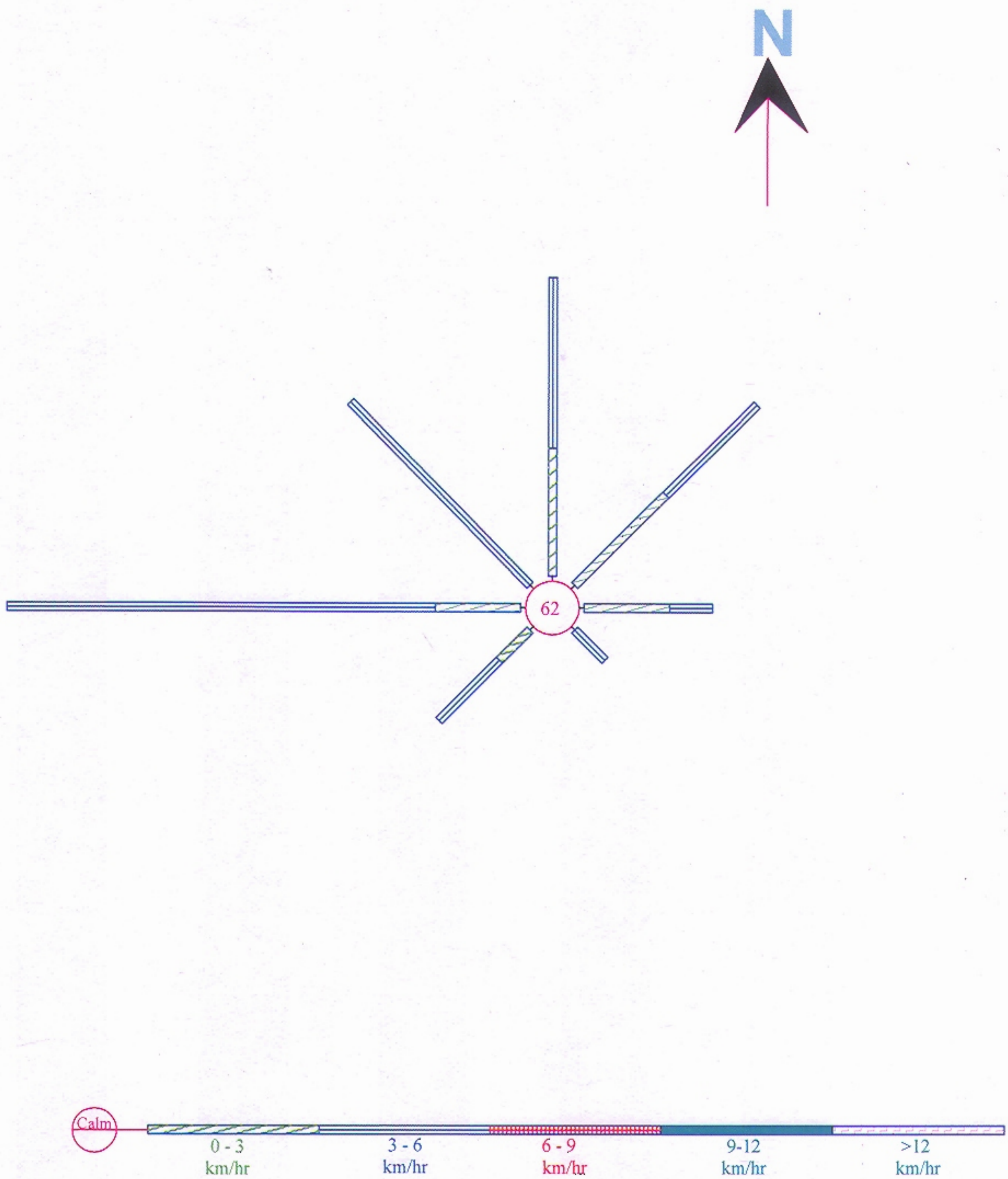
SPRING : - 17.30 Hrs.



ANNEXURE 3.1

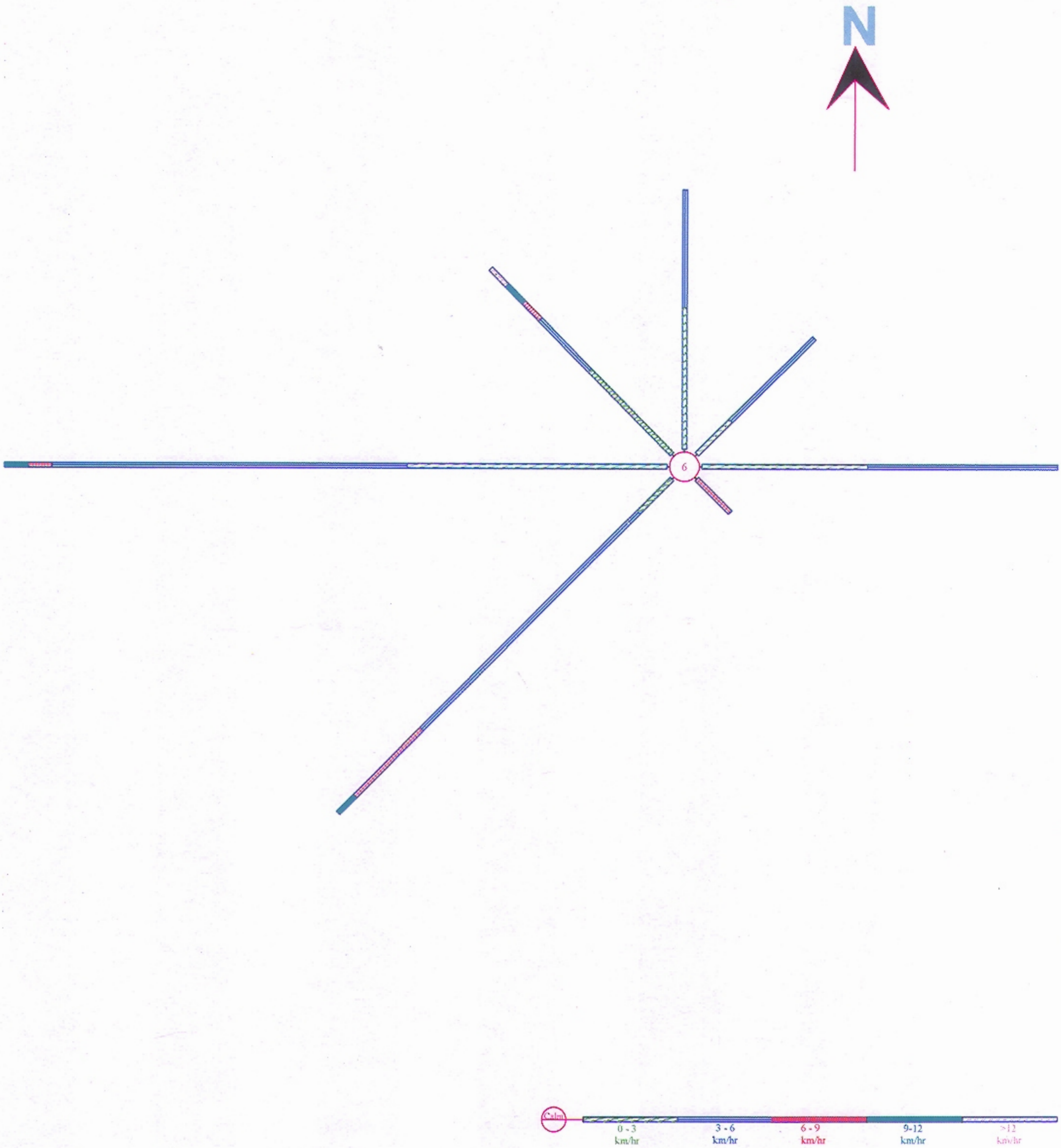
FIGURE NO. 7

SUMMER : - 8.30 Hrs.



ANNEXURE 3.1

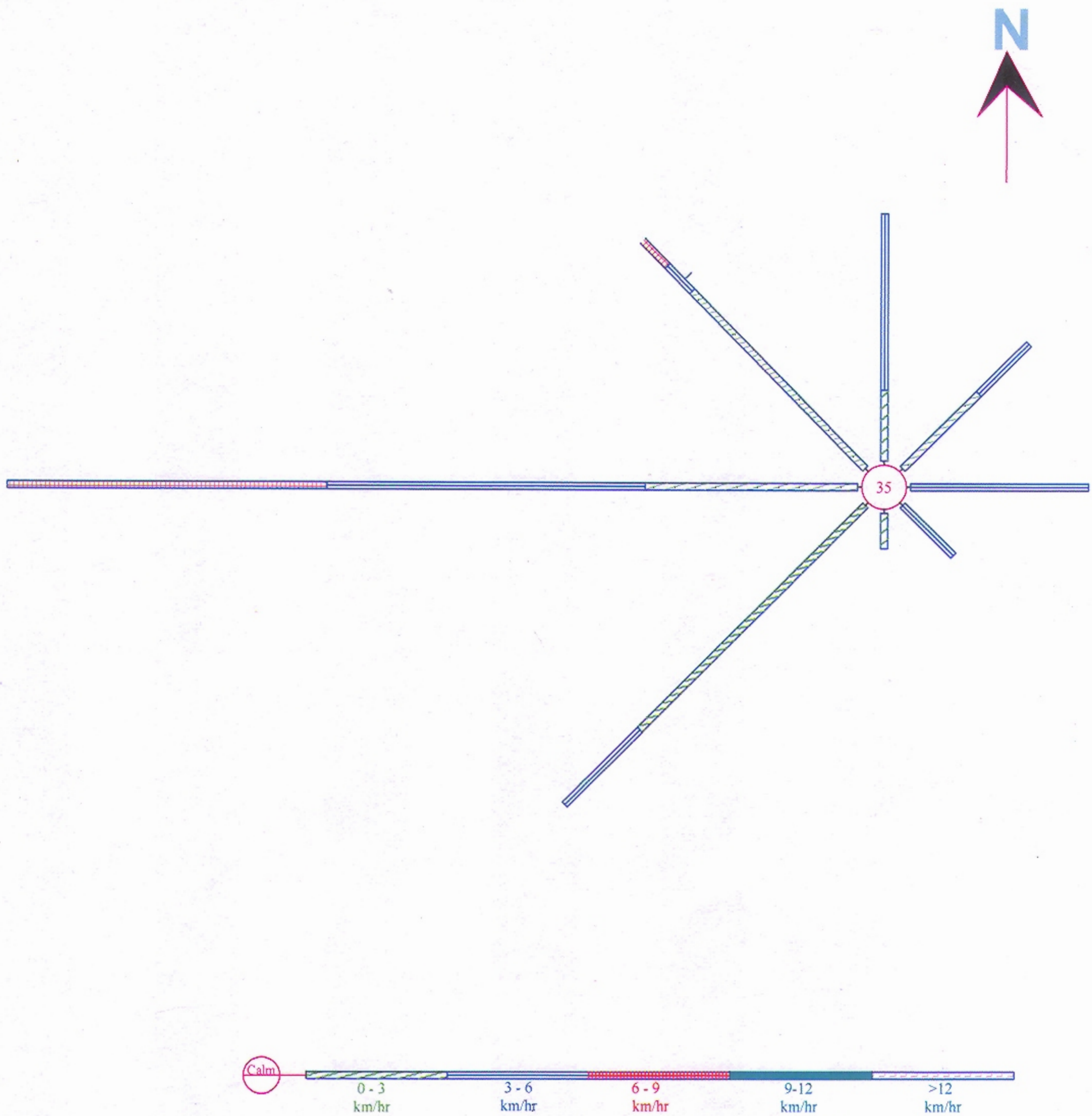
FIGURE NO. 8
SUMMER : - 17.30 Hrs.



ANNEXURE 3.1

FIGURE NO. 9

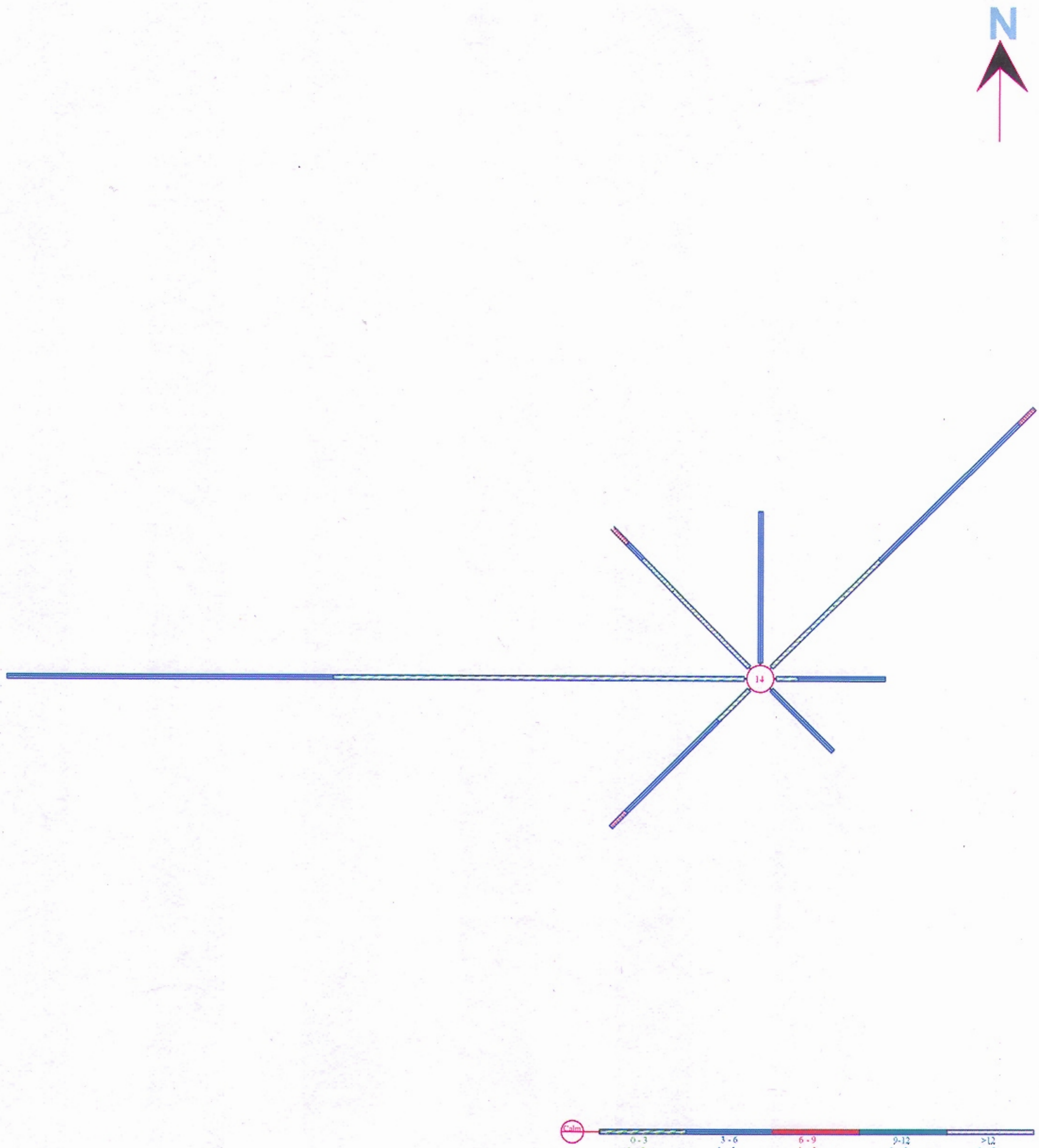
AUTUMN : - 8.30 Hrs.



ANNEXURE 3.1

FIGURE NO. 10

AUTUMN : - 17.30 Hrs.



Annexure 3.2-3.21

Results of Ecological Study

ANNEXURE-3.2
Plant diversity in the area

S. No.	Botanical Name	Local name	Status	Economic importance
	Tree species			
1.	*Albizia lebbeck (*Durazzini)	Siris	Common	Timber
2.	*Alnus nepalensis* (D. Don)	Utees	Common	
3.	***Bombax ceiba*** L.	Semal	Common	Edible, medicinal, wood
4.	*Bauhinia variegatan* (L.)	Kwiriyal	Common	Fodder
5.	*Betula alnoides* (Buch.-Ham)	Saur	Common	Fodder
6.	*Catnuaregam spinosa* (Thunb.)	Maindul	Common	medicinal
7.	*Celtis australis* (L.)	Kharik	Common	Fodder, Bark yields yellow dye
8.	*Cinnamomum tamala (*Buch.-Ham.)	Dalchini, Tejpat	Common	Bark and leaves used for flavouring food
9.	*Cupressus torulosa*	Surai	Common	Timber
10.	*Delbergia sericea (* G. Don)	Bhanir	Common	Fodder and to check soil erosion
11.	*Embelica officinalis (*Gaertner)	Aonla	Common	Fruits eaten raw or pickled, regarded as sacred tree
12.	*Erythrina suberosa* (Roxb.)	Mandar	Common	Soft wood used for minor articles
13.	*Ficus auriculata* (Lour.)	Timla	Common	Fodder, leaves made to cup and plates, fruit edible
14.	*Ficus palmata* (Forsk)	Bedu	Common	Leaves and twigs fodder, Fruits medicinal for digestive disorders
15.	*Ficus semicordata* (Buch.-Ham)	Khaina	Common	Fodder, fiber from bark, fruits edible
16.	*Grevillea robusta (*Cunningham.)	Silver oak	Common	Wood used for cabinet work
17.	*Holoptelea integrifolia* (Roxb.)	Papri	Common	Wood used for construction, charcoal and fuel
18.	*Lannea coromandelica* (Houttuyn)	Ghingaru		Wood for agricultural implements, gum and bark medicinal
19.	*Madhuca longifolia* (Koenig)	Mahuwa	Common	Flowers and fruits edible
20.	*Mallotus philippensis* (Lam.)	Ruins	Common	Red dye obtained from fruits also medicinal
21.	*Melia azedarach* (L.)	Dainkan, Bakain	Common	Leaves, fruits and seeds are useful in skin diseases
22.	*Phoenix humilis* (Royle.)	Khajoor	Common	Leaves used making rough fiber, fruits edible
23.	*Pinus roxburghii* (Sargent)	Chir	Common	Wood used for construction, resin for varnishes and paints
24.	*Sapium insigne (*Royle)	Khinna	Common	Leaves and branches used for intoxicating fishes
25.	*Syzygium cumini* (L.)	Jamun	Common	Fruits edible
26.	*Toona ciliate* (Roemer)	Tun	Common	Timber
27.	*Toona serrata* (Royle)	Dalla	Common	Timber
	Shrubs			
1.	*Agave cantula* (Roxb.)	Rambans	Common	Fiber and biological fence
2.	*Artemisia nilagirica* (C.B. Clark)	Kunjaa	Common	Medicinal
3.	***Artemisia scoparia*** (Waldstein & Kitaibel)			
4.	*Artemisia vulgaris*	Kunjaa	Common	Medicinal

5.	*Berberis aristata* (DC)	Kingor	Rare	Medicinal
6.	*Berberris asiatica* (Roxb.)	Kingor		Medicinal
7.	*Blumia spp*		Common	
8.	*Boehmeria platyphylla* (D. Don)	Khagsa	Common	Fodder and fiber
9.	*Callicarpa macrophylla* (Vahl)	Daiya	Common	Fruits edible and medicinal
10.	*Callistemon lanceolatus* (Smith)	Bottle brush	Planted	Ornamental
11.	*Cannabis sativa* (L.)	Bangh	Common	Fiber, fuel and seeds as condiment
12.	*Carrissa spinarum* (L.)	Karaunda	Common	Fruits edible
13.	***Casearia tomentosa*** *(*Roxb.)	Chilla	Rare	Wood as fuel, leaves medicinal
14.	*Cassia occidentalis* (L.)	Taror	Common	Medicinal
15.	*Cassia tora* (L.)	Chakunda	Common	Medicinal
16.	*Colebrookia oppositifolia* (J.E. Smith)	Bindu	Common	
17.	*Cotoneaster bacillaris* (Wallich)	Ruins, Rensu	Common	Medicinal
18.	*Cynoglossum indicus* (L.)			
19.	*Datura stramonium* (L.)	Datura	Common	Medicinal
20.	*Dedonia viscosa*	Dedonia	Common	Ornamental
21.	*Desmodium cephalotes* (Roxb.)	Bhatiya	Common	
22.	*Eupatorium adenophorum* (Sprengel)	Bakura, Basu	Common	Weed
23.	*Lantana camara*	Kuri	Common	Weed
24.	*Nepeta erecta*	Upraya ghas	Common	Medicinal
25.	*Nepeta graciliflora* (Benth.)	Upraya ghas	Common	Medicinal
26.	*Opuntia vulgaris* (Miller)	Naghfani	Common	
27.	*Parthenium hysterophorus* (L.)	Gajar ghas	Common	Exotic weed, believed to cause skin allergies
28.	*Ricinus communis (*L.)	Arand	Common	Castor oil, medicinal
29.	*Rosa brunoii* (Lindley)	Kunja	Common	
30.	*Rubus ellipticus* (Smith)	Hinssar	Common	Medicinal, fruits edible
31.	*Rubus niveus* (Thunb.)	Hisalu	Common	Medicinal, fruits edible
32.	*Solanum surattense* (Burm. F.)	Berketali	Common	Medicinal
33.	*Urtica dioca* (L.)	Kandali	Common	Medicinal and fodder
34.	*Vitex nigundo* (L.)	Shiwali	Common	Medicinal
35.	*Woodfordia fruticosa* (L.)	Dhola	Common	Medicinal
36.	*Xanthium strumarium* (L.)	Gokhuriya	Common	Medicinal
37.	*Xeromphis spinosa* (Thunb.)		Common	Mediicnal
38.	*Zanthoxylum armatum* (DC)	Timroo		Medicinal, Sometimes kept in the house door to get rid of evils
39.	*Zizyphus jujuba* (L.)	Ber	Common	Fruit edible, wood
40.	*Zizyphus mouritiana* (Lam.)	Ber	Common	Fruits edible
	Herbs			
1.	*Ageratum conyzoides* (L.)	Basya	Common	Medicinal
2.	*Ajuga bracteosa* (Wallich)	Neelkanthi	Common	Medicinal
3.	*Alysicarpus spp.*		Common	Fodder
4.	*Anaphalis adanata* (Wallich)	Bugla	Common	Medicinal
5.	*Arabidopsis thaliana* (L.)		Common	
6.	*Arisaema flavum* (Forsk.)	Meen	Common	Medicinal
7.	*Arisaema intermedium* (Blume)	Meen	Common	Medicinal
8.	*Arisaema tortuosum* (Wallich)	Bag-mungri	Common	Medicinal
9.	*Artemisia capillaries* (Thunb.)	Jhiun	Common	Medicinal
10.	*Asparagus adscendens* (Buch. Ham)	Jhirni	Common	Young shoots as vegetable, Medicinal
11.	*Bidens pilosa* (L.)	Kumar	Common	Medicinal, fodder
12.	*Blumea spp.*		Common	
13.	*Callicarpa macrophylla* (Vahl)	Daiya	Common	Fruits edible, medicinal
14.	*Callistemon lanceolatus* (Smith)	Bottle brush	Common	Ornamental

15.	*Capsella bursa-pastoris* (L.)	Tuntkya, Botlya	Common	Medicinal
16.	*Cassia occidentalis* (L.)	Chakunda	Common	Medicinal
17.	*Cassia tora* (L.)	Chakunda	Common	Medicinal
18.	*Centella asiatica* (L.)	Brahmi buti	Rare	Medicinal
19.	*Desmodium cephalotes* (Roxb.)		Common	
20.	*Euphorbia prostata* (L.)	Dhudhi	Common	Medicinal
21.	*Euphorbia hirta* (L.)	Dhudhi	Common	Medicinal (bronchial infection)
22.	*Euphorbia prolifera* (Buch-Ham)		Common	
23.	*Gloriosa superba* (L.)	Kalihari	Rare	Medicinal
24.	*Gnaphalium spp*	Buglya, Buglu	Common	Medicinal
25.	*Heliotropium strigosum* (Willd.)	Chitifal, Safed – bhangra	Common	Medicinal (skin diseases)
26.	*Jatropha curcas* (L.)	Lankabel	Common	Medicinal, bio diesel
27.	*Leucas lanata* (Benth.)	Bis-kapra/Guma	Common	Medicinal
28.	*Ludwigia spp*		Common	
29.	*Malva purpurea*	Sonchali	Common	Medicinal
30.	*Micromeria spp*	Gorakhopan	Common	Medicinal
31.	*Nepeta ciliaris* (Wallich)		Common	Medicinal and Essential oil
32.	*Nepeta elliptica* (Royle)	Zoofa	Common	Medicinal
33.	*Nepeta erecta*		Common	
34.	***Ocimum canum*** (Sims)	Jangali tulsi		Flavouring agent
35.	*Phyllanthus virgatus* (Forster)	Bhiuavate	Common	Medicinal
36.	*Pilea scripta*	Chailu	Common	
37.	*Potentialla gerardiana* (Lindley)	Bajradanti	Common	Medicinal
38.	*Rumax hastatus* (D. Don)	Almoru	Common	Medicinal
39.	*Thalctrium javanicum* (Blume)	Kirmoli, mamri	Common	Medicinal
40.	***Tridax procumberns*** (L.)	Kumra	Common	Medicinal
41.	*Vervascum thapsus* (L.)	Geedar Tambaku	Common	Medicinal
		Climbers		
1.	*Dioscorea bulbifera* (L)	Genthi	Common	Tubers as vegetables, medicinal
2.	*Cissampelos pareira* (L.)	Pahre	Common	Medicinal
3.	*Cuscuta reflexa* (Roxb.)	Akash laguli	Common	Medicinal
4.	*Rubia manjith* (Roxb.)	Majethi	Common	Dye, medicinal
		Grasses		
1.	*Apluda mutica*	Tachhale	Common	Fodder
2.	*Cynodon dactylon*	Dub	Common	Fodder
3.	*Cyprus spp.*		Common	Fodder
4.	*Elusine spp.*		Common	Fodder
5.	*Poa spp*		Common	Fodder
		Pteridophytes		
1.	*Adiantum capillus- veneris*		Common	
2.	*Dryopteris wallichiana*		Common	
3.	*Pteris cretica*		Common	
		Bryophytes		
1.	*Marchantia*		Common	
2.	*Riccia pathankotensis*		Common	
3.	*Funaria sp.*		Common	
		Lichens		
1.	*Graphis sp.*		Common	
2.	*Parmelia sp*		Common	
3.	*Usnea indica*		Common	
		Fungi		
1.	*Agaricus* sp		Common	

ANNEXURE-3.3

Frequency, density, abundance, basal area and importance value index (IVI) of plant species at S_1 (GPS reading: Lat: $30^0$40' 82.4" N , Long: $79^0$38' 63.0" E, Altitude :1042 m above m.s.l.)

Plants	Frequency (%)	Density (ind.ha^{-1})	Abundance	Basal area (ha)	IVI	Diversity index (Shannon Weiner)
Trees						
Pinus roxbergii	76	216	2.84	12.95	235.87	0.300
Sapium insigne	48	68	1.42	0.194	64.13	0.494
Total		**2.84**	**4.26**	**13.148**	**300**	**0.794**
Shrubs						
Artimisia scorpia	68	640	2.35	0.716	24.69	0.249
Berberris asiatica	56	384	1.71	0.680	20.16	0.177
Blumia spp	92	1184	3.22	1.503	43.73	0.359
Colobrokia oppositifolia	72	896	3.11	0.480	24.49	0.307
Eupatorium adenophorum	96	2064	5.38	0.560	40.02	0.465
Nepeta graciflora	84	1072	3.19	0.320	25.58	0.340
Parthenium hysterophorus	100	2096	5.24	0.560	40.85	0.468
Rosa brunoii	60	544	2.27	1.000	26.57	0.224
Rubus ellipticus	76	560	1.84	0.840	26.62	0.229
Urtica dioca	72	848	2.94	0.720	27.28	0.297
Total		**10,288**	**31.25**	**7.379**	**300**	**3.114**
Herbs						
Ageratum conyzoides (L.)	68	26400	3.9	0.332	34.25	0.394
Alysicarpus spp.	60	24400	4.1	0.159	26.32	0.378
Arabidopsis thaliana (L.)	72	28400	3.9	0.332	35.84	0.408
Arisaema tortuosum	72	20000	2.8	0.173	26.17	0.340
Bidens pilosa (L.)	68	22000	3.2	0.246	29.10	0.358
Capsella bursa-pestoris	32	3600	1.1	0.246	14.54	0.108
Euphorbia spp.	48	12400	2.6	0.314	23.59	0.255
Gloriosa superba	72	10000	1.4	0.051	16.85	0.222
Gnaphalium spp	32	10800	3.4	0.146	14.92	0.234
Heliotropium strigosum	64	10400	1.6	0.325	25.13	0.228
Holotropium indicum	48	6400	1.3	0.148	14.91	0.164
Leucas lanata	44	6000	1.4	0.147	14.14	0.156
Phyllanthus spp	44	11200	2.5	0.368	24.24	0.239
Total		**1,92,000**				**3.483**

ANNEXURE-3.4

Frequency, density, abundance, basal area and importance value index of tree species at sampling site S_2 (GPS reading: Lat: $30^0$40' 78.6" N, Long: $79^0$38' 14.2" E, Altitude: 1032 m above m.s.l.)

Plants	Frequency (%)	Density (ind.ha^{-1})	Abundance	Basal area (ha)	IVI	Diversity index (Shannon Weinner)
Trees						
Pinus roxburghii	64	152	2.38	19.55	213.59	0.425
Delbergia sisoo	12	20	1.67	0.52	21.08	0.296
Sapium insigne	40	72	1.80	0.27	65.33	0.520
Total		**244**	**5.84**	**20.33**	**300**	**1.241**
Shrubs						
Artimisia spp.	68	640	2.35	0.52	26.37	0.272
Blumia spp	80	896	2.80	0.51	30.74	0.333
Colobrokia oppositifolia	80	1072	3.35	0.53	33.01	0.367
Cannabis sativa	72	464	1.61	0.06	16.05	0.221

Debregeasia salicifolia	64	592	2.31	0.46	24.16	0.259
Eupatorium adenophorum	92	2032	5.52	0.56	46.03	0.486
Parthenium hysterophorus	96	1840	4.79	0.56	44.42	0.469
Rosa brunoii	56	432	1.93	0.81	28.10	0.211
Rubus ellipticus	60	480	2.00	0.58	24.80	0.226
Urtica dioca	72	496	1.72	0.57	26.33	0.231
Total		**8944**	**28.39**	**5.15**	**300**	**3.076**
Herbs						
Ageratum conyzoides	68	22000	3.2	0.29	38.39	0.365
Alysicarpus spp.	60	30000	5.0	0.15	33.56	0.425
Arabidopsis thaliana (L.)	64	19200	3.0	0.32	37.96	0.339
Bidens pilosa (L.)	32	6400	2.0	0.17	17.74	0.168
Cassia tora	76	39200	5.2	0.12	39.66	0.474
Euphorbia chamaesyce (prostata)	48	16000	3.3	0.14	23.44	0.305
Euphorbia hirta	76	13200	1.7	0.06	21.93	0.271
Genephalis spp.	76	12400	1.6	0.12	25.22	0.261
Holotropium indicum	40	5600	1.4	0.12	15.94	0.152
Leucas lanata	44	11200	2.5	0.14	20.31	0.244
Ludwigia spp	64	104	1.6	0.19	25.86	0.233
Total		**1,75,304**				**3.236**

ANNEXURE-3.5

Frequency, density, abundance, basal area and importance value index (IVI) of tree species at sampling site S_3 (GPS reading: Lat: $30^0$40' 29.8" N , Long: $79^0$31' 80.9" E, Altitude :892 m above m.s.l.)

Plants	Frequency (%)	Density (ind.ha^{-1})	Abundance	Basal area (ha)	IVI	Diversity index (Shannon Weinner)
Trees						
Alnus nepalensis	44	72	1.64	0.39	48.15	0.168
Mallotus phillipinenses	52	76	1.46	0.37	53.49	0.175
Pinus roxbergii	48	92	1.92	14.80	147.57	0.199
Sapium insaigne	48	76	1.58	0.28	50.79	0.175
Total		**316**	**6.60**	**15.83**	**300**	**0.717**
Shrubs						
Berberris asiatica	64	560	2.19	0.79	33.27	0.270
Blumia spp	80	896	2.80	0.50	33.98	0.356
Carrissa spinarum	88	1120	3.18	0.45	37.08	0.399
Debregeasia salicifolia	60	544	2.27	0.46	25.63	0.265
Eupatorium adscendensce	80	1600	5.00	0.53	43.58	0.466
Parthenium hysterophorus	88	1584	4.50	0.49	43.75	0.464
Rosa brunoii	60	480	2.00	0.49	25.38	0.245
Rubus ellipticus	72	592	2.06	0.66	32.15	0.280

Urtica dioca	40	544	3.40	0.59	25.16	0.265
Total		**7,920**	**27.39**	**4.94**	**300**	**3.011**
Herbs						
Ageratum conyzoides	60	20400	3.4	0.29	42.28	0.378
Alysicarpus spp.	52	16400	3.2	0.15	28.95	0.336
Cassia tora	36	7200	2.0	0.17	21.92	0.201
Euphorbia prolifera	68	18000	2.6	0.21	37.04	0.354
Euphorbia hirta	72	29600	4.1	0.12	39.05	0.449
Genephalis spp.	48	16000	3.3	0.14	27.14	0.331
Gloriosa superba	76	16800	2.2	0.06	27.33	0.340
Holotropium indicum	80	18000	2.3	0.12	33.23	0.354
Malva purpuria	40	7200	1.8	0.12	19.50	0.201
Phyllanthus spp	44	11200	2.5	0.14	23.55	0.268
Total		**1,60,800**				**3.211**

ANNEXURE-3.6
Inventory of wild fauna

S. No.	Zoological Name	English Name	Local Name
		Mammals	
1.	*Panthera pardus*	Common Leopard	Bagh
2.	*Selenarctos thibetanus*	Himalayan black bear	Bhalu
3.	*Felis chaus*	Jungle Cat	Banbiralu
4.	*Naemorhaedus goral*	Goral	Ghuran
5.	*Rhesus macaca mulatta*	Monkey	Bandar
		Birds	
1.	*Alectoris chukar*	Chukar Partridge	Chakor
2.	*Arborophila torqueola*	Hill partridge	Teetar
3.	*Gyps himalayensis*	Vulture	Gidh
4.	*Strixfaluco nivicola*	Owl	Uloo
5.	*Nyctyornis athertoni*	Koel	Mauli
6.	*Crous maerorhynchos*	Crow	Kauwa
7.	*Streptopelia orientalis*	Himalayan Dove	Ghugti
8.	*Catreus walli chii*	Cheer Pheasant	Cheer Kukhdo
9.	*Sphenurus cepi cauda*	Wedge tailed green pigeon	Malyo
10.	*Colius indicus*	Mouse bird	Musfekra
		Reptiles	
1.	*Varanus bengalensis*	Common Indian Monitor Lizard	Gaulu
2.	*Agama tuberculata*	Common Rock lizard	Chhipkali
3.	*Ramphotyphlops braminus*	Common worm snake	Saanp

ANNEXURE-3.7
Frequency, density, abundance and diversity index (Shannon and Weiner) of periphyton in Alaknanda river at sampling site S_1 (1,028 m above m.s.l.)

Periphyton	Frequency (%)	Density (ind.m^{-2})	Abundance	Diversity index (Shannon Weiner)
Bacillariophyceae				
Tabellaria fenestris	100	368	3.680	0.380
Diatoma vulgaris	80	324	4.050	0.355
Meridion circulare	48	48	1.000	0.099
Fragilaria inflata	100	284	2.840	0.330
Synedra ulna	28	28	1.000	0.065
Nitzschia	80	256	3.200	0.311
Navicula radiosa	72	252	3.500	0.308
Cocconeis placentula	48	96	2.000	0.164
Cymbella cistula	100	360	3.600	0.375
Gomphonema	72	208	2.889	0.274
Cyclotella	40	72	1.800	0.133
Stauroneis	28	40	1.429	0.086
Ceratoneis arcus	40	88	2.200	0.154
Denticula	32	56	1.750	0.111
Gomphoneis	40	48	1.200	0.099
Astrionella	56	68	1.214	0.128
Chlorophyceae				
Closterium leibleinii	56	56	1.000	0.111
Zygnema	36	36	1.000	0.079
Ulothrix zonata	36	40	1.111	0.086
Spirogyra	68	68	1.000	0.128
Oedogonium	44	44	1.000	0.092
Oscillatoria tenuis	32	36	1.125	0.079
Total		**2,876**		**3.944**

ANNEXURE-3.8
Frequency, density, abundance and diversity index (Shannon and Weiner) of periphyton in Alaknanda river at sampling site S_2 (1,018 m above m.s.l.)

Periphyton	Frequency (%)	Density (ind.m^{-2})	Abundance	Diversity index (Shannon Weiner)
Bacillariophyceae				
Tabellaria fenestris	92	336	3.652	0.357
Diatoma vulgaris	76	272	3.579	0.317
Meridion circulare	44	48	1.091	0.097
Fragilaria inflata	92	308	3.348	0.341
Synedra ulna	36	44	1.222	0.091
Nitzschia	80	252	3.150	0.304
Navicula radiosa	100	344	3.440	0.362
Cocconeis placentula	44	52	1.182	0.103
Cymbella cistula	96	324	3.375	0.350
Gomphonema	100	288	2.880	0.328
Cyclotella	52	56	1.077	0.109
Stauroneis	68	76	1.118	0.136
Ceratoneis arcus	40	40	1.000	0.084
Denticula	36	52	1.444	0.103
Gomphoneis	36	40	1.111	0.084
Astrionella	52	52	1.000	0.103
Chlorophyceae				
Closterium leibleinii	40	44	1.100	0.091
Zygnema	36	40	1.111	0.084
Ulothrix zonata	60	64	1.067	0.120
Spirogyra	40	44	1.100	0.091
Oedogonium	36	48	1.333	0.097
Myxophyceae				
Phormidium	48	60	1.250	0.114
Oscillatoria tenuis	44	60	1.364	0.114
Total		**2,944**		**3.980**

ANNEXURE-3.9

Frequency, density, abundance and diversity index (Shannon and Weiner) of periphyton in Alaknanda river at sampling site S_3 (975 m above m.s.l.)

Periphyton	Frequency (%)	Density (ind.m^{-2})	Abundance	Diversity index (Shannon Weiner)
Bacillariophyceae				
Tabellaria fenestris	84	376	4.476	0.378
Diatoma vulgaris	76	196	2.579	0.259
Meridion circulare	52	64	1.231	0.119
Fragilaria inflata	96	252	2.625	0.302
Synedra ulna	40	48	1.200	0.096
Nitzschia	84	252	3.000	0.302
Navicula radiosa	96	388	4.042	0.384
Cocconeis placentula	40	52	1.300	0.102
Cymbella cistula	84	316	3.762	0.344
Gomphonema	80	280	3.500	0.322
Cyclotella	60	108	1.800	0.174
Stauroneis	48	92	1.917	0.155
Ceratoneis arcus	48	72	1.500	0.130
Denticula	32	36	1.125	0.077
Gomphoneis	28	36	1.286	0.077
Astrionella	32	36	1.125	0.077
Chlorophyceae				
Closterium leibleinii	44	80	1.818	0.141
Zygnema	56	76	1.357	0.136
Ulothrix zonata	28	40	1.429	0.084
Spirogyra	48	72	1.500	0.130
Oedogonium	24	36	1.500	0.077
Myxophyceae				
Phormidium	20	20	1.000	0.049
Oscillatoria tenuis	32	36	1.125	0.077
Total		**2,964**		**3.995**

ANNEXURE-3.10

Frequency, density, abundance and diversity index (Shannon and Weiner) of phytoplankton in Alaknanda river at sampling site S_1 (1,028 m above m.s.l)

Phytoplankton	Frequency (%)	Density (ind.l^{-1})	Abundance	Diversity index (Shannon Weiner)
Bacillariophyceae				
Tabellaria fenestris	76	34.4	2.263	0.489
Diatoma vulgaris	20	4	1.000	0.141
D. elongata	0	0	0.000	0.000
Fragilaria inflata	76	34.4	2.263	0.489
Nitzschia	32	8	1.250	0.228
Navicula radiosa	36	8.8	1.222	0.242
Cymbella cistula	76	38.4	2.526	0.505
Gyrosigma	12	2.4	1.000	0.096
Ceratoneis arcus	24	4.8	1.000	0.160
Achnanthes	16	3.2	1.000	0.120
Chlorophyceae				
Cosmarium	4	0.8	1.000	0.041
Ulothrix zonata	20	4	1.000	0.141
Spirogyra	16	3.2	1.000	0.120
Myxophyceae				
Oscillatoria tenuis	8	1.6	1.000	0.071
Total		**148**		**2.842**

ANNEXURE-3.11

Frequency, density, abundance and diversity index (Shannon and Weiner) of phytoplankton in Alaknanda river at sampling site S_2 (1,018 m above m.s.l.)

Phytoplankton	Frequency (%)	Density (ind.l^{-1})	Abundance	Diversity index (Shannon Weiner)
Bacillariophyceae				
Tabellaria fenestris	72	41.6	2.889	0.513
Diatoma vulgaris	20	4.8	1.200	0.159
D. elongata	8	1.6	1.000	0.070
Fragilaria inflata	64	32	2.500	0.475
Nitzschia	24	5.6	1.167	0.177
Navicula radiosa	64	23.2	1.813	0.416
Cymbella cistula	60	24.8	2.067	0.429
Gyrosigma	0	0	0.000	0.000
Ceratoneis arcus	20	4	1.000	0.139
Achnanthes	12	2.4	1.000	0.095
Denticula	8	1.6	1.000	0.070
Chlorophyceae				
Cosmarium	8	1.6	1.000	0.070
Ulothrix zonata	20	4	1.000	0.139
Spirogyra	16	3.2	1.000	0.118
Total		**150.4**		**2.869**

ANNEXURE-3.12

Frequency, density, abundance and diversity index (Shannon and Weiner) of phytoplankton in Alaknanda river at sampling site S_3 (975 m above m.s.l.)

Phytoplankton	Frequency (%)	Density (ind.l^{-1})	Abundance	Diversity index (Shannon Weiner)
Bacillariophyceae				
Tabellaria fenestris	64	35.2	2.750	0.475
Diatoma vulgaris	24	5.6	1.167	0.165
D. elongata	0	0	0.000	0.000
Fragilaria inflata	64	31.2	2.438	0.454
Nitzschia	24	4.8	1.000	0.148
Navicula radiosa	64	33.6	2.625	0.467
Cymbella cistula	72	32.8	2.278	0.463
Gyrosigma	16	4.8	1.500	0.148
Ceratoneis arcus	0	0	0.000	0.000
Achnanthes	20	5.6	1.400	0.165
Denticula	0	0	0.000	0.000
Chlorophyceae				
Cosmarium	28	5.6	1.000	0.165
Ulothrix zonata	16	3.2	1.000	0.110
Spirogyra	4	0.8	1.000	0.037
Myxophyceae				
Oscillatoria tenuis	12	2.4	1.000	0.089
Total		**165.6**		**2.886**

ANNEXURE-3.13

Frequency, density, abundance and diversity index (Shannon and Weiner) of zooplankton in Alaknanda river at sampling site S_1 (1,028 m above m.s.l.)

Zooplankton	Frequency (%)	Density (ind. l^{-1})	Abundance	Diversity index (Shannon Weiner)
Cladocerans				
Daphnia	36	11.2	1.556	0.530
Copepods				
Cyclops	12	2.4	1.000	0.299
Rotifers				
Keratella	4	0.8	1.000	0.144
Asplanchna	12	2.4	1.000	0.299
Trichocera	40	12	1.500	0.526
Total		**28.8**		**1.797**

ANNEXURE-3.14

Frequency, density, abundance and diversity index (Shannon and Weiner) of zooplankton in Alaknanda river at sampling site S_2 (1,018 above m.s.l.)

Zooplankton	**Frequency (%)**	**Density (ind. l^{-1})**	**Abundance**	**Diversity index (Shannon Weiner)**
Cladocerans				
Daphnia	16	3.2	1.000	0.342
Copepods				
Cyclops	8	1.6	1.000	0.224
Rotifers				
Keratella	40	12.8	1.600	0.525
Asplanchna	8	1.6	1.000	0.224
Trichocera	36	11.2	1.556	0.531
Total		**30.4**		**1.845**

ANNEXURE-3.15

Frequency, density, abundance and diversity index (Shannon and Weiner) of zooplankton in Alaknanda river at sampling site S_3 (975 m above m.s.l.)

Zooplankton	**Frequency (%)**	**Density (ind. l^{-1})**	**Abundance**	**Diversity index (Shannon Weiner)**
Cladocerans				
Daphnia	4	0.8	1.000	0.122
Ceriodaphnia	8	2.4	1.500	0.260
Copepods				
Cyclops	16	3.2	1.000	0.310
Rotifers				
Keratella	56	16	1.429	0.520
Asplanchna	4	0.8	1.000	0.122
Trichocera	44	12.8	1.455	0.530
Total		**36**		**1.865**

ANNEXURE-3.16

Frequency, density, abundance and diversity index (Shannon and Weiner) of benthos in Alaknanda river at sampling site S_1 (1,028 m above m.s.l)

Benthos	Frequency (%)	Density (ind.m^{-2})	Abundance	Diversity index (Shannon Weiner)
Ephemeroptera				
Heptagenia	72	176	2.444	0.361
Baetis niger	68	140	2.059	0.318
Caenis	64	88	1.375	0.239
B. rhodani	68	100	1.471	0.259
Sipholonurus	56	84	1.500	0.232
Centroptilum	48	64	1.333	0.193
Leptophlebia	56	80	1.429	0.224
Ephemerella notata	52	64	1.231	0.193
Cloeon	44	92	2.091	0.246
Trichoptera				
Brachycentrus	80	136	1.700	0.313
Hydropsyche	80	148	1.850	0.328
Glossosoma	76	136	1.789	0.313
Diptera				
Tendipes	60	96	1.600	0.253
Antocha saxicola	48	76	1.583	0.217
Coleoptera				
Amphizoa lecontei	28	32	1.143	0.118
Total		**1,512**		**3.805**

ANNEXURE-3.17

Frequency, density, abundance and diversity index (Shannon and Weiner) of benthos in Alaknanda river at sampling site S_2 (1,018 m above m.s.l.)

Benthos	Frequency (%)	Density (ind.m^{-2})	Abundance	Diversity index (Shannon Weiner)
Ephemeroptera				
Heptagenia	76	172	2.263	0.331
Baetis niger	68	104	1.529	0.244
Caenis	60	116	1.933	0.261
B. rhodani	64	124	1.938	0.272
Sipholonurus	72	124	1.722	0.272
Centroptilum	52	88	1.692	0.218
Leptophlebia	52	92	1.769	0.225
Ephemerella notata	44	108	2.455	0.250
Cloeon	52	108	2.077	0.250
Trichoptera				
Brachycentrus	64	120	1.875	0.267
Hydropsyche	68	116	1.706	0.261
Glossosoma	60	108	1.800	0.250
Diptera				
Tendipes	76	140	1.842	0.293
Antocha saxicola	52	104	2.000	0.244
Coleoptera				
Amphizoa lecontei	56	108	1.929	0.250
Total		**1,732**		**3.887**

ANNEXURE-3.18

Frequency, density, abundance and diversity index (Shannon and Weiner) of benthos in Alaknanda river at sampling site S_3 (975 m above m.s.l.)

Benthos	Frequency (%)	Density (ind.m^{-2})	Abundance	Diversity index (Shannon Weiner)
Ephemeroptera				
Heptagenia	60	160	2.667	0.312
Baetis niger	56	140	2.500	0.288
Caenis	60	108	1.800	0.245
B. rhodani	56	124	2.214	0.267
Sipholonurus	40	116	2.900	0.256
Centroptilum	52	120	2.308	0.262
Leptophlebia	60	128	2.133	0.273
Ephemerella notata	60	100	1.667	0.233
Cloeon	64	108	1.688	0.245
Trichoptera				
Brachycentrus	64	108	1.688	0.245
Hydropsyche	92	128	1.391	0.273
Glossosoma	84	132	1.571	0.278
Diptera				
Tendipes	68	116	1.706	0.256
Antocha saxicola	56	116	2.071	0.256
Coleoptera				
Amphizoa lecontei	40	80	2.000	0.201
Total		**1,784**		**3.891**

ANNEXURE-3.19

Gross primary productivity (P_g), respiration (R), net primary productivity (P_n) per hour and P/R ratio of aquatic periphyton and phytoplankton

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}	
S_1	1.321	0.661	7.267	1.246	0.623	6.854	0.075	0.038	0.413	1.060
S_2	1.274	0.637	7.009	1.199	0.600	6.596	0.075	0.038	0.413	1.063
S_3	1.304	0.652	7.174	1.209	0.604	6.648	0.096	0.048	0.526	1.079

ANNEXURE-3.20

Gross primary productivity (P_g), respiration (R), net primary productivity (P_n) per month and P/R ratio of aquatic periphyton

Sites	Gross primary productivity (P_g)			Respiration (R)			Net Primary Productivity (P_n)			P/R ratio
	Biomass (dry) g m^{-3} $month^{-1}$	Carbon value g C m^{-3} $month^{-1}$	Calories of energy K Cal m^{-3} $month^{-1}$	Biomass (dry) g m^{-3} $month^{-1}$	Carbon value g C m^{-3} $month^{-1}$	Calories of energy K Cal m^{-3} $month^{-1}$	Biomass (dry) g m^{-3} $month^{-1}$	Carbon value g C m^{-3} $month^{-1}$	Calories of energy K Cal m^{-3} $month^{-1}$	
S_1	475.656	237.828	2616.109	448.630	224.315	2467.466	27.026	13.513	148.643	1.060
S_2	458.765	229.382	2523.207	431.739	215.870	2374.565	27.026	13.513	148.643	1.063
S_3	469.575	234.788	2582.664	435.117	217.559	2393.145	34.458	17.229	189.519	1.079

ANNEXURE-3.21
Inventory of fish species.

S.No.	Zoological Name	Local Name
1.	*Schizothorax richardsonii* Gray	Maseen
2.	*Schizothorax plagiostomus* Heckel	Maseen
3.	*Schizothoraichthys progastus* McClelland	Chongu
4.	*Tor tor* Hamilton	Dansulu
5.	*Tor putitora* Hamilton	Dansulu
6.	*Crossocheilus latius* Hamilton	Sunhera
7.	*Garra gotyla gotyla* Gray	Gondal
8.	*Barilius bendelisis* Hamilton	Fulra
9.	*Barilius barna* Hamilton	Fulra
10.	*Barilius barila* Hamilton	Fulra
11.	*Barilius vagra* Hamilton	Fulra
12.	*Noemacheilus rupicola* McClelland	Gadiyal
13.	*Noemacheilus beavani* Gunther	Gadiyal
14.	*Glyptothorax pectinopterus* Day	Nau
15.	*Pseudocheneis sulcatus* McClelland	Mungria Nau

Chapter –4

Socio Economic Assessment And Rehabilitation and Resettlement Plan

CHAPTER – 4

SOCIAL ECONOMIC ASSESSMENT AND REHABILITATION & RESETTLEMENT PLAN

4.1 GENERAL

The proposed Bowala-Nandprayag Hydro Electric Power project is proposed to develop under the public sector company (UJVNL) of Uttrakhand state. It shall involve construction activities for various components of the project like barrage, silting chambers, headrace and tailrace tunnels, powerhouse, project-township and offices, and other infrastructure works. These activities shall necessitate acquisition of about 81.004 ha land, out of which 9.604 ha private agricultural land, 10.43 ha is forest land, 11.06 ha underground land, 27.92 ha is Van Panchayat land and the rest 21.99 ha is Civil Forest Land. It is also observed that the project does not require acquisition of any built-up or homestead land.

Expropriation of lands from current owners/users (private owners) may lead to some extent of loss of livelihood and economic loss for the project-affected families/people (PAFs / PAPs). This land acquisition needs to be handled with utmost care and fore thought for issues relating to Resettlement and Rehabilitation of Project Affected Families. Such approach is important and more sensitive since the project area is in remote, where all categories of social groups of the society are concerned i.e. Scheduled Castes, Scheduled Tribes, Other Backward Castes and General Castes categories. In addition, the PAPs also include vulnerable population of society such as marginal farmers, widows and women. For successful implementation of the project, it is necessary to cultivate a productive and amicable relationship between the project offices and the affected families.

Besides the land acquisition, the construction activities shall also mobilize construction agencies together with their staffs in the area, which may change present economic activities within the area of impact of the project. The demographic changes during the construction period would also stress temporarily the local people and the local environment. After construction, finally the operational staffs shall settle down in the area to operate the project. In brief the project during construction as well as during operational period shall have a lasting impact over the demography and socio-economic structure of the project area. It shall bring positive and quantitative changes in the habitat after commencing, but shall raise some stress during construction. The negative impacts due to the project have raised voices of concern by public representatives at various levels / platforms.

While implementing the project, there is a need to take into account these disturbances and losses due to the project, their impact on socio-economic condition of the PAPs and plan for their mitigation measures to minimize any negative impacts. Governed by the consideration, an effort has been made, in this chapter, to understand the socio-economic condition of the project area (Chamoli) in general, and that of the project affected people in specific through a well-designed sample survey and field studies by the RITES experts. The opinion of project affected people/different stakeholders through consultations / discussions were collected and based on the collected information, the impacts of the project on the region and people are analyzed. Finally a Resettlement and Rehabilitation Plan is prepared to minimize the stress of PAPs in post project phase.

The assessment of the project area has been evaluated. A profile of chamoli district has been given to know the demographic and socio-economic status of the region at large. The district has been compared with other parts of the state. It would be followed by the profiles of the affected villages with the assessments of the Project Affected People.

4.2 PROFILE OF CHAMOLI DISTRICT

In order to place the project-affected people / villages in the right perspective, it was considered appropriate to take up in brief an overview of the demographic and socio-economic characteristics of the Chamoli district of Uttaranchal in which the project site is located. It is also appropriate to consider the broad characteristics of the affected villages by taking up a detailed consideration of the households. Thus, it may be possible to understand the way in which the wider socio-economic and cultural context of the region is compared with the project-affected people. Chamoli district has important place in the state as is known for its religiously important places and water resources. A general description of the district explaining its socio-economic conditions, population, natural resources and infrastructures have been given below.

4.2.1 Administrative Structure

On 9th November 2000, Uttranakhand carved out from the state of Uttar Pradesh and became as 27th independent state of the Republic of India. It is one of the most beautiful, well preserved and enchanting regions located in the northern part of India. The state comprises 13 districts of the erstwhile Uttar Pradesh, 49 tehsils, 95 blocks and 16,414 villages. The state of Uttranachal is spread over an area of 53,483 sq. kms and the population 8489349 (Census 2001). The state has 20th rank in terms of population size and 18th in terms of area. The population density per kilometer is 159, which is less than ¼ of population density of Uttar Pradesh (689). The state is 11th most sparsely populated state in the country. The density increased from 133 to 159 and sex ratio improved from 936 to 964 however decadal (1991-2001) growth rate of population came down from 24.23 to 19.20.

4.2.2 Location and Area

Chamoli district lies between 30.0^0 to 31^0 North latitude and 79^0 and 80^0 East longitude. It is in the north-west corner of the state, the area being 7691 sq. kms. in the rugged terrain of the mystic Himalayas. On its north lie Tibet, while on its south touch the districts of Garhwal, Almora and Bageshwar. District of Bageshwar and Pithoragarh bound it in the east and the territory of districts of Uttarkashi and the Rudraprayag in the west.

Since the project site comes under Chamoli tehsil of Chamoli district, the demographic profile of the tehsil and district and the state has been given in the **Table- 4.1** to know the comparative demography of the region.

TABLE 4.1
DEMOGRAPHIC AND SOCIO-ECONOMIC CHARACTERISTICS OF CHAMOLI TEHSIL, CHAMOLI DISTRICT AND UTTRANACHAL

S. NO.	CHARACTERISTICS	CHAMOLI TEHSIL	CHAMOLI DISTRICT	UTTARANCHAL
1	Total Area (in sq. km)	1442	7691	53483
2	No. of Households	19239	76121	1603242
3	Total Population	91993	370359	8489349 (rural-6310275 & urban-2179074)
3.1	Male	46826	183745	4325924
3.2	Female	45167	186614	4163425
4	SC Population	19886	67539	1517186
4.1	SC Male	10244	33991	780772
4.2	SC Female	9642	33548	736414
5	ST Population	3691	10484	256129
5.1	ST Male	1756	5083	131334
5.2	ST Female	1935	5401	124795
6	Sex Ratio (No. females per 1000 males)	965	1016	962

4.2.3 Population

According to 2001 census, total population of the Chamoli district is 3,70,359, comprising of 1,83,745 males and 1,86,614 females. Rural population of the district is 3,19,656 (1,54,197 males and 1,65,459 females) and urban population is 50,703 (29,548 males and 21,155 females). The decennial growth rate of population of the district has been 13.51 % during the period 1991-2001. The Scheduled Castes and Scheduled Tribes population of the district as per 2001 Census is 67,539 and 10,484 respectively. People from all religions namely Hindu, Muslim, Christian, Sikh, Buddhist, and Jain live in the district.

4.2.4 Agriculture and Irrigation

Kharif and Rabi are the two main crops of the district. Paddy, small millets and potato are the main kharif crops and wheat and barley are the main rabi crops. Almost 80% of cropped area is claimed by these crops. Paddy is one of the most important Kharif food crops in the district. Kharif is sown in June or little earlier in the hills and reaped in September and October and the Rabi sown in October-November and reaped in March in the plains and in April and May in the hills. The terraces made on sloping hill sides are the main fields of cultivation. The steep hills do not lend themselves to terracing and are used for shifting cultivation after burning the scrubs and bushes. Hoe is the main instrument for rowing. People say that the yield of potato for a hectare of land could be doubled by adopting the package of improved agricultural practices suitable to the terrain. The improved seed is to be increased. The increase is expected with the use of fertilizers.

4.2.5 Animal Husbandry and Livestock

Animal husbandry is an important source of supplementing income of the rural population in the project area. Sheep rearing and wool spinning and weaving play an important role in sustaining the population of the area. As a constraint, the availability of cultivable land is the main obstacle. The low fertility of soil, short cropping season, low temperature, high altitude, soil erosion and small holdings mar the prospect of agriculture. Therefore, instead of cultivation, the sheep rearing for production of wool and meat, spinning, weaving of wool and other cottage industries based on forest produce offer good scope. The quality of stock is poor and the milk yield per milch animal is very low. Measures are being taken to improve the breed of the livestock. Production of silk cocoon is almost 717.3 K.G. annually. About 1526 K.G. of tusser cocoon is being produced.

4.2.6 River, Canals and Waterways

Alakhananda along with its tributaries, the Nandakini and Pindar are the main rivers of the district. The former merges with Alakhananda and Nandaprayag while the later at Karnaprayag and thus embodying these places an aura of spiritual pilgrimage and great reverence. Dhauliganga and its tributaries have the network in the north-eastern part of the district.

4.2.7 Industries

Deposits of dolomite iron ore, limestone and markable magnesite sulphur are known to occur in the district. However these deposits are not considered at present important from the point of view of their exploitation and there are no mineral based industries in the district. There are no factories registered under Factory Act 1948 except one medium scale concern in Augustmuni under Public Sector concern. About 850 small scale factories are registered with the Directorate of Industries. Wool and Woolen goods production occupy prominent place in the industry. Namdas, tweeds and blankets are the main products in the district. Basket making, mat – weaving and wood crafts are other important and popular cottage products.

Forest and horticulture based industries have much avenues in the district. Transportation and marketing facilities are to be created to develop these industries. Tourism has tremendous potential in the district.

4.2.8 Tourism

Tourism possesses tremendous possibility of development in the district. There are beautiful hill resorts and places like Badrinath, famous for its Hindu religion, Valley of flowers (Tehsil Joshimath) is very beautiful place for nature lovers, Hemkund Saheb is a sacred lake situated at the height of 4320 meters and is a famous pilgrim centre for Sikhs.

Badrinath (Josimath Tehsil): One of the four main pilgrimage centers of Hindu mythology, the temple is situated on the right bank of Alaknanda river and is equi - distant from to mountains of Nar and Narayan in the east and west sides. The temple lies at an altitude of 3122 meters above the sea level. The temple is dedicated to Badri Narayan, an incarnation of Vishnu. However, the Jains and Buddhas differ from the traditions of the Hindus about the nature of the temple. According to the former the temple is dedicated to a Tirthankar while the letter asserts that the temple is a shrine of Lord Buddha. *Namboodiri-pad-Brahmins* of the south are the head priest to the temple for generations. The temple is covered with snow from November to the middle of May and the establishment retires down to Joshimath, the winter headquarters. The view of Neelkanth, a snow-clad peak, is clearly visible from Badrinath. Opposite to the temple, on the other side of the Alakhnanda river is situated the Tapa Kund (literally a tank of hot water) besides this, the other worth seeing places are Vasudhara water fall and vyas-gupha the letter of which is ascribed as the place where the sage Vyas compiled the Mantras and Chhandas of the Vedas.

Valley of Flowers (Joshimath Tehsil): For the nature lovers, the district contains a paradise of flowers in the full riot of colors, especially during the month of August at valley of flowers when the surrounding wilderness looks like a painting against the sheer dazzling whiteness of the snow. More than a thousand variteties of flowers, shrubs and orchids in various shades and textures makes the valley a gorgeous hue of colors looking like an artistic creation. The valley is located at the height of 3352 meters to 3658 meters. The valley is almost 19 kms from Govind Ghat where a Gurudwara of the Sikhs is located.

Hem-Kund Saheb (Joshimath Tehsil): It is sacred lake situated at the heights of 4320 meters and is a pilgrim centre of Sikhs, due to its association with Guru Govind Singh, who performed the penances at this place. The place can be visited from Govinda Ghat through the valley of flowers.

The other worth seeing sacred places are the Karnprayag, which is situated on the confluence of Pindar and Alaknanada rivers and is famous for Uma Devi and Karna temples. Nanda Prayag situated on the confluence of Alakhananda and Mandakani Rivers are famous for Gopal Ji Ka Mandir, Joshimath is sacred because of the Temple of Jagat Guru Sankar Acharya Ji. Sonprayag is the confluence of the rivers Son Ganga and Mandakini and is in the pathway to Trijuginarayan which is almost three kilometers away from Sonprayag, Gauri Kund where the temples of Parvati and Krishna are located and there is a hot water spring. Ukhimath famous for the temples of Usha, Shiva, Parvati, Anirudha and Mandhata and is the most important Shiva Pith after Kedarnath, is the residence of Rawal priests and also it is an important halting place on way to Kedarnath: Gopeshwar which is the seat of the district administration and famous for its Shiva and other Temples. Besides, above mentioned places, the other sacred places in the district are Pandukeshwar Tunganth, Rudranath, Kalpnath, Augustmuni, Kalimath and Guptakashi.

4.2.9 Education

In Chamoli district, according to 2001 Census, the population of total literates excluding the population of the age group of 0-6 is 1,63,501 persons; of these 1,07,016 are males and 56,485 are females. In rural areas of the district, 1,45,787 (95,958 males and 49,829 females) are literate and in urban areas 17,714 (11,058 males and 6,656 females) are literate. The rate of literacy has increased to 89.89 in 2001, as it was 60.40 in 1991.

4.2.10 Town, Villages and Amenities

As mentioned above Chamoli district at present comprises of 6 tehsils. The urban population of the district as percentage of total population in the census year 2001 is indicated below. It also shows the sex ratio (female per 1000 males) and density (population per sq. km.) in the urban population of the district in relation to the state.

Villages have education, medical, drinking water, post and telegraph, market and haat, approach road and power and water supply.

4.2.11 Communications

Railways are conspicuous by their non-existence in this district leaving the communication solely dependent on roads and pathways. In remote areas transportation is done through pack animals like horses, ponies, etc. National highway no. 58 touches Karnprayag, Nandprayag, Chamoli, Joshimath and Badrinath. There is about 64 K.M. of the State highway and a total length of 231 K.M. of road fall under the management of D.G.B.R. and M.E.S. The ratio of pucca road per lakh of population is 201 K.M. The district thus lacks communications facilities.

4.2.12 Public Health

In Chamoli district, there are 6.72 beds per thousand of population in urban area. The highest ratio of 15.45 beds is observed in Chamoli-Gopesshwar. The second largest ratio of 3.18 beds is observed in Karnaprayag. Gauchar with 1.22 beds per thousand of its population shows the least ratio.

4.3 SOCIO-ECONOMIC SURVEY

To evaluate and study the socio-economic conditions of the project affected families, a Socio-Economic Survey (SES) was undertaken. The information gathered during social survey helped to examine the impact of the proposed project thereupon and prepare an indicative Rehabilitation and Resettlement Action Plan (RRAP) for PAFs to mitigate and compensate the losses due to the upcoming project.

4.3.1 Project Affected People and Sample Design for Survey

As a pre-requisite for conducting socio-economic survey, a verification exercise is required to be conducted to identify the project-affected people and study their socio-economic condition including family structure, land holdings and economic activities. Information verified during this exercise formed the base for carrying out the socio-economic analysis.

Private land from five villages namely Bowala, Dusat, Maithana, Pursari and Nandprayag shall be required for the project. A list of persons whose land has/shall be acquired from these villages including the area of land acquired / to be acquired, has been submitted separately by the project proponent and is presented in **Annexure-4.1.** As per the list, land from 50 persons (households) has been / shall be acquired for the project.

For the purpose of socio-economic survey, the project affected people of the above mentioned five villages have been included in the study. RITES carried out a sample socio-economic survey and public consultations from January 17 to January 21, 2007. Village wise demographic data is presented in **Table-4.2.** A sample of 26 households spread over these five villages was randomly selected for the survey. **Table 4.2** shows that out of the total families (723) living in the five villages only 6.92% (50) have lost their land resources due to the project. It also shows that village Bowala has least affected households 1.96% (02) as affected families of its total household among the affected village, which is followed by Nand Prayag 2.53% (09). 6.45% (02) of total (31) households of Pursari village shall lose the land in the project. However highest 16.04% household of village Maithan which is followed by 13.64% households of Dusat village shall be losing the land for the project. Thus the impact based on household identified most affected village is Maithan and least affected village is Bowala.

Out of total 723 households of five villages, 50 households were identified as directly affected families. Out of these 50 families, 26 households (approximately 52%) were selected for sample social survey for the present purpose. The survey of these sample households well represents the socio-economic profile of the affected people.

TABLE-4.2
SAMPLE SPECTRUM OF PROJECT AFFECTED FAMILIES

S. NO	NAME OF VILLAGES	TOTAL POPULATION*			NO. OF HOUSEHOLDS*	NO. OF PAF (HH)	SURVEYED HOUSEHOLD
		TOTAL	MALE	FEMALE			
1.	Bowala	492	232	260	102	02 (1.96)	02 (100)
2.	Maithan	891	473	418	212	34 (16.04)	12 (35.29)
3.	Dusat	99	54	45	22	03 (13.64)	02 (66.67)
4.	Pursari	157	77	80	31	02 (6.45)	02 (100)
5.	Nand Prayag	1704	1062	642	356	09 (2.53)	08 (88.89)
TOTAL		**3343**	**1898**	**1445**	**723**	**50 (6.92)**	**26 (52)**

PAF (HH): Project Affected Families or Household (whose land has been acquired / proposed to be acquired)
** As per 2001 Census Report*

4.3.2 Data Collection

Primary data for the study was collected through Interview Schedule with the project-affected families with the help of pre-tested and well-structured questionnaire. Important aspects covered in the questionnaire are the identification particulars of PAPs, his/her family details, type of effects, assets and acquisition, irrigation facilities, details of structures, land utilization, cropping pattern, commercial / self employment activities, household income, etc. Questionnaire used for the survey is placed as **Annexure-4.2**. A list of interviewed PAFs is given as **Annexure-4.3**. Clippings of the social survey and Public Consultation have been placed as **Annexure–4.4.** Secondary data was collected from the Central/State level census handbooks and various other projects related documents.

4.3.3 Data Analysis

The data, so collected, have been compiled, processed and analyzed critically for the purpose of this project report. Based on the information collected during social survey through interview and public consultation, the Social Impact Assessment (SIA) was carried out. The information has been divided under two sections (i) Socio-Economic Characteristics which gives description of the socio-economic characteristics of PAFs/PAPs, and (ii) Social Impact Analysis which gives description of effects and social changes due to proposed project.

4.4 SOCIO-ECONOMIC ANALYSIS OF PROJECT AFFECTED FAMILIES (PAFs)

Based on the sample survey, socio-economic analysis of the project-affected families has been documented in this section.

4.4.1 Sex and Age of Project Affected People (PAPs)

The sex and age particulars of the surveyed PAPs are presented in **Table 4.3.** Total population of the surveyed households is 207. Among them 112 (54.11%) are male and 95 (45.89%) are female. Age structure refers to the contribution of population in various economic and social activities as well as the dependent population. About 34.78% are in the age group of 19-35 years closely followed by 22.22% are in the age group of 36-60, 18.84% in the age of 0-6 years, 10.63% in 7-12 years, 10.14% are above 60 years, 3.38% in the age group of 13-18 years. Lowest percentage 3.38% has been observed in the age group of 13-18 years, however highest in the age group (19-35 years) of working people. The male outnumber female in the age groups of 0-6, 7-12, 13-18, 19-35, 36-60, however the female dominates in the age group of above 60 years. The age structure of the project area indicates the high demands for jobs, however an indication to decrease in the future work force. Thus PAFs shall demand employment opportunities in the project works as the majority of the population is of working population.

4.4.2 Educational Attainment

Educational attainment is the best indicator of socio-economic development of a region and is also a basic need. From **Table 4.4**, it is observed that 15.94% of the PAPs have their education up to primary level, 9.18% and 21.74% of them have their education up to middle and high school level respectively. The highest percentage (22.17%) of PAPs has attained the education at college level. It is also important to note that 11.59% of the PAPs are illiterate. In the project area, out of the total PAPs, male outnumbered female at the middle, high and college levels of education. However female dominates at primary education level. It shows male preponderance in education attainment in the project area. The higher level of education indicates a high aspiration which leads to the high level of trade and commerce as well as the aspiration for jobs.

TABLE-4.3
AGE AND SEX WISE DISTRIBUTION OF PROJECT AFFECTED PEOPLE

VILLAGE	NO. OF HH	0-6			7-12			13-18			19-35			36-60			60 & ABOVE			TOTAL		
		M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T
Bowala	02	03 (30)	01 (16.67)	04 (25)	00 (00)	00 (00)	00 (00)	01 (10)	00 (00)	01 (6.25)	04 (40)	03 ((50)	07 (43.75)	02 ((20)	02 (33.33)	04 (40)	00 (00)	00 (00)	00 (00)	10 (62.5)	06 (37.5)	16 (100)
Maithana	12	04 (10.53)	04 (13.33)	08 (11.76)	02 (5.26)	03 (10)	05 (7.35)	02 (5.26)	01 (3.33)	03 (4.41)	18 (47.37)	09 (30)	27 (39.71)	09 (23.68)	06 (20)	15 (22.06)	03 (7.89)	07 (18.42)	10 (14.71)	38 (55.88)	30 (44.12)	68 (100)
Dusat	02	03 (27.27)	01 (16.67)	04 (23.53)	02 (18.18)	00 (00)	02 (11.76)	00 (00)	00 (00)	00 (00)	04 (36.36)	03 (50)	07 (41.18)	00 (00)	02 (33.33)	02 (11.76)	02 (18.18)	00 (00)	02 (11.76)	11 (64.71)	06 (35.29)	17 (100)
Pursari	02	01 (16.67)	03 (37.5)	04 (28.57)	00 (00)	00 (00)	00 (00)	00 (00)	00 (00)	00 (00)	02 (33.33)	02 (25)	04 (28.57)	02 (33.33)	03 (37.5)	05 (35.71)	01 (16.67)	00 (00)	01 (7.14)	06 (42.86)	08 (57.14)	14 (100)
Nandprayag	08	11 (23.40)	08 (17.78)	19 (20.65)	08 (17.02)	07 (15.56)	15 (16.30)	02 (4.26)	01 (2.22)	03 (3.26)	10 (21.28)	17 (37.78)	27 (29.35)	12 (26.67)	08 (17.78)	20 (21.74)	04 (8.51)	04 (8.89)	08 (8.70)	47 (51.09)	45 (48.91)	92 (100)
TOTAL	26	22 (19.64)	17 (17.89)	39 (18.84)	12 (10.71)	10 (10.53)	22 (10.63)	05 (4.46)	02 (2.10)	07 (3.38)	38 (33.93)	34 35.79	72 (34.78)	25 (22.32)	21 (22.11)	46 (22.22)	10 (8.93)	11 (11.58)	21 (10.14)	112 (54.11)	95 (45.89)	207 (100)

M-Male; F-Female; T-Total; HH-Household
Figure in bracket indicate percentage

TABLE-4.4
EDUCATIONAL ATTAINMENT OF PROJECT AFFECTED PEOPLE

VILLAGE	ILLITERATE			LITERATE			PRIMARY			MIDDLE			HIGH SCHOOL			COLLEGE (UP TO PG)			NON SCHOOL GOING CHILDREN			TOTAL		
	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T
Bowala	00 (00)	02 (33.33)	02 (12.5)	00 (00)	00 (00)	00 (00)	02 (20)	01 (16.67)	03 (18.75)	02 (20)	01 (16.67)	03 (18.75)	04 (40)	01 (16.67)	05 (31.25)	01 (10)	00 (00)	01 (6.25)	01 (10)	01 (16.67)	02 (12.5)	10 (62.5)	06 (37.5)	16 (100)
Maithana	00 (00)	13 (43.33)	13 (19.12)	00 (00)	00 (00)	00 (00)	05 (13.16)	05 (16.67)	10 (14.71)	07 (18.42)	02 (6.67)	09 (13.24)	09 (23.68)	05 (16.67)	14 (20.59)	15 (39.47)	03 (10)	18 (26.47)	02 (5.26)	02 (6.67)	04 (5.88)	38 (55.88)	30 (44.12)	68 (100)
Dusat	02 (18.18)	02 (33.33)	04 (23.53)	05 (45.45)	03 (50)	08 (47.06)	03 (27.27)	00 (00)	03 (17.65)	00 (00)	00 (00)	00 (00)	00 (00)	00 (00)	00 (00)	00 (00)	00 (00)	00 (00)	01 (9.09)	01 (16.67)	02 (11.76)	11 (64.71)	06 (35.29)	17 (100)
Pursari	00 (00)	00 (00)	00 (00)	00 (00)	03 (50)	03 (21.43)	00 (00)	00 (00)	00 (00)	01 (16.67)	00 (00)	01 (7.14)	04 (66.67)	01 (12.5)	05 (35.71)	00 (00)	01 (12.5)	01 (7.14)	01 (16.67)	03 (37.5)	04 (28.57)	06 (42.86)	08 (57.14)	14 (100)
Nandprayag	01 (2.13)	04 (8.89)	05 (5.43)	00 (0)	03 (6.67)	03 (3.26)	06 (12.77)	11 (24.44)	17 (18.48)	05 (10.64)	01 (2.22)	06 (6.52)	10 (21.28)	11 (24.44)	21 (22.83)	18 (38.30)	09 (20)	27 (29.35)	07 (14.89)	06 (13.33)	13 (14.13)	47 (51.09)	45 (48.91)	92 (100)
TOTAL	03 (2.68)	21 (22.11)	24 (11.59)	05 (4.46)	09 (9.47)	14 (6.76)	16 (14.29)	17 (17.89)	33 (15.94)	15 (13.39)	04 (4.21)	19 (9.18)	27 (24.11)	18 (18.95)	45 (21.74)	34 (30.36)	13 (13.68)	47 (22.71)	12 (10.71)	13 (13.68)	25 (12.08)	112 (54.11)	95 (45.89)	207 (100)

M-Male; F-Female; T-Total; HH-Household
Figure in bracket indicate percentage

4.4.3 Religion and Caste

Hindu families fully dominate in all surveyed villages. In order to understand the relative significance of different castes in the project area, a functional classification of caste is presented in the **Table 4.5**. All main categories of social groups (ST, SC, OBC and General caste) are present in the Project area, however among PAFs only General and OBC groups were found. **Table 4.5** shows that the General castes group comprises 96.15% and OBC holds 3.85% of the total surveyed household. All the five villages comprised general caste categories however village Maithan has OBC population also.

TABLE 4.5
CASTE-WISE DISTRIBUTION OF PROJECT AFFECTED FAMILIES

VILLAGE	NUMBER OF HOUSEHOLDS	SOCIAL GROUP			
		ST	SC	OBC	GENERAL
Bowala	02	--	--	--	02 (100%)
Maithana	12	--	--	01 (8.33%)	11 (91.67%)
Dusat	02	--	--	--	02 (100%)
Pursari	02	--	--	--	02 (100%)
Nandprayag	08	--	--	--	08 (100%)
TOTAL	26	--	--	01 (3.85%)	25 (96.15%)

4.4.4 Occupation

In response to the question 'which occupation is normally undertaken in the project affected families?' the respondent reported about the main and subsidiary occupation pursued by head of the family. Though most of the families get assistance from other members but the main source of household economy was the income and earning of head of the family, so occupation meant the occupation of head of the family. The particulars of the responses are presented in **Table 4.6**. Majority of the project-affected families (73.08%) have agriculture as their main occupation. About 11.54% reported in service, 11.54% reported in business and 3.85% indicates that they are involved in other works. So far as secondary occupation of head of household is concerned, all cultivator-agriculturists have no secondary occupation, however people involved in service and other-works followed agriculture as their secondary occupation.

TABLE 4.6
OCCUPATION OF THE PROJECT AFFECTED FAMILIES

VILLAGE	NO. OF HOUSEHOLDS	OCCUPATION				
		AGRICULTURE	LABOUR	BUSINESS	SERVICE	OTHERS
Bowala	02	02 (100%)	--	--	--	--
Maithana	12	08 (66.67%)	--	01 (8.33%)	02 (16.67%)	01 (8.33%)
Dusat	02	02 (100%)	--	--	--	--
Pursari	02	02 (100%)	--	--	--	--
Nandprayag	08	05 (62.50%)	--	02 (25%)	01 (12.5%)	--
TOTAL	26	19 (73.08%)	--	03 (11.54%)	03 (11.54%)	01 (3.85%)

4.4.5 Family Income

Table 4.7 shows that highest percentage of (34.62%) of project affected families fall under the income group of Rs. 20,001-50,000/= per annum. The next highest percentage (23.08%) is found with an annual income ranging from Rs. 50,001 to 1,00,000/=. About 19.23% of them have an annual income ranging from Rs. 1,00,001 to 2,00,000. 7.69% of them have incomes more than 2 Lakhs, however 15.38% managed their households with the income of under Rs. 20,000 per annum. The mean average income of project affected families is Rupees 1,14,625.30 per annum. The survey data indicates that the project area has comparatively better economic conditions as the mean average income of the PAFs is more than a lakh per annum.

TABLE 4.7
FAMILY INCOME OF THE PROJECT AFFECTED FAMILIES (RUPEES PER ANNUM)

VILLAGE	NO. OF HOUSEHOLDS	FAMILY INCOME				
		<20,000	20,001-50,000	50,001-1,00,000	1,00,001-2,00,000	ABOVE 2,00,001
Bowala	02	--	02 (100%)	--	--	--
Maithana	12	04 (33.33%)	04 (33.33%)	02 (16.67%)	02 (16.67%)	--
Dusat	02	--	01 (50%)	01 (50%)	--	--
Pursari	02	--	02 (100%)	--	--	--
Nandprayag	08	--	--	03 (37.5%)	03 (37.5%)	02 (25%)
TOTAL	**26**	**04 (15.38%)**	**09 (34.62%)**	**06 (23.08%)**	**05 (19.23%)**	**02 (7.69%)**

4.4.6 Marital Status

From **Table 4.8** is evident that out of 207 person, 53.14% are married (male 49.11% and female 57.89%) and 43% are unmarried (male 50.89% and female 33.68%) and remaining 3.86% of total population are widows in which 8.42% are widows of total woman among PAPs.

TABLE 4.8
MARITAL STATUS OF PROJECT AFFECTED PEOPLE

VILLAGE	MARRIED			UNMARRIED			WIDOW/WIDOWER			TOTAL		
	M	F	T	M	F	T	M	F	T	M	F	T
Bowala	04 (40%)	04 (66.67%)	08 (50%)	06 (60%)	02 (33.33%)	08 (50%)	00 (00)	00 (00)	00 (00)	10 (62.5%)	06 (37.5%)	16 (100%)
Maithana	18 (47.37%)	18 (60%)	36 (52.94%)	20 (52.63%)	06 (20%)	26 (38.24%)	00 (00)	06 (20%)	06 (8.82%)	38 (55.88%)	30 (44.12%)	68 (100%)
Dusat	05 (45.45%)	05 (83.33%)	10 (58.82%)	06 (54.55%)	01 (16.67%)	07 (41.18%)	00 (00)	00 (00)	00 (00)	11 (64.71%)	06 (35.29%)	17 (100%)
Pursari	04 (66.67%)	04 (50%)	08 (57.14%)	02 (33.33%)	04 (50%)	06 (42.86%)	00 (00)	00 (00)	00 (00)	06 (42.86%)	08 (57.14%)	14 (100%)
Nandprayag	24 (51.06%)	24 (53.33%)	48 (52.17%)	23 (48.93%)	19 (42.22%)	42 (45.65%)	00 (00)	02 (4.44%)	02 (2.17%)	47 (51.09%)	45 (48.91%)	92 (100%)
TOTAL	55 (49.11%)	55 (57.89%)	110 (53.14%)	57 (50.89%)	32 (33.68%)	89 (43%)	00 (0)	08 (8.42%)	08 (3.86%)	112 (54.11%)	95 (45.89%)	207 (100%)

4.4.7 Family Pattern and Size

It is observed from **Table 4.9** that among 26 surveyed households, 53.85% obey the rules of joint social family and 46.15% observe the nuclear family pattern consisting husband, wife and children. There is no individual family among the PAFs. Family size has been classified into 3 categories i.e. small (1-4), medium (5-7) and large (above 8). Most of the families (50%) are large in size, 34.62% are medium and remaining 15.38% are small in size. The mean average size of family is 7.96 (**Table 4.10**). Thus the people prefer living in the bigger families to get all types of securities in the difficult hilly terrain.

TABLE 4.9
FAMILY PATTERN OF PROJECT AFFECTED PEOPLE

VILLAGE	NO. OF HOUSEHOLDS	FAMILY PATTERN		
		JOINT	NUCLEAR	INDIVIDUAL
Bowala	02	02 (100%)	00	00
Maithana	12	03 (25%)	09 (75%)	00
Dusat	02	02 (100%)	00	00
Pursari	02	01 (50%)	01 (50%)	00
Nandprayag	08	06 (75%)	02 (25%)	00
TOTAL	**26**	**14 (53.85%)**	**12 (46.15%)**	**00**

TABLE 4.10
FAMILY SIZE OF PROJECT AFFECTED FAMILIES

VILLAGE	NO. OF HOUSEHOLDS	FAMILY SIZE		
		SMALL (1-4)	MEDIUM (5-7)	LARGE (8 & ABOVE)
Bowala	02	00	01 (50%)	01 (50%)
Maithana	12	04 (33.33%)	04 (33.33%)	04 (33.33%)
Dusat	02	00	01 (50%)	01 (50%)
Pursari	02	00	01 (50%)	01 (50%)
Nandprayag	08	00	02 (25%)	06 (75%)
TOTAL	**26**	**04 (15.38%)**	**09 (34.62%)**	**13 (50%)**

4.4.8 Enlistment

From the field data, it is observed that all the surveyed project affected families have been included in the voter list and hold voter identity card. All the surveyed PAFs had ration cards and been using for government sponsored schemes.

4.4.9 Family Assets and Acquisition

Land: The main asset of the project-affected families is land. **Table 4.11** details the number of households with various ranges of the land holding. Among 26 surveyed households, there was no household which shall be landless after the acquisition of the land required for the project. The average size of landholding by household is 5.34 Acres. 15.38% of households owned land up to 01 Acre, 23.08% owned up to

1.1 to 2 Acres, 38.46% hold land between 2.1 to 4. Those holding more than 4 Acres of the land constituted 23.08% of the total respondents. It is noted from the data that the households (38.46%) having land are marginal farmers hold less than two acres of land.

Houses: Another important asset owned by the project affected families is house. Among 26 households, 04 houses were kuchcha (wooden), 19 houses were pucca with cemented roof and the remaining 03 houses were mixed type (half bricks and half wooden structure). The average size of houses varied from approximately 350 sq. ft. to 2650 sq ft. During field visits, it was observed that most of the households had average three to seven rooms. All the surveyed households were electrified, and the average household electricity bill was about Rupees 115/= per month. All 26 households have electricity for more than three years.

Trees: People in surveyed villages have grown a few fruit bearing trees over the years. Among the surveyed 26 households, 42.31% of the total households have grown both fruit bearing as well as non-fruit bearing trees within their possessions of land. The species of trees commonly found in the project area are santra, nimbu etc.

TABLE 4.11
VILLAGE WISE DISTRIBUTION OF LAND HOLDINGS

VILLAGE	NO. OF HOUSEHOLDS	LANDHOLDINGS (IN ACRES)					AVERAGE
		LANDLESS	UPTO 1 ACRE	1.1 TO 2 ACRE	2.1 TO 4 ACRE	4.1 AND ABOVE	
Bowala	02	00	00	00	01 (50%)	01 (50%)	4.2
Maithana	12	00	02 (16.67%)	02 (16.67%)	08 (66.66%)	00	2.75
Dusat	02	00	02 (100%)	00	00	00	0.85
Pursari	02	00	00	02 (100%)	00	00	1.75
Nandprayag	08	00	00	02 (25%)	01 (12.5%)	05 (62.5%)	4.26
TOTAL	**26**	**00**	**04 (15.38%)**	**06 (23.08%)**	**10 (38.46%)**	**06 (23.08%)**	**3.10**

4.4.10 Infrastructure Facility

The infrastructure facilities available in the project-affected villages have been presented in **Table 4.12**. As mentioned above, all the villages are electrified. None of the villages except Nandprayag have post offices. Bus transportation links Maithana, Pursari and Nandprayag from Joshimath to Dehradun via Devprayag. The kuchcha road touches Bowala and Dusat villages of the project area. People of the project affected villages reach the nearby market of Nandparayag and district headquarter - Chamoli to buy their daily use goods available in the local market. People also use private vehicles i.e. jeeps, cars and motorcycles as means of transportation to move around. There is no telephone service in Bowala, however other four villages of the Project Area have telephone facilities. No allopathic dispensary was available in the villages however Nandparayag has one Ayurvedic hospital. People of the surveyed villages depend on the quakes for their immediate medical needs. All surveyed villages have primary/middle schools.

TABLE 4.12
INFRASTRUCTURE FACILITIES IN PROJECT AFFECTED VILLAGES

VILLAGE	INFRASTRUCTURE FACILITIES						
	ROAD	TELEPHONE	DISPENSARY	SCHOOL	ELECTRICITY	POST OFFICE	TRANSPORT
Bowala	N	N	N	Y	Y	N	N
Maithana	Y	Y	N	Y	Y	N	Y
Dusat	N	Y	N	Y	Y	N	N
Pursari	Y	Y	N	Y	Y	N	Y
Nandprayag	Y	Y	Y	Y	Y	Y	Y

Y: Yes, N: No

4.5 PUBLIC CONSULTATIONS

Public consultation envisages identification of stakeholders, procedure and consultation with the people in various stages of the project and gets to know about their view and suggestion and accordingly setting up of mechanism by which their problem can be resolved during the entire stage by organizing public meetings. The general information about the project, such as investment, proposed alignment, details of acquisition of land, compensation criteria etc. needs to be provided to the local people in group discussions for effective public participation in the project. The public consultations for this project were held on 17th - 21st January, 2007 by Project proponents and RITES team. The public consultations included an investigation of the social, economic and environmental status of people living in the project area and in surrounding villages. The venue for the public consultation was fixed in four villages namely - Maithana, Dusat, Pursari and Nandprayag. The response of the people in all the villages was quite positive. All the likely to be affected people (directly) were found to be apprehensive about the compensation to be paid for their lands. However they assured to their all support to make the project successful. Project options suggested by them included: proper cash compensation (some of them demanded Rs. 2,25,000 per nalli, however few requested for land compensation as per existing market rate for land), job opportunities in the project itself for at least one from each PAFs. The other stakeholders and indirectly project affected people desired to get preference in the project works and subsidiary works available in the project area. RITES experts communicated the views/opinions of the stakeholders to the project proponent. The project developer also desired to extend all kind of support to the local people based on the priority. It is accepted that the project affected families shall get first priority and then the local people. The cost for land shall be in consensus of the PAFs and project proponent, however an estimated/indicative cost for land is provided **under section 4.7.2.1**. Villagers of Maithan demanded for approach road to the village, which has also been considered and provision has been made under **4.8.4.4 Infrastructure Development Support.**

4.6 SOCIAL IMPACT ANALYSIS

Taking the findings of socio-economic analysis and field observations, positive and negative impacts of the proposed hydroelectric project on socio-economic conditions of project affected people have been examined in this section.

4.6.1 Loss of Agriculture Land

As mentioned earlier that PAFs will be losing only their agricultural land. It is observed that the extent of loss of agriculture land varied between 0.006 Ha to 0. 058 Ha. Agriculture happens to be the primary occupation of the people. Loss of agriculture land has major impact on their well being as well as on their daily life. It shall limit their base for livelihood earning and also the employment days. A large number of economic opportunities in rural areas are directly linked with agriculture. However the loss of agriculture land will be limited to 50 families due to the project development, which is 6.92% of the total families in the five affected villages.

4.6.2 Loss of Crop Yield

In the project area main crop is paddy, wheat, pulses, maize, etc. The average yield of paddy / maize is approximately 25 quintals per hectare during kharif season and the average yield of wheat and pulses is approximately 15 quintals per hectare during rabbi season. Most of the land grows two crops per year and most of the PAFs will be compensated for the two crops loss during acquisition. Total private land to be acquired is 9.604 ha which is cultivable. Total land shall lose approximately 385 quintals crop grains per year. For kharif season approximately Rs. 62500 / ha and during rabbi season crops loss shall be approximately Rs.50,000/-. Thus composite loss of crops shall be approximately Rs. 1,12,500/- per hectare for a year for both the kharif and rabbi. The affected families shall get Rs. 10.80 lakhs per year, and total compensation for two years shall come about **Rs. 21.60 Lakhs**.

4.6.3 Employment Opportunities

The project is likely to provide direct employment opportunities to 1200 persons during construction period of 60 months and approximately 118 persons during operation and maintenance of the project at all levels. In addition to this, project will also provide indirect employment in general to the local people.

4.6.4 Benefits to the Economy

Development of infrastructure and availability of reliable power supply as a result of the project realization would contribute towards better economic activities.

4.6.5 Recreation and Tourism Potential

Improvement of access road and other infrastructure facilities due to the implementation of the project is likely to boast tourism in the area and revenue generation from the same.

4.6.6 Pressure on Existing Infrastructure

As mentioned in s.no. 15 of Table 2.1, the construction period of the proposed hydroelectric project will take about 60 months, during which manpower will be required for various construction activities. It is estimated that about 1200 person including workers and technical staff will be required during the construction of the project. Out of these, the workers migrating from outside of the project area, aggregation of workers along with their families is likely to put significant pressure on exiting infrastructure facilities in the project area. Thus management of problems due to population needs to be looked into critically. Necessary infrastructure and facilities would be developed in the worker’s camp area.

4.6.7 Cultural Conflicts

The state of Uttaranchal and the region have unique culture and society. People of the area have distinct habits of food and clothing, because the region is historically important. During construction period of the project, migrant population is expected from other parts of the country having different cultural habits/habits however, no cultural conflict is foreseen due to these migrants, as they will be largely settled in separate conglomerates having all facilities and less interactions with the local people.

4.6.8 Cost of Living and Inflation

Minor increase in cost of living and inflation would be experienced in the project area as a result of increased commercial activities however the same factors will also increase the per capita income of the people in the area and take care of the inflation. Overall the minor economic change shall improve the region and the people.

4.7 REHABILITATION AND RESETTLEMENT OF THE PROJECT

Ministry of Rural Development, Department of Land Revenue, Land Reform Division, Government of India has published the National Rehabilitation and Resettlement Policy for Project Affected Families (NRRP-2007) on 31st October, 2007. The policy addresses the resettlement and rehabilitation (R&R) issues of the Project Affected Families (being displaced) in case of compulsory acquisition of land for public purpose including infrastructure projects. The policy says that it will be applicable to projects displacing 400 families or more enmass in plain areas and 200 families or more en mass in hilly areas, DDP blocks mentioned in Schedule V and Schedule VI of the constitution of India. It also states that the rehabilitation grants and other monetary benefits proposed in the Policy would be minimum and applicable to all project affected families whether belonging to BPL (Below Poverty Line) or non-BPL families. States where R&R packages are higher than proposed in the Policy are free to adopt their own package. Uttranchal Jal Vidyut Nigam Ltd. (UJVNL) has also formulated a Rehabilitation and Resettlement Policy, which has also been consulted while preparing the R&R package for the affected people.

As mentioned earlier in this chapter, total land required for the project under private ownership measured about 8.785 ha. By the acquisition of the land, total number of affected families shall be about 50. Total number of affected families is much less than 200 and the region do not fall in the Schedule category of the Constitution. Hence the NRRP-2007 is not compulsorily applicable in this case. It is reported that the state of Uttaranchal also does not have any R&R policy in place, as on date. For the present purpose NRRP – 2007 is being used as recommended in the policy.

4.7.1 Objectives of the Rehabilitation and Resettlement

R&R has two distinct components namely rehabilitation and resettlement. While the first addresses itself socio-economic transformation of PAPs so as to improve quality of their life, the later aims at shifting of PAPs and creating civic amenities at new settlements. The objective of the R&R is to ensure that Project Affected Persons regain their previous standard of living, if not better, within a reasonable transition period. R&R has two distinct components namely resettlement and rehabilitation. While the first addresses itself to shifting of PAPs and creating civic amenities at new settlements, the later aims at socio-economic transformation of PAPs so as to

improve quality of their life. As mentioned earlier, due to this project about 50 families are affected due to acquisition of 8.785 ha of private land.
NRRP-2007 has laid down objectives of the R&R policy which are as follows:

- To minimize displacement and to promote, as far as possible, non-displacing or least- displacing alternatives;
- To ensure adequate rehabilitation package and expeditious implementation of the rehabilitation process with the active participation of the affected families;
- To ensure that special care is taken for protecting the rights of the weaker sections of society, especially members of Scheduled Castes and Schedule Tribes, and to create obligations on the state for their treatment with concern and sensitivity
- To provide a better standard of living, making concerted efforts for providing sustainable income to the affected families;
- To integrate rehabilitation concerns into development into the development planning and implementation process; and
- Where displacement is on account of land acquisition, to facilitate harmonious relationship between the requiring body and affected families through mutual cooperation

4.7.2 REHABILITION AND RESETTLEMENTS BENEFITS

The R&R benefits shall be extended to all the PAFs whether belonging to BPL (below poverty line) or non-BPL. As mentioned earlier, due to this project about 50 families are affected due to acquisition of 8.785 ha of private land. The number of affected families is 50, that is much less than 200 and the project area and Chamoli region of Uttarakhand does not fall in the Schedule category of the Constitution. Hence the Social Impact Assessment (SIA) under NRRP-2007 is not compulsorily applicable in this case. It is reported that the state of Uttarakhand also does not have any R&R policy in place, as on date. But keeping the needs of people, executing agency and other concerned body, a brief R&R plan has been made for the use. R&R plan includes social cost of the project which is explained in this section.

4.7.2.1 Compensation for Loss of Land

Acquisition of land for infrastructure projects displaces people forcing them to give up means of livelihood. In most cases, the system of extending cash compensation does not enable the affected families to obtain cultivable agricultural land and other resources which they have to surrender to the state. The difficulties are more acute for persons who are critically dependent on the acquired assets for their subsistence / livelihood. Keeping it in mind the state has made provisions to extend some extra help in monetary term other than the actual compensation for the acquired land to rehabilitate the affected people in time without ‘loss of nerve’ in such a hectic process. NRRP 2007 mentions that PAFs shall get a monthly subsistence allowance equivalent to 25 days of minimum agricultural wage per month for a period of one year. Further if PAFs belong to ST categories shall get an additional financial assistance equivalent to 500 days minimum agricultural wage for loss of customary rights/usage of forest produce. **No tribal families are found in the list of project affected families, so this grant is not applicable in this case.**

As mentioned above the loss of agriculture land will be limited to 50 families in the project area, which is 6.92% of the total families in the five affected villages. Total loss of private land is 9.604 Ha. Assuming average sell value as Rs. 42.5 Lakh per hectare total cost of the land is **Rs. 408.17 Lakhs** at the same price for 9.604 ha private land.

4.7.2.2 Rehabilitation Grant

Para 7.14 of NRRP 2007 writes in case of a project involving land acquisition on behalf of a requiring body, the affected families who have not been provided agricultural land or employment shall be entitled to a rehabilitation grant equivalent to seven hundred fifty (750) days minimum agricultural wages or such other higher amount as may be prescribed by the appropriate government. Assumed 10% of the affected families shall get employment in the project work and remaining 90% of the PAFs are entitled for rehabilitation grants. As per the section 6 (1) of NREGA (National Rural Employment Guarantee Act) amended on 10 July 2009, the minimum agriculture wage is @ Rs. 100/- per day. However for this purpose the minimum wage is considered @ Rs. 200/- per day. Assumed 40 families shall be entitled to get rehabilitation grant for 750 days. Total amount to be paid under the rehabilitation grant shall be **Rs. 60.00 Lakhs** (Rs. Sixty Lakhs only).

4.7.2.3 Monthly Subsistence Allowance

As per the section 7.16 of NRRP 2007, each affected family which is involuntarily displaced shall get a monthly subsistence allowance. One member from each project affected household will get 25 days minimum agricultural wage per month for a period of one year from date of displacement. As per the section 6 (1) of NREGA (National Rural Employment Guarantee Act) amended on 10 July 2009, the minimum agriculture wage is @ Rs. 100/- per day. As above in section 4.7.2.2, for this purpose the minimum wage is considered @ Rs. 200/- per day. For a year, this amount will come around **Rs. 30,00,000**/- (Rs. Thirty Lakhs only).

4.7.2.4 Compensation for House Building

As mentioned above that no house/structure will be acquired for this project purpose. Not even a single family will be fully displaced either under submergence or for the any other purposes of the project.

4.7.2.5 Compensation for Crops

In the project area main crop is paddy, wheat, pulses, maize, etc. The average yield of paddy / maize is approximately 25 quintals per hectare during kharif season and the average yield of wheat and pulses is approximately 15 quintals per hectare during rabbi season. Most of the land grows two crops per year and most of the PAFs will lose two crops during acquisition. Total land to be acquired is 9.604 ha which is cultivable. The total land shall lose two crops per year approximately 385 quintals crop grains per year. The average cost for paddy is taken Rs. 2500 / quintal; wheat Rs. 2500 / quintal; pulse Rs. 5000 / quintal. For kharif season approximately Rs. 62500 / ha and during rabbi season crops loss shall be approximately Rs. 25,000/- for wheat and Rs 25,000/- for pulses. Thus composite loss of crops shall be approximately Rs. 1,12,500/- for a year for both the kharif and rabbi. Loss of crop yield is calculated @ Rs. 1,12,500/ha. Total loss of paddy grains shall be 240.10 quintals, wheat 90.04 quintals and pulses 48.02, hence total compensation to be paid for paddy crop loss is Rs. 6.0 Lakh, wheat Rs. 2.25 Lakhs and pulses Rs. 2.40 Lakhs of a year for 9.604 ha of private land. The affected families shall get compensation for two years, this comes about **Rs. 21.30 Lakhs.** Based on the above description, R & R cost has been calculated as given in **Table 4.13**. Rehabilitation & Resettlement cost is estimated as **Rs. 837.75 lakhs**.

TABLE – 4.13
RESETTLEMENT AND REHABILITATION COST

S.No.	Items	Unit	Rate (in Rs)	Amount (in Lakh)
Compensation for Land				
1	Land (agricultural)	9.604 ha	42,50,000	408.17
2	Rehabilitation Grant*	40	200	60.00
3	Subsistence Allowance*	50	200	30.00
4	Building/Structures	Nil	--	Nil
Compensation for Crop				
5	Compensation for Crops @25 quintal per hectare during kharif (paddy) and @15 quintals per hectare during rabbi (wheat + pulses) for two years	25 quintals paddy 10 quintals wheat 5 quintals pulses	2500 per quintal 2500 per quintal 5000 per quintal	21.30
Other Administrative Charges				
6	Solatium Charges on Compulsory Acquisition of Private Land	408.17	@30%	122.45
7	Legal Charges on the amount paid to items 1	408.17	1%	4.08
8	Interest Charges @ 12% on amount of private land for 2 years	408.17	12%	97.96
9	Establishment Charges on amount paid to items 1 & 5	429.47	6.25%	26.85
10	Labor and Material for Land demarcation on item 1	408.17	1%	4.08
11	10% expenditure for private land acquisition on the item no 1, 6 & 8 above.	628.58	10%	62.86
			TOTAL	**837.75**

*as per the NRRP 2007

4.8 COMMUNITY DEVELOPMENT SCHEME (CDS)

The project area provides natural resources as well as human resources to the planned development in the region. If the development and developers require local resources, it became the preliminary duty of developers to develop the local community and resources for sustainability. In addition to it, acquisition of land affects not only the actual land losers but also the communities living in the area. Keeping in view the social dimensions of the project, a broader social perspective requires something to be done in a larger perspective. In view of this, a comprehensive **Community Development Scheme** has been envisaged for the project as described below. The consultant and project developer shall include the issues / demand raised by the various stakeholders during Public Hearing, in the final version of the report.

4.8.1 Objectives of the CDS

The basic objectives of the CDS shall be:

- Generate a sense of affinity and own ness, not alienation, among the people living within the project area.
- Initiate changes that are made and perceived for betterment of the area and the society. Special support shall be extended in up gradation of rural infrastructure and gender equality.
- Focus on weaker section of the society and female.
- Take care of project-affected families and compensate them according to the prescribed norms in terms of cash as well as creation of employment opportunities for them towards their socio-economic development.
- Acknowledge constructive role of the local population through technical training inputs, participatory research programs, demonstration of trying out the adaptation and penetration of innovative technologies that lead to lesser dependence on natural resource in support of animal husbandry and agriculture.
- Develop a participation mechanism in which village level committees are formed in implementation of the CDS. In such committees 7-10 members representing all sections of the society from each village shall be taken through gram panchayat. At least 50% of such members shall be women; who are being less privileged and yet most active class needs to be involved as the focus group.
- Involve the society in the CDS so as to ensure acceptability of the project and social response program as their own.
- Provide livelihood support activities for the local community which will gather economic benefits for the project affected people and restore/improve their economic condition.
- Ensure the participation of the project affected people at every stage from planning through implementation and to keep them abreast, educated and informed about the program on a regular basis.

4.8.2 Methodology

The CDS shall aim to have a specific community development program for the project-affected area, in which the following steps shall be involved:

- **Creation of separate CDS Cell** headed by a specialist CDS officer with support staff. The cell shall remain under administrative control of the General Manager of the project. It shall be responsible to identify the areas of thrust, methodology and implementation of 'Social Response Program'. The cell shall also look into the local demands as they arise from time to time and shall respond to the needs of the project as well as project affected people i.e. during Public Hearing (*Lok Sunvayee)* for Environment Clearance, Socio-Economic Surveys etc. cost involvement towards the R&R cell is estimated as under;

- **Identification of affected families:** For the purpose of extending benefit of CDS, the project-affected families shall be categorized in following graduated order.

    - Category A: Affected families rendered landless
    - Category B: Affected families who are rendered houseless
    - Category C: Affected families losing partial land and becoming marginal farmer left with unirrigated land holding upto 1ha or irrigated upto ½ ha
    - Category D: Affected families losing partial land and becoming small farmer left with unirrigated land holding upto 2ha or irrigated upto 1 ha
    - Category E: Affected families losing partial land but not covered in categories A,B,C,D
    - Category F: Agricultural Labourer who normally is a resident of the affected area for a period of not less than three years and does not own land in the acquired area, but who earns his/her livelihood by manual labour on agricultural land
    - Category G: Non agricultural labour affected families living in the affected zone.
    - Category H: Affected families of SC & ST in the affected area
    - Category I: Encroachers i.e. families occupying government land in the affected zone without a legal title
    - Category J: Families residing in the "affected villages", but their land are not acquired.

- **Conducting demographic and socio-economic survey:** An independent institution (NGO/University) shall be appointed to carry out the census survey (100%) of project-affected people and categorization of the families i.e. categories A-J. The agency shall study the baseline socio-economic status of the affected persons and the impact of the project on them, opportunities for them depending upon their qualification and aptitude. On the basis of these surveys and continuous interaction with the locale, an action plan shall be prepared in coordination with the CDS cell. A budgetary provision of Rs. 2,00,000 is kept for this purpose.

- **Establishment of "participative mechanisms":** Each affected village will first be motivated and facilitated to form community-based organization henceforth termed as Community Welfare Committee (CWC). These committees shall be registered under Societies Registration Act in the preparatory phase itself before taking up any work. The authorized representative nominated by District Magistrate of Chamoli district shall be Patron of the committee. The committee shall have proper representation from all sections of the community with at least 50% of members being the female, with the total number of members being 7 to

10. It shall have two nominated members, one each by the local administration and the project authorities. The committee shall further nominate small groups known as User Groups promoting specific activities. The committee will focus its activities for socio-economic development as well as eco-restoration (based on micro- watershed level works) in the village. It shall be responsible for preparation of plans and their execution. The CDS cells shall co-ordinate and supervise the progress of works by the Community Welfare Committee, including providing funds. Cost for establishment and maintenance of Social Response Program cell is estimated in **Table 4.14.**

TABLE 4.14
COST ESTIMATE OF ESTABLISHMENT AND MAINTENANCE OF CDS CELL

S. NO.	ITEM	COST (RS)
1.	Capital Cost:	
	Office building 50 sqm. @ Rs 8,000/sqm.	4,00,000/-
	Office furnishings (computer, audio visual aid and furniture)	1,00,000/-
	Vehicle 1 no.	4,00,000/-
2.	Recurring cost:	
	Manpower for 60 months	
	R&R officer 1 no. @ Rs 25,000/month	15,00,000/-
	Support staff 1 no. @ Rs.10,000/month	6,00,000/-
	Vehicle running cost @ Rs. 3,000/month	1,80,000/-
	Office maintenance and consumables @ Rs. 10,000/month	6,00,000/-
3.	Advertisement and public contact programs @ 20,000/month	12,00,000/-
4.	Misc. and unforeseen expenses L.S.	2,00,000/-
	Total	**51,80,000/-**

4.8.3 Project Execution Mechanism

The Community Welfare Committee shall execute the program in following manner;

- The strategy for implementation will be sufficiently flexible to respond to the needs of individual village/groups. Participatory site-specific plan prepared by the Community Welfare Committee will form the basis of activity implementation. The implementation will be backed by trained social coordinator village level motivators and multidisciplinary activities related with horticulture and animal husbandry department.
- The social motivators especially in women section shall be trained to facilitate participation of community during planning and implementation process. A detailed sketch shall be drawn illustrating various forms of participation needed to execute the project. A proper accounting and reporting procedure shall be developed for this purpose.
- Financial assistance for the identified works shall be given in advance to Community Welfare Committee in installments. The cost of work shall be determined on the basis of norms of similar type of activities. In the first year community shall be given test activity on collective participation for protection of nearby degraded or depleted catchments patches and to develop these areas to meet fodder and fuel requirements.

4.8.4 Works to be carried out under CDS in project affected area (villages)

CDS is an essential component of the R&R to support PAPs for their betterment and also for the region. Following assigned works has been proposed to be carried out by the project developer under this segment in the project affected area.

4.8.4.1 Livelihood Enhancement Works

Depending upon the needs, following well-defined programs could also be undertaken in collaboration with the concerned department of State Government along with the enhancement of local training institution i.e. ITI and polytechnic.

- **Animal Husbandry:** Animal husbandry is one of the most important aspects of the rural community. Inputs shall be given as; introduction of nutritious grass cultivation, better stall feeding practices, awareness of animal health program, breed improvement and installation of mini community thresher. For all the five villages, a provision for Rs. **10 Lakhs** has been kept.
- **Horticulture and Medicinal Plants:** The works under this subhead shall be support for; growing fruit trees, nuts, oil seeds and medicinal plants. This would also include value addition, processing units, market research etc. It shall also a budget provision of **Rs. 10 Lakhs** for project area.
  - **Training and Others:** To develop skills for self employment, short training programs shall be organized to equip locals for self employment. A budgetary provision of **Rs 10 lakhs** shall be made for this purpose.

A budgetary provision of **Rs 30 lakh** shall be made for the livelihood enhancement works which includes animal husbandry, horticulture and development of medicinal plants and training for capacity buildings of the local people.

4.8.4.2 Public health Support

Under this head major concern areas of health at local level as well as at the site specific shall be identified and addressed. Priority shall be given in organizing health camps to cater weaker sections, distribution of medicine, etc. Emphasis shall be given on reproductive health and family welfare of the project area. A budgetary provision of **Rs. 25 Lakh** shall be made for this purpose.

4.8.4.3 Gender Support

Women folk shall be kept in the center stage in program implementation so that they can play an active role in socio-economic development of the area. A budgetary provision of Rs**. 10 lakh** shall be made for this purpose.

4.8.4.4 Infrastructure Development Support

Works like approach road to the villages, community-building etc. shall come under this head and a budgetary provision of **Rs 40 lakhs** has been kept for the purpose.

4.8.4.5 Education Assistance

Education is important to the local society and it plays an important role in capacity building for the people. If younger generation gets education, it equips skills and skills give opportunities in employments. The family members of PAFs may be given @Rs. 2000/month for pursuing technical education such as medical and engineering course. Education assistance shall also be used to enhance the facilities for students in the project region. It shall have a budget of **Rs. 20 lakhs** for educational assistance through distribution of course materials and scholarships for technical education on priority basis for project affected people as categorized in para 4.7.3.

4.8.4.6 Direct and Indirect Employment Opportunities in Project

At the project management level the project-affected people shall be involved in the employment generation at various ways like:

- Educating them to develop support supply systems for the construction workers.
- Creating contractual opportunities for suitable local agencies.
- Providing direct employment to suitable candidates at subordinate levels.
- Engagement in support activities like hiring of vehicles/ drivers, security guards, casual labour, etc.
- Providing shops in the colony.

4.8.4.7 Other Development Works in the Area

The project authorities taking a larger perspective of the social issues and overall development of the area may have identify some more works to be undertaken in addition to the works mentioned above, as listed below. Budgetary provision for these works has been made in the cost estimate of CDS works.

- Up gradation of the government medical Hospital Nandprayag. An x-ray machine for Rs. 3,00,000/- shall be purchased to upgrade and facilitate the hospital. The modern equipments as per the requirements indicated by the hospital doctors shall also be purchased for the cost of Rs. 2,00,000/-. In addition, a stock of life saving drugs / emergency medicines shall be procured and kept in the hospital, it shall have a budget of Rs. 5,00,000/-. The hospital building shall be repaired and painted. The work shall have a budget of Rs. 5,00,000/-. Total fund allocation for up gradation of the medical hospital is **Rs. 15,00,000/-.** The up gradation of hospital will provide medical facilities to the project staffs as well as the affected families in the region.

- The schools in project area shall be repaired and painted. If required, with the consultation of villagers and school teachers, the schools shall also be up graded. It may have a budget of **Rs. 5 lakhs.**

- Training and other support programs shall be organized as per the demand of the project affected families and local people. The project proponent shall organize vocational training to the PAPs. The training shall equip the PAPs to work either on the project assignment or earn their employment in the outside world. It may use **Rs. 5 Lakhs**.

- The people of affected villages have their own water supply system for drinking purposes and do not require additional support from the project authority. The water of the river Alaknanda is not used for drinking purposes. However supply of drinking water is very important for local people. If required up gradation and enhancement of water supply for the local people, a provision of **Rs. 5 Lakhs** shall be kept and used according to the demand of the local people.

4.8.4.8 Monitoring and Concerted Evaluation

A system shall be evolved to have a continuous feed back for implementation of the program. A separate body comprising the representatives from project management & public representatives shall be formed for monitoring and concerted evaluation of the CDS.

4.8.4.9 Public Information System and Grievance Redressal

It is one of the most important tools to keep a continuous interaction with the affected areas and to keep them informed with the actions, achievement and program underway. It shall have to be ensured that there is no communication gap between project authorities and the affected persons. The composition, powers functions of the grievance cell shall be as per prevailing norms, however it must include one male and one female from the project affected people. The project-affected-people could elect these representatives among themselves. Any aggrieved persons from the affected area could move his/her application to the cell and it is finally concluded.

4.9 Cost Estimate for CDS

The estimated cost of CDS works to keep a budgetary provision of **Rs. 233.80 Lakhs** shall be as given in **Table 4.15** below.

TABLE 4.15
COST ESTIMATE OF COMMUNITY DEVELOPMENT SCHEME

SL. NO.	ITEM	COST (IN LAKH RUPEES)
1.	Census survey and preparation of CDS report through an NGO/University	2.00
2.	Establishment and maintenance of CDS cell	51.80
3.	Works in affected villages through Community Welfare Committee	
	Payment to village motivators for 5 villages for 60 months @ Rs. 60,000 per annum	15.00
	Livelihood Enhancement Works	30.00
	Public health Support	25.00
	Gender Support	10.00
	Infrastructure Development Support	40.00
	Education Assistance	20.00
4.	Other development works in the area	30.00
5	Other works as per the need of local demand emerged urgently (the amount shall be reserved for social welfare/emergency which shall be spent with the approval of GM (project)	10.00
Total (Rupees Two Hundred Thirty Three Lakhs and Eighty Thousands)		**233.80**

4.10 COST ESTIMATE FOR R & R and CDS

R&R and CDS cost have been calculated in **Table 4.13** and **4.15** respectively. R & R Cost and CDS cost shall be taken in Environmental Cost of the project. The total R & R and CDS cost is Rs. 609.66 lakhs which is summarized in **Table 4.16**. The cost for R&R and CDS are indicative and based on the field studies and discussions with PAPs. The provisions of NRRP 2007 are also considered while preparing R&R plan. The cost of land may vary with the existing local land market and conditions. The CDS is also indicative in which few issues may be added if required after conducting the public hearing for the purpose and that cost would be the final budget for social. It is proposed that the budget allocated to the items of CDS may be converted from one head to another in consultation with the concerned officers of UJVNL, CWC and local people.

TABLE 4.16
TOTAL COST FOR R&R AND CDS

S.NO.	ITEM	COST (IN LAKH)
1.	Rehabilitation and Resettlement	837.75
2.	Community Development Scheme	233.80
	Total	**1071.55**

The socially sensitive project proponent is committed to develop the project area, so with the help of RITES social expert identified some issues in the project area for its sustainable development for that economical supports is proposed. Thus keeping all these the social budget for the project is approximately **Rs. 1071.55 lakhs**, which includes land cost for 9.604 ha of private land and other components for development of the project area and PAFs in totality.

4.11 EPILOGUE

The social impact assessment has been conducted for the project. The rehabilitation and resettlement plan has been prepared not only to compensate the affected families but also to regain/restore their previous life in a better economic condition. A community development scheme has also been formulated to upgrade and enhance the community life with comparatively better infrastructure facilities in the project area. The project developer shall look forward for the suggestions from stakeholders during each stage of the project cycle particularly during public hearing, when a larger gathering of the stakeholders is anticipated. Subsequently valuable suggestions from the stakeholders are likely to be collected, based on those suggestions, changes in the rehabilitation and resettlement action plan and community development scheme shall be made.

****

Annexure 4.1

List of PAF's

ANNEXURE – 4.1

LIST OF THE PAFS WITH THEIR LAND TO BE ACQUIRED

Village: Bowala		
S.No.	**Name**	**Area of Land (in ha) to be Acquired**
1.	Gopal Singh	0.229
2.	Dilip Singh	0.008
Village: Maithana		
1.	Balkrishan	0.162
2.	Basant Kumar	0.323
3.	Bhagwati Prasad	0.029
4.	Bishuda Nand	0.118
5.	Brij Mohan	0.028
6.	Chandra Prakash	0.167
7.	Chatura Prasad	0.135
8.	Durlabh Singh	0.480
9.	Devi Prasad	0.066
10	Dwarika Prasad	0.210
11	Gyananand	0.049
12	Ghapedu	0.029
13	Girija Prasad	0.050
14	Govind Prasad	0.046
15	Gyananand	0.049
16	Jag Mohan	0.108
17	Kali Ram	0.115
18	Kamla Kant	0.139
19	Kedari	0.025
20	Khanaya	0.057
21	Kosatakmani	0.137
22	Laxmi Prasad	0.056
23	Lokanand	0.126
24	Mahanand	0.018
25	Mahendra Kumar	0.058
26	Mukut Prasad	0.110
27	Purshotam	1.027
28	Ram Chandra	0.592
29	Rama Dhar	0.544
30	Satya Prasad	0.078
31	Satyeshwar Prasad	0.188
32	Tika Prasad	0.176
33	Tota Ram	0.049
34	Vijar Ram	0.080
Village: Dusat (Pole Nala)		
1	Avtar Singh	0.030
2	Jarkit Singh	0.152

3	Pushkar Singh Adi	0.040
Village: Pursari		
1	Poornanand	0.089
2	Uday Singh	0.353
Village: Nandprayag		
1	Deepak	0.226
2	Gopal Singh	0.182
3	Indu Devi	0.124
4	Madhusudhan	0.258
5	Milochana	0.082
6	Ram Singh	0.154
7	Ram Nand Lal	0.021
8	Surendra Singh	1.487
9	Uday Singh	0.662

Annexure 4.2

Questionnaire for Social Survey

Annexure 4.2

RITES Ltd., Gurgaon

QUESTIONNAIRE FOR SOCIAL SURVEY

State Code ☐☐ **District Code** ☐☐ **Block Code** ☐☐☐ **Village Code** ☐☐☐☐☐

1. IDENTIFICATION **NAME**

1.1 Village ☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐

1.2 Panchayat ☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐

1.3 Taluk/Tehsil ☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐

1.4 District ☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐

1.5 State ☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐

2. GENERAL INFORMATION

2.1 Name of head of the household: ……………………………………………………………………………

2.2 Name of the Respondent: …………………………………………………………………………………

2.3 Relationship of respondent with household head: ………………………………………………………… **(Use CODE)**

2.4 Religious Group: Hindu **- 1** Muslim **- 2** Christians **- 3** ☐
Jains **- 4** Others (specify) **- 5**

2.5 Social Group: SC **- 1** ST **- 2** OBC **- 3** ☐
General **- 4**

2.6 Family Pattern : Joint **- 1** Nuclear **- 2** Individual **- 3** ☐

2.7 Size of Family : Small (2-4) **- 1** Medium (5-7) **- 2** Large(Above 7) **- 3** ☐

3. FAMILY PARTICULARS *(Start from head of the household)*

Sr No	**Name of the member**	**Relation-ship to HH Head**	**Sex**	**Age (years)**	**Marital Status**	**Literacy Level**	**Usual Activity**	**Occupation**	
								Main	**Subsidiary**
3.1	3.2	3.3	3.4	3.5	3.6	3.7	3.8	3.9	3.10
1									
2									
3									
4									
5									
6									

7									
8									
9									
10									

Male **-1**	0-6 yrs **-1**	Married **-1**	Illiterate **-1**	Agriculture **-1**
Female **-2**	**7**-12 yrs. **-2**	Unmarried **-2**	Literate **-2**	Labourer **-2**
	13-18 yrs **-3**		Primary **-3**	Business **-3**
	19-35 yrs **-4**		Middle **-4**	Services **-4**
	36-60 yrs **-5**		H. S. **-5**	Others (specify) **-5**
	Above 60 **-6**		Graduate **-6**	
			P.G. **-7**	

4. FAMILY INCOME

4.1 Family income (annual)

Below 20,000/- **- 1**   20,001-50,000/- **- 2**   50,001-1,00000/- **- 3** ☐
1,00001-2,00000/- **- 4**   Above 2,00000/-- **- 5**

4.2 **Sources of Family Income**

Sr. No.	**Source**	**Income (Rs.)**
4.2.1	4.2.2	4.2.3
	Agriculture	
1.	Cultivation	
2.	Rental Value of land	
3.	Hiring charges of farm implementation	
4.	Activities allied to agriculture	
	Wages	
5.	Farm	
6.	Non-farm	
	Self-employment	
7.	HH industries	
8.	Artisan activity	
9.	Shop keeping	
10.	Trade/ business	
11.	Professional activities	
12.	Govt. Pvt. Sector	
13.	Remittance/ rent etc.	
14.	Others (specify)	
	Total	

5. ENLISTMENT

5.1 Whether included in voters list (if yes, checkup for the voters list and confirm domicility) ☐
Yes **-1**
No **-2**

5.2 If no, please give reasons ☐
1………………………
2………………………

5.3 Does your family hold a ration card? ☐
Yes **-1**
No **-2**

5.4 If yes, since when?

5.5 If No Why? 1…………………………
2…………………………

6. PARTICULARS OF FAMILY ASSETS

Land Holdings:

Land particulars	Area (ha)				Estimated value/ha (Rs.)	Sources of irrigation Well - 1 Tank -2 Canal -3 Tube well -4
	Owned (1)	Leased in (2)	Leased out (3)	Operational holding (1+2-3)		
a. Cultivated Rainfed (1) Irrigated (2)						
b. Uncultivated Permanent Fallow (1) Short-term Fallow (2)						
c. Total land						

6.2 Agricultural Equipments owned

Instruments	Number	Current Value (Rs.)
Pump sets		
Tractors		
Ploughs		
Bullock Cart		
Harvester		
Other (Specify)		

6.3 Livestock owned

Livestock type	Number	Current Value (Rs.)	Expenses (Monthly Rs.)	Income (Monthly Rs.)
Bullock				
Buffalo				
Cow				
Sheep/ Goat				
Poultry				
Pigs				
Other (Specify)				

6.4 Consumer Durable Owned

Type	Number	Current Value (Rs.)
Radio		
Tape Recorder		
Bi-Cycle		
Two Wheeler		
Gas Stove		
Gober gas plant		
Other (Specify)		

6.4 Other Assets owned

Type	Number	Current Value (Rs.)
Farm house		
Pump house		
Storage/Godown		
Open well		
Tube well/Bore well		
Fruit Bearing Trees *(Please mention name of trees)*		
Non- Fruit Bearing Trees *(Please mention name of trees)*		
Other (Specify)		

7. HOUSING DETAILS

House ☐

Owned - **1**
Rented - **2**
Transit shed - **3**

7.2 If rented Rent per month (Rs.) ☐☐☐☐

Plinth area of the house (in Sq. m.) ☐☐☐

7.3 Area encroached (in Sq. m.) ☐☐☐

Is your construction legalized? ☐

Yes - **1**
No - **2**

If yes, are paying house tax? ☐

Yes - **1**
No - **2**

7.5 Is the construction an encroachment?

Yes -1
No -2

7.6 If yes, since when and how much

Since (in Year)

Annual amount (Rs.)

7.7 Type of construction

Kutcha - 1
Pucca - 2
Mixed - 3

7.8 Year of construction

7.9 Stored of house

Independent - 1
Multiple block - 2

7.10 Condition of house

Bad - 1
Worst - 2
Fair - 3
Good - 4

7.11 Is the house electrified?

Yes - 1
No - 2

7.12 Is it a legalized connection?

Yes - 1
No - 2

7.13 Average monthly electricity bill Amount (Rs.)

7.14 Drinking water facilities

Available near house - 1
Not available - 2

7.15 If drinking water not available near the house, please mention distance at which available Distance (in k.m.)

7.16 Source of drinking water

Well - 1
Tube well - 2
River/canal - 3
Other (specify) - 4

7.17 Does the house consist a

* Separate bathroom
Yes -1
No -2
* Separate sanitary latrine
Yes -1
No -2

8. CROPPING PATTERN AND YIELD LEVELS

Season	Rainfed				Irrigated			
	Crop name	Area Cultivated (sq.mts.)	Yield (Qts.per ha)	Rate per Qt. (Rs.)	Crop name	Area Cultivated (sq.mts.)	Yield (Qts.per ha)	Rate per Qt.(Rs.)
Kharif								
Rabi								
Summer								

Acre = 0.4047 Ha. **100 Acre = 40.47 Hectare**

ENTER THE AREA IN HECTARE ONLY

9. COMMERCIAL /SELF-EMPLOYMENT ACTIVITIES

9.1 Name of the Owner of the structure (Commercial): ………………………………………………………………………

9.2 What is the type of business? ☐
- Individual **- 1**
- Partnership **- 2**

9.3 When was the business activity started in this structure? Year…. ☐☐☐☐

9.3 Whether the business activity has license? ☐
- Yes **- 1**
- No **- 2**

9.4 Type of structure ☐
- Kutcha **- 1**
- Pucca **- 2**
- Semi pucca **- 3**

9.6 Year of Construction ☐☐☐☐

9.7 Type of finished goods/services sold: ☐
- Grocery **- 1**
- Pan shop **- 2**
- Vegetables/fruits **- 3**
- Hotel **- 4**
- Fancy item **- 5**
- Bicycle/scooter repairing **- 6**
- Cloth/Dresses **- 7**
- Tailoring **- 8**
- Clinic **- 9**
- School/College **- 10**
- Electrical work **- 11**
- Manufacturing **- 12**

(Specify product)
Others (specify)

10. ANNUAL EXPENDITURE (*last year*)

Sl.No.	Item	Expenditure (Rs.)
1.	Food	
2.	Clothing	
3.	Shelter (rent/repair/tax)	
4.	Education	
5.	Transportation	
6.	Fuel	
7.	Loan repayment	
8.	Medical	
9.	Animal husbandry	
10	Water bill	
11	Telephone bill	
12.	Others	
13.	TOTAL	

11. INDEBTEDNESS

Source	Amount Borrowed (Rs.)	When Borrowed (Year)	Purpose of Borrowing	Rate of interest per annum	Amount outstanding as on date
Institutional					
1					
2					
3					
Non-Institutional					
1.					
2.					
3.					

12. FAMILY OBLIGATION DURING THE NEXT 10 YEARS

Sl.No.	Obligation	Amount needed (Rs.)
1.	Family maintenance (annual)	
2.	Old age livelihood	
3.	Education	
4.	Marriage	
5.	Others	
6.	TOTAL	

13. PARTICULARS OF CHRONIC ILLNESS IN THE HOUSEHOLD

Sl.No.	Name	Age	Sex	Nature of Illness	Since when	Treatment undergone
1.						
2.						
3.						
4.						
5.						

14. TYPE OF EFFECTS/LOSS

14.1 Type of effect ☐

Losing entire house	- 1
Losing a part of the house	- 2
Losing house + entire land	- 3
Losing a part of house+entire land	- 4
Losing a part of house+part of land	- 5
Losing house + part of land	- 6
Losing entire holding	- 7
Losing part of holding	- 8
Losing house + economic bases	- 9
Losing economic bases	- 10

15. REHABILITATION AND RESETTLEMENT

15.1 In case you are displaced (residentially where and how far you prefer to be located? ☐

Within the village	- 1
Outside the village	- 2

Place name: ………………………………………..

Distance (in k.m.) ☐☐☐

15.2 What do you expect from government for relocation? (Multiple answers) (√)

1. House site ☐
2. Constructed house ☐
3. House construction assistance ☐
4. Shifting expenses ☐
5. Others (specify) ☐

15.3 What assistance do you need in the process of rehabilitation in the new place? (Multiple answers) (√)

1. A site for shop/work place ☐
2. A constructed shop/shed ☐
3. Assistance for construction ☐
4. Assistance in reestablishment of shop/economic activity ☐
5. Finance for operational expenses ☐
6. Others (specify) ☐

15.4 Incase you loose agricultural land, what assistance do you require in recovering this loss? (Multiple answers) (√)

1. A land for cultivation ☐
2. Assistance for taking up allied activities ☐
3. Irrigation to the left over land ☐
4. Crop loan ☐
5. Others (specify) ☐

16 Special comments and remarks of the investigator:

Annexure 4.3

PAFs and Interviewed PAFs with Their Land to be Acquired

ANNEXURE – 4.3

PAFs AND INTERVIEWED PAFS WITH THEIR LAND TO BE ACQUIRED

Village: BOWALA			
S.N.	Name	Whether Interviewed	Area of Land (in ha) to be Acquired
1.	Gopal Singh	Yes	0.229
2.	Dilip Singh	Yes	0.008
Village: MAITHANA			
1.	Balkrishan		0.162
2.	Basant Kumar		0.323
3.	Bhagwati Prasad		0.029
4.	Bishuda Nand	Yes	0.118
5.	Brij Mohan		0.028
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8.	Durlabh Singh	Yes	0.480
9.	Devi Prasad	Yes	0.066
10	Dwarika Prasad	Yes	0.210
11	Gyananand		0.049
12	Ghapedu		0.029
13	Girija Prasad		0.050
14	Govind Prasad		0.046
15	Gyananand	Yes	0.049
16	Jag Mohan	Yes	0.108
17	Kali Ram	Yes	0.115
18	Kamla Kant		0.139
19	Kedari		0.025
20	Khanaya		0.057
21	Kosatakmani		0.137
22	Laxmi Prasad		0.056
23	Lokanand		0.126
24	Mahanand	Yes	0.018
25	Mahendra Kumar		0.058
26	Mukut Prasad		0.110
27	Purshotam		1.027
28	Ram Chandra		0.592
29	Rama Dhar	Yes	0.544
30	Satya Prasad	Yes	0.078
31	Satyeshwar Prasad		0.188
32	Tika Prasad	Yes	0.176
33	Tota Ram		0.049
34	Vijar Ram		0.080
Village: Dusat (Pole Nala)			
1	Avtar Singh	Yes	0.030

2	Jarkit Singh		0.152
3	Pushkar Singh Adi	Yes	0.040
Village: Pursari			
1	Poornanand	Yes	0.089
2	Uday Singh	Yes	0.353
Village: Nandprayag			
1	Deepak	Yes	0.226
2	Gopal Singh	Yes	0.182
3	Indu Devi	Yes	0.124
4	Madhusudhan		0.258
5	Milochana	Yes	0.082
6	Ram Singh	Yes	0.154
7	Ram Nand Lal	Yes	0.021
8	Surendra Singh	Yes	1.487
9	Uday Singh	Yes	0.662

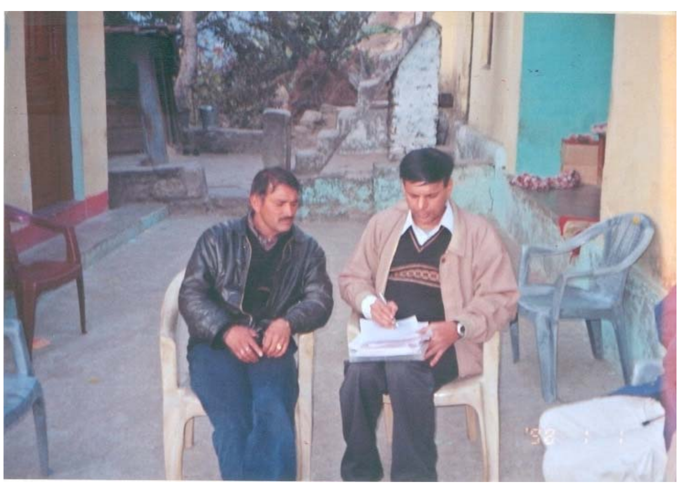
Annexure 4.4

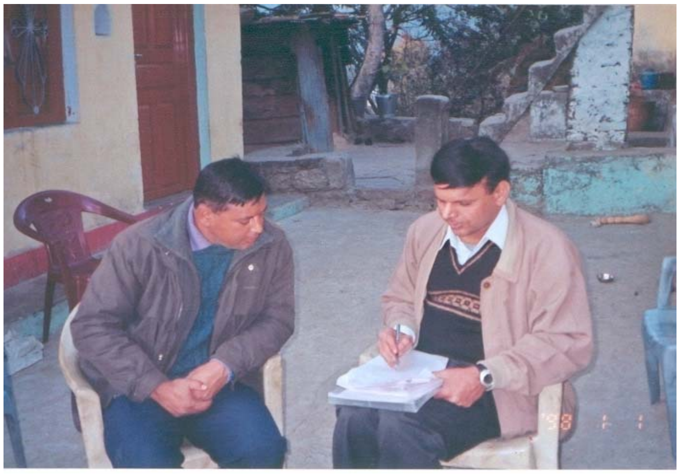
Public Consultation

ANNEXURE-4.4

PUBLIC CONSUTALTION

SOCIAL SURVEY





Chapter –5

Environmental Impacts

CHAPTER-5
ENVIRONMENTAL IMPACTS

5.1 GENERAL

In the process of development there has been intensive use of natural resources, very often leading to ecological imbalance. With rapid strides in economic development, the need for rationalizing the development has become imperative. In pursuance of the global goals of conservation of nature and protection of environment, the union and state governments have initiated plans, schemes and actions to implement various legislation, the latest being the Environment (Protection) Act, 1986 with it's amendments. In May 1994, and September 2006 MoEF had issued a notification on EIA for developmental projects. Schedule of this notification has a list of the projects, which need environmental clearance. River valley projects (including hydropower) are included in this list. Following Acts, Rules and Standards have been consulted for the purpose of this study:

- *Environmental (Protection) Act 1986, amended in 1991.*
- *Water (Prevention and Control of Pollution) Act 1974, amended in 1988.*
- *Forest (Conservation) Act 1980, amended in 1988.*
- *Air (Prevention and Control of Pollution) Act 1981, amended in 1987.*
- *The Wildlife (Protection) Act, 1972, amended in 1993.*
- *The Environmental Clearance Notification, 1994, 2006*
- *The National Environmental Appellate Authority Act, 1997.*
- *National Forest Policy, 1988.*
- *Noise Pollution (Regulation and Control) Rules, 2000.*
- *Ministry of Environment and Forest, Guidelines for EIA for River Valley Projects.*
- *River Valley Projects & Environment: Concerns & Management, CWC, 2001.*
- *National Policy on Resettlement &Rehabilitation for Project Affected Families – 2003, MORD (2004).*

In projects like this, which involve large-scale construction activities, conservation of ecological environment including the flora and fauna is an important aspect to be considered vis-a-vis the economic development. Potential negative and positive impacts of the proposed project have been assessed in this chapter.

5.2 IMPACT IDENTIFICATION

The environmental impact assessment process begins by identifying the development and operational activities resulting from the proposed project. Potential impacts due to the proposed hydroelectric project on the environment in different phases of the project cycle namely location, construction and operation have been identified. The type and magnitude of the impacts however, depend on the specific attributes of the given environment. As far as possible, attempts have been made to quantitatively predict the impacts due to the project. For non-quantitative impacts, qualitative assessment has been done. Potential impacts on environmental components due to the proposed hydroelectric project activities have been summarized in **Table 5.1.** The impacts due to project location are generally irreversible and could be mitigated through environmental enhancement measures. Impacts related to construction are normally short term, which can be set-off by observing a simple set of precautionary measures.

TABLE 5.1
POTENTIAL ENVIRONMENTAL IMPACTS OF THE PROJECT

	PRE CONSTRUCTION	CONSTRUCTION PHASE							OPERATION PHASE
		CONTRACT-ORS CAMP, SERVICE ROADS	SITE CLEARANCE	EXCAVATION FOR FOUNDATION / TUNNEL ADITS	BARRAGE / INTAKE WORKS POWER HOUSE, TAIL RACE WORKS	TUNNELING (HRT/ TRT)	RESIDENTIAL COLONY AND SERVICE BUILDINGS	CATCHMENT AREA TREATMENT	E &M PLANT
SOIL	-	Increase in soil erosion	Increase in soil erosion due to loss of vegetation	Increase in soil erosion and loss of soil cover	Increase in soil erosion	-	Increase in soil erosion	Decrease in sediment load. Stabilization of slopes	-
SURFACE WATER	-	Water pollution from sanitary and other wastes	Increase in silt load due to loss of vegetation	Increase in silt load	Increase in silt load	Increase in silt load due to muck dumping	Increase in silt load	Decrease in sediment load	-
DRAINAGE	-	-	Change in drainage pattern			-	Change in drainage pattern	-	-
AIR QUALITY	-	Air Pollution due to fuel burning	-	Increase in SPM, NOx & SO_2		Air Pollution due to muck dumping	Increase in SPM, NOx & SO_2	Improvement in air quality	-
NOISE LEVEL	-	-	Reduced buffering of noise due to loss of vegetation	Increase in noise level due to construction plant & machinery				Creation of noise buffer due to plantation	Increase in noise level
FOREST / VEGETATION	Tree cutting / site clearance	Loss of vegetation / trees						Reforestation	-
AQUATIC LIFE	-	-	-	-	Reduction in flow between barrage and TRT	-	-	-	-
SAFETY				Health effects of workers.					
INFRASTRUCTURE				-					
OTHERS	-	-	-	Cultural Effects			Increased human activity	-	-

5.3 ENVIRONMENTAL IMPACTS

This section identifies and appraises various negative impacts likely to result from the proposed development as reported under **Chapter-2,** on environmental baseline conditions as reported in **Chapter-3.** Negative impacts likely to result from the proposed development on land, water, air, noise, ecology and socio-economics have been listed under various phases of project cycle under the following headings:

- Impacts due to project location
- Impacts due to construction works, and
- Impacts due to project operation

5.4 IMPACTS DUE TO PROJECT LOCATION

The environmental impacts, which may take place due to location of the project, are as under:

- Loss of land / Change in land use,
- Encroachment into forest/Govt. land,
- Encroachment into wildlife habitat/corridor,
- Loss of historical, cultural and religious monuments/structures,
- Loss of Infrastructure,
- Sediments,
- Disruption of hydrological balance,
- Risk due to earthquake,

5.4.1 Loss of Land/ Change in Land use

Permanent change in land use shall be due to construction of various permanent features of the project on ground like; barrage, head regulator, sedimentation tank, head race tunnel, surge tank, penstock, power house, tail race works. and colonies. Land will also be required for Infrastructure facilities like access road and storage of magazines and for dumping areas. **Table 5.2** reports the land requirement along with its category for various facilities of the project. It is observed that out of the total 81.004 hectare land requirement of the project, 10.43 is reserve forest, 27.92 ha is Van panchayat, 21.99 hectare is Civil Forest, 9.604 ha is private land, and remaining 11.06 hectare is Underground land. The project, however, does not require any built-up area. Land acquisition plan has been presented as **Figure 5.1**

FIGURE 5.1
LAND ACQUISTION PLAN

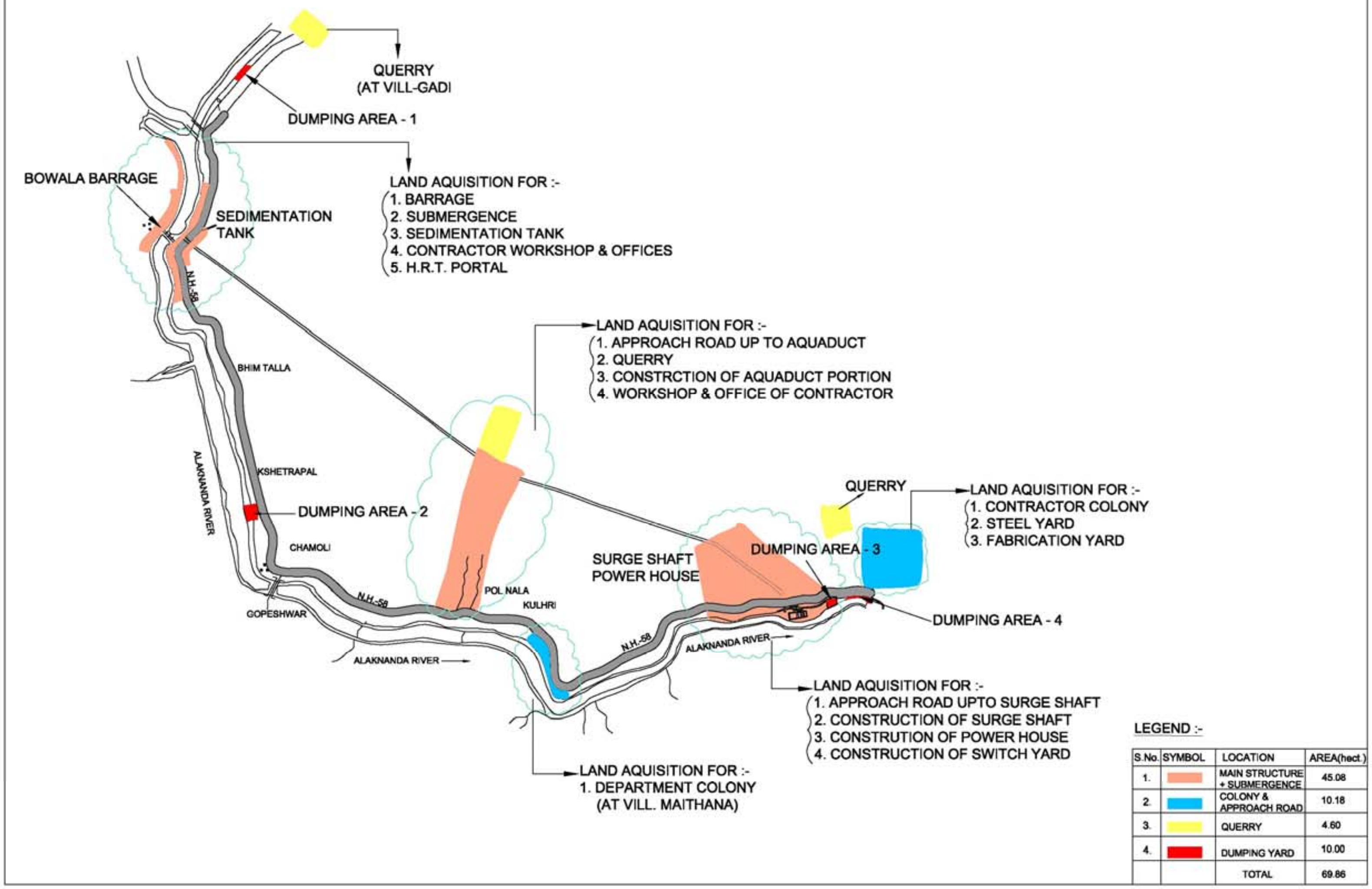


TABLE 5.2
LAND REQUIREMENT FOR THE PROJECT (hectare)

Location	Type of Land				Total
	Reserve Forest	Van Panchayat	Private	Civil Forest	
Barrage Site including Desilting Chamber	6.63	9.282	0	7.432	23.344
Pol Nala Adit	0	4.971	0.02	0.017	5.008
Surge Shaft and Power House	0.2	13.667	0.442	2.498	16.807
Quarry	3.6	0	0	1	4.6
Dumping Area	0	0	0.506	9.5	10.006
Colony and Approach road	0	0	8.636	1.543	10.179
Sub Total	**10.43**	**27.92**	**9.604**	**21.99**	**69.944**
Under Ground land					**11.06**
Grand Total					**81.004**

5.4.2 Encroachment into Forest/Govt. Land

The proposed project envisages acquisition of 10.43 hectares of Reserve Forest Land, 27.92 hectares of Van panchayat and 21.99 hectares of Civil Forest **(Table 5.2)**. During construction and operation of the project, there may be efforts to collect wood from nearby forest for various purposes legally or illegally, which can affect the forest. This shall be avoided as LPG to the workers shall be provided as per the provision shown in this report.

5.4.3 Encroachment into Natural Reserves Wildlife Habitat/Corridor

The project area of 10-km radius with barrage site as its center does not encroach into any wildlife sanctuary or any other type of natural reserve. No rare or endangered species of wildlife/trees have been reported within the 10-km radius area. Villagers reported stray incidences of sighting wild animals like Common Leopard, Himalayan black bear, Jungle Cat, Goral and Monkeys etc. in the area, which otherwise infest in deep jungles. There is no indication that the project area functions as a corridor for movement of wildlife. It could, therefore, be concluded that the project would not have any impact on the wildlife. Scanning the status of herbs present in the project area revealed only one herb species, *Blepharis maderaspatensis* (L.) was found to be a rare species Few shrubs and herbs of medicinal value are also observed in the study area

5.4.4 Loss of Historical, Cultural and Religious Monuments/ Structures

No historical, religious or cultural monuments will be lost due to the project location or its activities.

5.4.5 Loss of Infrastructure

Infrastructure comprises of schools, hospitals, establishments, communication, post offices, community resources, etc. There is no house or structure coming under this project. Only agricultural land would be required for various project facilities.

5.4.6 Disruption of Hydrological Balance

The proposed barrage has been sited near village Bowala on river Alaknanda about 800m downstream of confluence of Birehi Ganga with river Alaknanda. The flow of water in the stretch from barrage site to power house site would be affected due to the construction of barrage and diversion of water. The flow of water in about 11 km long stretch of the river, downstream of the barrage site, would be affected due to the construction of barrage. However, there are many streams/nallahs, which join between barrage and confluence of tailrace channel from powerhouse and out fall into the affected stretch. There are four perennial tributary between barrage and power house which joins Alakhnanda river. These perennial tributary are Bhim Dhara (3 d/s from Barrage), Bal Khila (7Km d/s of Barrage) Pole Nala (8 km d/s from Barrage), Pursadi Nala (12 Km d/s of Barage). Some seasonal streams also join the Alakhnanda river between the point of diversion and the tailrace outlet. These perennial streams have a total discharge of more than 85.65 cusec (2.42 cumec). The total streams/nallahs between the diversion location and Tail Race location, which are perennial in nature, on the left bank are 3 and one on the right bank. A minimum sacrificial flow of about 4.3 cumecs would also be maintained from barrage. This total lean season discharge of 6.72cumecs would be available to the local downstream villages, as the waters from these streams are not planned to be tapped by the Project. It is observed during site inspection that water is not drawn from the affected portion of the river (between barrage site and power house) for irrigation or any kind of industrial use. The people residing in the nearby locality rarely use it for washing, bathing etc. Water supply in villages is done by storing water in a reservoir from natural streams and then it is conveyed through piped supply in the villages. Impacts of only minor magnitude are anticipated on the hydrological balance of the project area. The available downstream discharge is given in **Table 5.3**

TABLE-5.3
DOWNSTREAM DISCHARGE IN ALAKHNANDA RIVER

S.No.	Name of Stream	Distance from Barrage	Discharge (cumec)
1	Bhim Dhara	3.0km (L/B)	0.045
2	Pole Nala	8.0km (L/B)	0.062
3	Pursadi Nala	12.0km (L/B)	0.097
4	Bal Khila	7.0Km (R/B)	2.220
		Total	**2.42**

5.4.7 Risk due to Earthquake

The project area falls in zone IV of the Indian Standard Seismic Map and quite sensitive from seismic point of view. For safety of the structures, necessary factors and appropriate co-efficient have to be incorporated in designing the structures under worst combination of forces. Provided with the appropriate design of the barrage, tunnel, penstock, power house and other structures of the scheme, the risk due to earthquake can be minimized to desired limits. With the available experience, it has been scientifically established that water retaining structures, using modern methods of design and construction can safely withstand high intensity earthquakes. The experience of tunneling in Tehri Hydro electric project and other Himalayan region projects of similar nature would provide important data in this aspect.

5.5 IMPACTS DUE TO PROJECT CONSTRUCTION

Although environmental hazards related to construction works are mostly temporary in nature, this does not mean that these should be given less importance. Appropriate measures need to be included in the work plan and budgeted for. The most likely hazards related to the construction works are:

- Increased Soil Erosion at Construction Sites,
- Muck Generation from Tunneling Operation,
- Transportation of Muck and Construction Material,
- Health Risks,
- Cultural Effects,
- Air Pollution
- Noise Pollution,
- Water Pollution and Quality,
- Quarry including crushing operations
- Impact of Tunneling on Surface and Groundwater Resources,
- Safety Hazards of Tunnel Construction.
- Landslide

5.5.1 Increased Soil Erosion at Construction Sites

Any ground-breaking activity for construction works, whether permanent or temporary, would require removal of vegetation cover from ground. Runoff from unprotected excavated areas, muck disposal sites, quarry sites, etc., would result in increased soil erosion. Excavations on slopes would also decrease its stability. Given with the topography of the area, unprotected excavations on sloping grounds will make them landslide prone sites, especially during the rainy season. Excessive soil erosion and mass movement of soil is likely to disrupt the natural drainage, which can lead to impounding of runoff in dangerous preposition.

5.5.2 Muck Generation from Tunneling Operation

About 24,00,000 cum of muck would be generated from various construction activities, out of which 3,00,000 will be used for backfill. 21,00,000 cum needs to be disposed in nearby area. Muck disposal sites shall present large surfaces with loose soil liable to erosion. The disposal sites, are to be designed properly to prevent mass movement of soil blocking the natural drainage and causing other sequential problems.

5.5.3 Transportation of Muck and Construction Material

As mentioned in previous paragraph, 21,00,000 cum of muck will have to be transported from various construction activities to the dumping site. Considering that one dumper trip carries 6 cum muck and the construction activities are completed in 60 months, each month having 26 working days, there would be about 224 dumper trips every working day. Coarse aggregate and stones shall have to be transported from quarry site/source to the stone crusher and further from crusher to various construction sites. Transportation of this material would add SPM and other vehicular pollutants to the local air shed.

In addition, about 295000 tonnes of cement, 17000 cum of stone, 18693 tonnes of steel, and electrical/ mechanical equipment will have to be transported from Rishikesh/ Haridwar Dehradun. The increased traffic on the roads would also increase air pollutions though; the same would disperse in the vast volumes of available clean background air not having any noticeable impact on the air quality along these routes.

5.5.4 Health Risk

Health risk during construction phase of the barrage and other works, include disease hazards due to lack of sanitation (water supply and human waste disposal), vector borne diseases and hazards due to local carriers. About 3000 people are expected to be working during peak construction period at project site. Therefore, mitigation measures must include proper sanitation, health care and human waste disposal facilities. Sanitation facilities are included in the project estimate to take care of cost towards human waste disposal facility during construction.

5.5.5 Cultural Effects

The district of Uttrakhand has its unique culture. People of this area have distinct habits of food and clothing. They have deep religious faith and celebrate their festivals with great enthusiasm. During construction phase cultural exchanges would be possible because of difference in customs of outside workers and local residents.

5.5.6 Air Pollution

Consumption of fuel in construction activities and movement of construction vehicles will be the principal cause of increase in air pollution. Diesel powered trucks used for the haulage of construction material and running of construction machinery at the construction sites are the sources of air pollution. The data on fuel utilization rates of the units expected to be in operation during the construction are provided in **Table 5.4.**

TABLE 5.4
FUEL CONSUMPTION RATES FOR CONSTRUCTION MACHINERY

MACHINE	FUEL CONSUMPTION IN LITERS/ HOURS
Cement Concrete Mixer	7
Cranes with Clamshell Bucket	8
Generator	30
Truck	8
Bulldozer	20
Graders	12
Rollers	20
Excavators	20
Dumpers, Trucks & Tippers	18
Water Tanker	8

About 550000 cum of coarse aggregate would have to be produced by crushing the rock/boulders, which would require crusher working for 10-12 hours a day during the peak construction period. Operation of the stone crushers would add noise and air pollution to the local air shed.

Background concentration of air pollutants, as reported in **Chapter-3,** is very low. The increase in concentration of air pollutants during construction would be of temporary nature and would remain well within the prescribed limits. The project is unlikely to cause any kind of air pollution during operation. It is, therefore, considered that the project will not cause any air pollution of any significance.

5.5.7 Noise Pollution

The major sources of noise pollution during construction are movement of vehicles for transportation of construction material to the construction yard and the noise generating activity at the yard itself. The primary noise generating activities at construction yards can be:

- Blasting & Drilling,
- Crushing of rock/ boulders
- Concreting & Mixing,
- Casting and Material movement.

Expected noise levels due to operation of various construction machinery at site are indicated in **Table 5.5.**

TABLE 5.5
TYPICAL NOISE LEVELS OF CONSTRUCTION EQUIPMENTS

S. NO.	MACHINE	dB(A)
1	Drilling Machine	120-130
2	Motor Scraper	85-95
3	Face Shovel	80-90
4	Dump Truck	80-90
5	Compactor	81-85
6	Dozer	80-85
7	DG Set	80-110
8	Pumps	80-100
9	Grouting m/c	100-120

Source: US Environmental Protection Agency, Noise from Construction Equipments & Operations

As seen from the above table, construction activities are expected to produce noise levels at source in the range of 80-130 dB (A), which will decrease with increase in distance. The construction works will be carried out during the daytime. The impact of noise produced during the construction will, however, be limited to a distance of about 50 to 200 meters at which the noise level of various equipment will come down below 55 dB (A). It could therefore be concluded that the construction activities would not have a significant impact on existing ambient noise levels. Due to the high noise levels of construction machinery, the personnel operating the machines and the workers stationed close to the machines are prone to exposure of high levels of noise. There are no sensitive receptors around the project site to have direct noise impact due to construction activity.

5.5.8 Water Pollution and Quality

The major sources of water pollution downstream during construction phase may occur due to one or more of the following reasons:

- Soil erosion
- Wash water from plant and machinery
- Sewage and waste disposal

Silt and mud transported downstream during construction may lead to water pollution. The dissolved oxygen (DO) content gets reduced ultimately affecting the aquatic life. The DO level below 4 mg/l hampers aquatic life. Careful planning of excavation and disposal/reuse of excavated material can prevent the silt transport downstream. The wash water from equipments and workshop yard may cause water pollution downstream. Since the plants and yards are proposed to be located away from the riverbank, there will not be any water pollution. Sewage and waste disposal from labour camp colonies pollute the water if released in river. During peak construction period about 3000 labours will be employed. Considering per capita water requirement as 70 lpcd, peak water demand during construction phase of the project is estimated as 210 KL per day. The total sewage production will be about 0.80 x210 = 168KL/day. Total BOD load contributed by the domestic sewage will be about 240-kg/ day considering the BOD load as 80g/per capita per day. The sewage from workers camp and other establishments need to be treated before its final disposal.

5.5.9 Quarry Operation

The project would require about 5,50,000 cum of stone/river boulder to fulfill the requirement of coarse aggregate and stone for construction, which shall be quarried from the riverbeds of Alakhnanda River and by crushing nearby available boulders. Location of quarries has been identified as shown in **Figure 5.1.** Excavation on hill slope shall have its impact on the stability of slope, whereas excavation in riverbed shall increase the turbidity of water temporarily. The quarrying operation may cause dust pollution. However, the impact of dust pollution will be temporary and can be minimized by regular sprinkling of water to suppress dust during the working season. The proposed quarry sites do not have any wildlife corridor hence impact on wildlife due to quarrying is insignificant. The quarrying operation will lead to clearance of vegetation for approach and excavation. Restoring the area by revegetation can mitigate this impact on vegetation.

5.5.10 Impact of Tunneling on Surface and Groundwater Resources

It is established that blasting/digging activities can cause building up of excessive water pressure at particular location, which may lead to shift in the position of a spring or reduction in the flow rate of spring, but complete drying of springs is not likely.

Tunneling work could result in ruptures in the overburden layers, through which water may leak into the tunnel during construction. The water leakage could result in drying of the groundwater source i.e. springs falling in the tunnel influence zone and channels crossing the tunnel alignment. The leakage may also result in lowering down of the ground water table in the tunnel influence zone. Water resources of Sendungra, Rupa. Dusadgaon, Harmani, Baratt which fall in the vicinity of the tunnel alignment, may be affected. In case of drying up of any water resources in the vicinity of the Project area alternative water supply shall be provided.

It would be pertinent to mention here that water leakage into the tunnel from overburden can occur only during the construction period until the lining is done. However, after concrete lining there would not be any chances of leakage into the tunnel and hence on ground water resources.

5.5.11 Safety Hazards of Tunnel Construction

At one time, tunnel accidents claimed one life for every half mile of tunnel constructed. Increased concern over tunnel construction safety has led to improvements in the miner's working conditions, with a subsequent reduction in the frequency of death and disabling accidents. However, accidents still occur at more than twice the frequency for underground workers compared with other construction workers, and three times the rate for manufacturing workers. Approximately the same ratio applies to fatalities. Obviously there is a need for more care in the underground works. The major causes of these accidents are; Uncontrolled contact between personnel and material or equipment; failure of temporary structure; Inherent construction hazard such as use of explosives and unsafe practices or carelessness by individual workers.

5.5.12 Landslides

Besides earthquakes, landslide is another natural hazard, frequent in the mountainous terrain. Landslides in the region is triggered by downslide movement of soil, debris and rocks, resulting from natural causes, vibrations, overburden of rock material, removal of lateral supports, change in the water content of rock or soil bodies and blocked drainage, etc. The mass movement varies in magnitude from soil creep to landslides. Loss of life; damage to houses, roads and other means of communication, agricultural land; and floods are some of the major consequences of landslides in the mountainous region. Flash floods, particularly in the narrow river gorges are one of the leading causes of landslides. These in turn jeopardize the stability of the hill as a whole.

The approach roads will have to be constructed as a part of the access to the construction site. In a hilly environment, construction of roads sometime disturbs the scenic beauty of the area. In addition, landslides are often triggered due to road construction because of the loosening of rocks by water trickling from various streams. In the proposed project new road to the power house, switchyard and access road to the aqueduct site in Pol Nala is to be constructed. Some improvements in the existing roads will also be needed

5.6 IMPACTS DUE TO PROJECT OPERATION

The impacts due to project operation shall be long term and can be both positive and negative in nature. The positive impacts are discussed in para 5.7. The negative impacts could be:

- Deforestation,
- Effect on Wildlife,
- Increased Incidence of Water Borne Diseases,
- Impact on Aquatic Life and Fish Migration and
- Public Health Facilities

5.6.1 Deforestation

During operation phase, all the activities and the staff will be mostly confined to the Power House area which is far away from the forest thus it will not affect forest area. On the other hand the requirements of fuel wood for heating and cooking will be replaced by cheap electricity generated by hydropower projects, ultimately reducing deforestation.

5.6.2 Effect on Wildlife

Most of the human population as well as its activities in the Himalayan terrain in which the project is located are concentrated in the river valleys due to availability of some agricultural land and perennial source of water. The human activities have already pushed the wild life away from these places. The operation of project would increase the human activities in the area, however, it is not expected to affect the wildlife which is already away from the project area.

5.6.3 Increased Incidence of Water Related Diseases

The factors enhancing the proliferation of water related diseases are vectors and pathogens. Stagnant water and vegetation provide favorable breeding places for vector life such as mosquitoes and snails. The project being a run of the river scheme, does not have any significant impoundment of water. Regular testing of water for these factors would be carried out for prevention & control of water borne diseases. Additional health facilities will improve the future status. However, field survey showed that the typical vector borne diseases are not common in the project area.

5.6.4 Impact on Aquatic Life and Fish Migration

A very small population of fish has been reported in the river water. To keep them alive a minimum perennial flow would have to be maintained. Minimum water requirement downstream of barrage/head works will be maintained for survival of aquatic life. The length of river in which the flow will be reduced due to withdrawal of water in between barrage and tailrace tunnel is just 11.0 km. In downstream, arrangement will be made to release a minimum sacrifice discharge of 4.3 cumec.

Also small perennial streams are feeding the Alkhananda river between diversion works and the powerhouse. Due to very steep bed slope, velocity of flow in river Alkhananda is higher than 0.42 km/hr in all the seasons hence no spawning habitat for fish is found in the river. The present flow at 0.5m depth at three downstream points of Barrage is presented in **Table 5.6** below. As seen the sacrificial discharge of 4.3 cumec is more than the present actual flow.

TABLE 5.6
DISCHARGE AT 0.5M DEPTH

S.No.	Location	Distance from Barrage Axis (m)	Present Discharge (Cumec)
1	Chinka Bridge		3.570
2	Miathana Bridge		2.724
3	Bowala Nand Pryag G&D Site		1.233

Fish spawning in flowing water depends on the velocity of water as under:

S. NO	SPAWNING FEATURES	VELOCITY (km/hr)
1	Span dispersed irregularly	0.0
2	All spawning stationary	0.09
3	Spawning migrate upstream and some taking shelters	0.14 - 0.21
4	Spawn carried downstream	0.36 - 0.42

5.6.5 Public Health Facilities

Public health facilities, such as water supply and sanitation are much needed at colony, powerhouse and weir site. In all about 118 residential quarters are likely to be constructed for operation of the project/in the colony. Domestic water requirements @ 135 liters/capita/day: assuming 4 persons per family for 118 units works out to 63,720 lpd say, 64 cum per day. Adding the water requirement for 118 person in office @ 70liter/person, the total requirement of water during operation works out to about 0.072 mld, which could be met with the water from springs and the river using pumping arrangements. However, the water needs preliminary treatment like chlorination and sedimentation before use. Sanitation facilities for residential colony of operation staff would be provided as discussed in **Chapter-6.**

5.7 POSITIVE IMPACTS

The proposed hydropower project has both positive and negative impacts. The positive impacts have been listed under the following headings:

- Clean and Renewable Source of Energy
- Employment Opportunities,
- Recreation and Tourism Potential,
- Catchment Area Treatment (CAT**),**

- Benefits to Economy,
- Less Fuel Consumption,
- Reduction in Air Pollution,
- Reduction in Greenhouse Gas (Carbon Dioxide) Emission, and
- Increased Infrastructure

5.7.1 Clean and Renewable Source of Energy

On completion, the project would provide 300 MW of electricity. Hydropower is a non-polluting and renewable source of energy, which accounts for more than 97% of the electricity generated in the country by renewable sources. Other sources including solar, geothermal, wind and biomass account for less than 3% of renewable electricity production.

5.7.2 Employment Opportunities

The project will provide short and long term employment opportunities. Construction of the project is likely to be completed in 60 months, during which manpower will be needed to take part in various project activities. An average of about 1200 persons are likely to work during construction period. (Equivalent to 1200 persons X 26 working days X 60 months=18.72 lakhs mandays). In operation phase, about 118 persons will be deployed for operation and maintenance of the project. (Equivalent to 118 persons X 312 working days per year = 36934 mandays per year) This employment will be at all levels starting from unskilled worker to plant operator and administrator. The project construction would also require indirectly related support services, which shall accelerate business and commercial activities in and around the project area and provide substantial indirect employment to the people. Thus the project would provide substantial direct as well as indirect employment in general and to the local people specifically.

5.7.3 Recreation and Tourism Potential

Tourism has the potential of contributing significantly to the economy of any region. Therefore, development projects ought to be scanned for the possibility of recreation and tourism, which needs to be exploited to the fullest extent. Chamoli is synonymous with natural splendours and scenic wonders and is famous for being the gateway for Badrinath, Hemkund Sahib, Joshimath, Valley of flowers The world-class winter games resort Auli is around 50 kms from Chamoli Improvement of access road and other infrastructure facilities due to the project is also likely to boost tourism in the area. Benefit in terms of revenue generation from tourism will depend upon the size and kind of infrastructure developed.

5.7.4 Catchment Area Treatment (CAT)

One of the major beneficial impacts of hydropower projects is the treatment of degraded catchment area of the project to control the soil erosion. This results in regeneration of natural forests and other ecosystems significantly benefiting the environment.

5.7.5 Benefits to Economy

Development of infrastructure and availability of reliable power supply as a result of the project realization would contribute to the stimulation of economic activities like small-scale industry in the area. Expansion of industrial and agricultural activity will receive a boost as a result of this project Long term stationing of permanent staff would lead to allied economic activities in the project area. The project will benefit the economy at both local and national level.

5.7.6 Less Fuel Consumption

The project capacity is 300MW and it would generate 1069 Mu (GWh) power annually on 90% dependability. Considering specific consumption of coal as 1.06kg/Kwh, in no project scenario, in order to generate this power by thermal power plant, about 1.19 million tones of coal would be utilized. With the implementation of this project equal amount of coal is saved. This will directly benefit to the tune of Rs.1360 million per year.

5.7.7 Reduction in Air Pollution

The major pollutants that define the ambient air quality are: Suspended Particulate matter, Sulphur dioxide, and Nitrogen oxides. In addition to the above pollution, un-burnt products like aldehydes, acetaldehyde and smoke are byproducts of emissions. With the existing system of no hydropower scenario, the total estimated pollution load to install 300MW thermal power plant is 8626 tonnes per year. The details are reported in **Table 5.7**.

TABLE 5.7
ESTIMATED POLLUTION LOAD (Tones/year)

TYPE OF FUEL	POLLUTION PARAMETER		
	NO_X	SO_2	PARTICULATES (SOOT CARBON)
Coal	544	8019	63

5.7.8 Reduction in Greenhouse Gas (Carbon Dioxide) Emission

The emissions of carbon dioxide depend on quality of coal, combustion characteristics and excess air available in the combustion. The CO_2 production varies from 2800 ton/MW/year to 6000 ton/MW/year. We have assumed about 997gm/kwh emission factor for CO_2 generation (based on CPCB study). About 1.066 million ton of CO_2 will be emitted from 300MW coal fired thermal power plant. With the construction of proposed hydropower plant equal amount will be eliminated. This will reduce 1.066 million tones of green house gas contribution to the global environment every year. The cumulative reduction in Green House gas (CO_2) taking 70 years lifetime of the project thus works out to 74.61 million tones. The other indirect benefits of a hydropower project over thermal one are reduction in water pollution, noise pollution, thermal, fly-ash and health effects in and around the area.

5.7.9 Increased Infrastructure

Present infrastructure is either likely to be upgraded or new infrastructure to be set up with the implementation of the new project. Basic infrastructure required to be developed are roads, health facilities, educational facilities etc. The project-affected people shall be benefited due to development of better infrastructure in the project area.

5.8 CHECKLIST OF IMPACTS

Based on negative (**section 5.6)** and positive impacts **(section 5.7)** a screening checklist of environmental impacts has been prepared and presented in **Table 5.8**. Environmental impacts at various stages of the project e.g. location, construction and operation are listed and the degree of environmental impact is shown. The terms nil, minor, medium and major are used in the checklist to classify the magnitude of impact. In the checklist, the location, construction and operation phases have been considered separately in order to distinguish the short term and long term impacts. It should be noted that identification given in the checklist relates to the level of impact, assuming that no negative impact mitigation measure or benefit enhancement are adopted.

TABLE 5.8
CHECKLIST OF IMPACTS DUE TO THE PROJECT

S. NO	PROJECT PHASE/ ENVIRONMENTAL IMPACT	IMPACT		MAGNITUDE			
		POSITIVE	NEGATIVE	NIL	MINOR	MEDIUM	MAJOR
A.	**IMPACT DUE TO PROJECT LOCATION**						
1	Displacement of People			*			
2	Loss of Land / Change in Land Use		*		*		
3	Encroachment into Forest Land/ Loss of Forest Produce		*		*		
4	Encroachment into Wildlife Habitat/Corridor			*			
5	Loss of Historical, Cultural Monuments/Structures			*			
6	Loss of Infrastructure			*			
7	Erosion and Silt Risks		*		*		
8	Disruption of Hydrological Balance		*		*		
9	Risk Due to Earthquake		*		*		
10	Environmental Risks Due to Future Development		*		*		
B.	**Impacts Due to Project Construction**						
1	Increased Soil Erosion at Construction Sites		*			*	
2	Muck Generation from Tunneling Operation		*			*	
3	Transportation of Construction Material		*			*	
4	Health Risks		*		*		
5	Cultural Effects		*		*		
6	Air and Noise Pollution		*		*		
7	Water Pollution and Quality		*		*		
8	Quarry Operation		*		*		
9	Impact of Tunneling on Surface and Groundwater Resources		*		*		
10	Safety hazards of Tunnel Construction		*		*		
C.	**Impacts Due to Project Operation**						
1	Deforestation		*		*		
2	Effect on Wildlife			*			

S. NO	PROJECT PHASE/ ENVIRONMENTAL IMPACT	IMPACT		MAGNITUDE			
		POSITIVE	NEGATIVE	NIL	MINOR	MEDIUM	MAJOR
3	Increased Incidences of Water Borne Diseases			*			
4	Impact on Aquatic Life and Fish Migration			*			
5	Public Health Facilities	*					*
D.	**Positive Impacts**						
1	Clean and renewable source of energy	*					*
2	Employment Opportunities	*					*
3	Recreation and Tourism Potential	*					*
4	Catchment Area Treatment	*					*
5	Benefits to Economy	*					*
6	Less Fuel Consumption	*					*
7	Reduction in Air Pollution	*					*
8	Reduction in Greenhouse gas Emissions	*					*
9	Increased Infrastructure	*					*

5.9 EPILOGUE

A comparison of the negative and positive impacts of the project as described above shows that the overall negative impacts due to this project are of low to medium magnitude and are basically during the construction stage. Positive impacts are of major magnitude and of long term. Positive impacts have prevailed upon the negative impacts of low magnitude like air, noise and water pollution. To mitigate and minimize the negative impacts arising during various stages of this project, management plan have been prepared as reported in **Chapter-6**

Chapter –6

Environmental Management Plan

CHAPTER-6
ENVIRONMENTAL MANAGEMENT PLANS

6.1 MANAGEMENT PLANS

Based on planned project activities (**Chapter 2**), environmental baseline conditions (**Chapter 3**) and the impacts assessed in **Chapter 5**, this chapter enumerates a set of measures to be taken during implementation and operation, to eliminate or avoid/ offset adverse environmental impacts or to reduce them to acceptable levels, together with the action which need be taken to implement them.

The Bowala Nand Prayag Hydroelectric power project will provide cheap and clean power, direct and indirect employment opportunities, economic benefits at local, state and national level, additional water resource, reduction in green house gas emissions, and tourism potential on one hand and problems of deforestation, increased soil erosion, muck disposal, potential risk due to earthquake, air and water pollution and safety hazards on the other hand. The issues likely to develop at various stages of the project e.g. pre-construction, construction and operation could be addressed by preparing a compatible Environmental Management Plan (EMP) and its effective implementation.

An abstract of the EMP for the project has been prepared and presented in **Table 6.1**, which defines actions to be undertaken during the pre-construction (including those already undertaken), construction, and operation stage of the project. The mitigation measures given in the table have been described in the subsequent paragraphs.

The important actions during the pre-construction stage would be/have been; site selection to minimize the land acquisition so that least people are affected and no displacement of people; adequate design provisions for safety of project structures in general and the HRT in specific against seismological hazards.

Construction time mitigation measures include; control of soil erosion/mass movement at excavation sites and muck disposal area; control of air, noise and water pollution as a result of various construction activities; good housekeeping practice at workers camp and close monitoring of any impact on water resources, houses and infrastructure facilities of the local villagers in the close proximity of tunneling and powerhouse construction. The effectiveness of these environmental considerations will, however, depend on appropriate inclusion of these in the work contracts.

Operation period mitigation would involve good house keeping practice, wastewater disposal and maintenance/upbringing of green area/plantation. The operation unit will also be required to confirm, receipt of the construction period mitigation report and prepare a follow on timetable of actions.

TABLE 6.1
ENVIRONMENTAL MANAGEMENT PLAN (EMP)

ENVIRONMENTAL IMPACT/ ISSUE	MITIGATION MEASURE	LOCATION	TIME FRAME	RESPONSIBILITY	
				IMPLEMENTATION	SUPER VISION
1. PRE-CONSTRUCTION/PROJECT LOCATION STAGE					
Compensation for Loss of Land	Ensure that private land acquisition is compensated as per norms of the local administration.	Villages	Before taking possession of the land	Local revenue department	UJVNL
Deforestation and loss of terrestrial ecology	Minimise forest area cutting	Different project components	During feasibility study	Planning and investigation division of UJVNL	UJVNL
Preservation of endangered species/species of medicinal value of terrestrial flora	Facilitate for nurseries of those endangered species	Suitable place in/around the project area	During entire construction period	Local forest department	UJVNL
Sedimentation load from catchment area runoff	Implement catchment area treatment plan	Directly draining and other identified location in the catchment area	As per the schedule given in CAT plan	PIU through local forest department	UJVNL through project implementation Unit (PIU)
Inadequate design provision for safety against seismological hazard	Make sure that design provides for safety of structures against worst combination of forces in the probability of an earthquake likely to occur in seismic zone-IV.	All structures of the project	DPR and detailed design stage	DPR and design consultant	Planning and Investigation division of UJVNL
Failure to maintain minimum flow of water	Provide to release a minimum of 4 cumec flow at any time	Barrage structure	During feasibility study and DPR stage	DPR consultant	Planning and Investigation division of UJVNL
Failure to include environmental clauses in contracts defining the mitigation actions with time frame and measurable	Prepare environmental contract clauses for Special Conditions & Technical Specifications of work contracts with reference to this EMP. In defining these clauses provide specific items for mitigation measure, such that a failure to provide evidence that these items have been complied with could be grounds for withholding interim payments to the contractor	With reference to the entire EMP, and mitigation actions required during various stages of the project development	Before construction begins	Planning and Investigation division of UJVNL through consultant	Planning and Investigation division of UJVNL
2. CONSTRUCTION PERIOD					
Lack of environmental awareness among project engineers/ managers	Environmental training programs would be organized for effective implementation of the EMP	Any where on the project sites.	Initially before starting the construction work and subsequent periodic refreshing courses.	Training consultant and environmental engineering division of the PIU	PIU
Uncontrolled erosion of soil	Selection of appropriate site for muck filling, Provide retaining walls for retaining sides of fill, mechanical compaction of soil/muck in disposal area, vegetation cover on top surface of fill. No loose earth, either at excavation or filling area during rainy season	Muck disposal area, excavation for foundation of structures	Entire construction period	Contractor	UJVNL through project implementation Unit (PIU)
Indiscriminate felling of trees	Plan construction operation to have minimum cutting of trees and obtain prior approval for cutting of any tree. Contractor to provide for alternative fuel at	Entire project area All contractors camp	Entire construction period Entire construction	PIU through Contractor Contractor	UJVNL through PIU UJVNL through PIU

ENVIRONMENTAL IMPACT/ ISSUE	MITIGATION MEASURE	LOCATION	TIME FRAME	RESPONSIBILITY	
				IMPLEMENTATION	SUPER VISION
	workers camp to control unauthorized tree cutting for fuel wood.		period		
	Plant minimum double the number of trees planned to be cut, include quarterly physical verification in plantation program by UJVNL. through PIU.	Locations identified in the CAT plan	Till completion of the plantation program including maintenance period.	PIU through local Forest Department	UJVNL through PIU to monitor monthly physical progress of plantation
Air and noise pollution	Provide pollution control devices and obtain necessary license from state pollution control board in case of stone crusher. Specify norms of air and noise pollution control for various construction equipment/machinery.	Throughout project area	Entire construction period	Contractor	PIU
Deterioration of existing road network due to transportation of construction material	Define contractor's responsibility towards maintenance of approach/service roads in the work contracts in conditions of particular application.	All construction sites and approach roads	Throughout construction period	Contractor	PIU
Drinking water facility and Pollution Control at Workers Camp	Provide drinking water, waste water disposal & solid waste management facility	All workers camp	Throughout construction period	Contractor	PIU
Workers health hazard	First aid facilities at every work site. Indoor treatment facility for workers should be provided at contractors cost, which need be mentioned in the conditions of particular application	Any construction/ camp site.	Throughout construction period	Contractor	PIU
Cultural Effects	Give priority to employment of local people having requisite qualification. Make provision in conditions of particular application.	All construction works	Throughout construction period	Contractor	UJVNL through PIU
	Provide for cultural upliftment and education assistance	All villages in the valley from barrage site up to TRT	Throughout construction period	PIU through local administration or NGO	UJVNL
Depletion of water in ground and surface water sources	Observe the effect of tunneling on water resources. Provide alternative source of water supply for affected population	Water resources in the vicinity of tunnel	Tunnel construction period	PIU Through contractor	PIU
Failure of PIU to submit final compliance Report	The PIU will prepare a final mitigation report, in the form of a matrix table, defining the mitigation actions taken by the contractors, when and where these were taken, the benefits achieved and the future actions needed during the operation period.	----	At the end of construction Period	PIU	UJVNL
Land slide chances	Provision of suitable drainage, Constructions of masonry check wall and undertaking of vegetative measures	All construction sites and approach roads	Throughout construction period	Contractor	PIU
3. OPERATION PERIOD					
Receipt of PIU's Monitoring Report and preparation of an operational period environmental mitigation schedule	The operation unit in charge will actively obtain the mitigation report and based on that prepare the implementation timetable for the operating stage of the project	To cover all areas defined in the EMP	At time when construction is completed	Operation unit through PIU	UJVNL

ENVIRONMENTAL IMPACT/ ISSUE	MITIGATION MEASURE	LOCATION	TIME FRAME	RESPONSIBILITY	
				IMPLEMENTATION	SUPER VISION
Water quality	Regular monitoring of water quality	Upstream and downstream of the barrage	Operation period	Environmental engineer of the operation unit	UJVNL
Solid waste and sewage disposal facility	Provide waste water and solid waste treatment/disposal facility	At all office and residential accommodation	During operation period	Operation unit through contractor	UJVNL

The most reliable way to ensure, that the plan will be integrated into the overall project planning and implementation is to establish the plan as a component of the project. This ensures that it will receive funding and supervision along with the other investment components. For optimal integration of the an EMP into the project, it should be linked for:

- Funding,
- Management and Training,
- Monitoring.

The purpose of the first link is to ensure that proposed actions are adequately financed. The second link helps in imparting training, technical assistance, staffing and other institutional strengthening items needed to implement the mitigation measures in the overall management plan. The third link is necessary to provide a critical path for implementation and, to enable sponsors and the funding agency to evaluate the success of mitigation as part of project supervision and as a means to improve future projects.

6.2 MITIGATION MEASURES

Mitigation measures required to be taken during various stages of the project, and as mentioned in the EMP have been listed and described below.

6.2.1 PRE-CONSTRUCTION STAGE

6.2.1.1 Compensation for Loss of Land

The general principle is that all those who loose land or their means of livelihood should be suitably compensated to achieve sustainable development. For this project 9.604 ha of private agricultural land would be acquired. It is proposed to pay cash compensation to the concerned person as per government norms. The compensation will have to be paid through Land and Revenue Department of Government of Uttarakhand. Compensation for standing crops, trees available on the proposed land shall be paid extra. The compensation should, however, not be less than the prevailing market rate of the land. It is suggested that the developer, before taking possession of the land, should ensure that the affected persons have been adequately compensated and address the shortcomings if found any. Other benefits to be given to the affected people by the developer have been addressed under Social Response Program in chapter IV. Cost of such compensation shall be provided in the project estimate.

6.2.1.2 Compensatory Afforestation

The forest area affected by the project falls under Chamoli Forest Division. The Forest Conservation Act of 1980 stipulates strict forest protection measures and outlines procedures (Guideline 1/08-1 (ii)) for compensatory afforestation if the department accepts conversion of forestlands for other purposes:

- If non-forest land is not available, compensatory forest plantation is to be raised on degraded forest land to the extent of twice the affected or lost forest area;

- If non-forest land is available, compensatory afforestation is to be raised over an area equivalent to the affected/lost area of the forest.

As reported in Chapter-5, 49.28 ha of forest land will be lost due to location of project components. It is proposed to do compensatory afforestation over 120.68 hectare area in nearby degraded forest area. The objectives of the re-afforestation programme should be to develop natural areas in which ecological functions could be maintained on sustainable basis. Therefore planting of miscellaneous indigenous tree species should be applied. The afforestation work will be carried out through the Local Forest Department. The cost of compensatory afforestation @ Rs. 0.6732 lacs/ha works out to Rs. 81.24 lacs. This cost, however, does not include the supplementary works such as nursery development, engineering works, establishment cost, maintenance etc., which has been taken care in the CAT works estimate.

6.2.1.3 Preservation of Rare and Medicinally Important Species of Terrestrial Flora

20 species of shrubs were found to be of medicinal value and most of the herb species were having the medicinal value. Only one species of shrub, three species of herbs, two species of climbers are of rare/endangered/threatened which may be affected due to the project activities as reported in Chapter 3. Efforts will be made to preserve these species by including them in the plantation programs under reforestation and CAT plan. It is also proposed to establish and maintain nursery specially for these species. The work will have to be carried out through the local forest department.

6.2.1.4 Sedimentation Control

A comprehensive Catchment Area Treatment (CAT) plan has been presented in Vhapter-7 of the report, which would help in reducing the sedimentation load in the river. The project design, envisages removal of suspended particles of size greater than 0.20 mm from water entering the HRT through sedimentation tanks, which takes care of any possible damage to the turbine by suspended particles. Sedimentation tanks will be flushed out at regular interval to remove the accumulated sediments. The collected sediments will again be put into the river.

6.2.1.5 Minimum Sacrificial Flow

A number of perennial streams having considerable flow join the river down stream of the proposed barrage. There are four perennial tributary between barrage and power house which joins Alakhnanda river These perennial streams have a total discharge of more than 85.65 cusec (2.42 cumec). Neither water is drawn for any purpose nor any effluent is discharged in this critical length (between barrage and powerhouse) of the river. A minimum sacrificial flow of 4.3 cumec which is 10% of minimum flow i.e 43 cumec of 90% dependable year (1971-72). has been provided to sustain the aquatic life and any other down stream use of the river water. Provision to maintain this flow shall be made in the barrage structure. An electronic flowmeter is proposed to measure the river flow and sacrificial flow.

6.2.2 CONSTRUCTION STAGE

The construction period mitigation would include the following measures;

- ❖ Soil Erosion Control,
- ❖ Muck Disposal,
- ❖ Measures for Road Construction,
- ❖ Quarry slope stabilization,
- ❖ Measures to Control indiscriminate felling of Trees,
- ❖ Air Pollution Control,
- ❖ Noise Control Measures,
- ❖ Water Supply and Wastewater Treatment Facility for Workers Camps,
- ❖ Solid Waste (Domestic) Management for Labour Camps,
- ❖ Health Facilities,
- ❖ Precautions towards Depletion of Water Resources in the vicinity of Tunnel,
- ❖ Safety Precautions in Tunnel Construction,
- ❖ Catchment Area Treatment,
- ❖ Cultural Upliftment and Education Assistance,
- ❖ Fishery Management and
- ❖ Training and Extension

6.2.2.1 Soil Erosion Control

Careful planning & selection of borrow pits, timing of cut and fill operations and re-vegetations are required to mitigate the soil erosion. A general guideline to control soil erosion shall be to stop all the earthwork activities during rainy season so that surfaces having loose earth are not exposed to rains. The cutting and filling area, on completion of the work shall be dressed well, compacted and covered with plantation. Measures specific to works like muck disposal, road construction have been discussed in subsequent paragraphs.

6.2.2.2 Muck Disposal

The project authorities, after careful consideration of various locations, have identified four sites on the basis of their merits for safe disposal of the muck from tunneling. Considerations for selection of these sites have been its accessibility, storage capacity, intensity of ground slope, cost implication towards development of site and requirement of protection works like retaining wall etc. Location of the muck disposal sites has been shown on plan in **Figure 5.1.** The total area required for the purpose is 6.602 ha. The muck shall be filled in these areas in layers and compacted mechanically. Dumping sites on sloping ground shall be protected adequately against any possible slide/slope failure through engineering measures. The entire muck disposal area on completion of the filling operation shall be provided with a layer of good earth on the top, dressed neatly and covered with vegetation. Cross sectional details of the protection structure for muck disposal is presented as **Figure 6.1. to 6.4** A provision of Rs 18.78 lakhs towards development of muck disposal sites as green patches has been made as estimated in **Table 6.2** below.

TABLE 6.2
COST OF DEVELOPMENT AND RESTORATION OF MUCK DISPOSAL SITES

S. NO.	ITEM	COST (RS. IN LAKHS)
1.	Engineering measures:	
	Leveling of sites before dumping	Part of Engineering Estimate
	Boulder crate as per requirement	Part of Engineering Estimate
	Catch water drain as per requirement	Part of Engineering Estimate
	Masonry Retaining wall as per requirement	Part of Engineering Estimate

S. NO.	ITEM	COST (RS. IN LAKHS)
	Fencing in selected patches for 2 km @ Rs. 80,000/km	1.60
	Provision of top soil for plantation including leveling/dressing,19806cum@ Rs.60/cum	11.88
2.	Biological measures:	
	Plantation @Rs. 30,000/ha	1.98
	Maintenance of plantation and greenery up to fifth year @ Rs. 20,000/ha	1.32
	Beautification works LS	2.00
	TOTAL	**18.78**

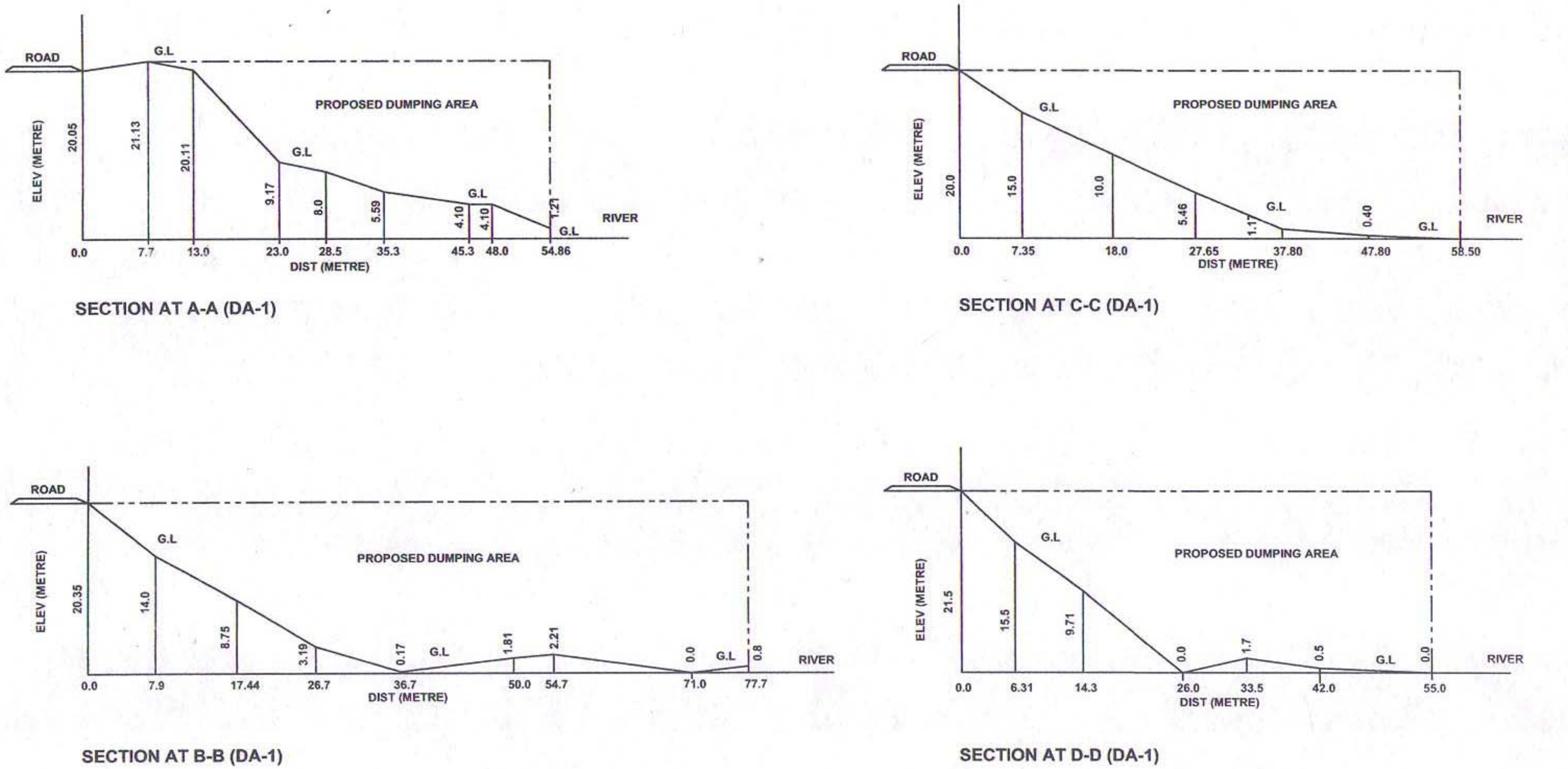
6.2.2.3 Measures for Road Construction

The proposed project would require construction of approach roads for various construction sites, camps and material yards etc. Following guidelines need to be followed during road construction:

- The clearing shall be kept minimum as per technical requirement of the road. The clearing area shall be demarcated to save trees and to keep tree cutting to minimum,
- The cut and fill shall be done at the same time to avoid large accumulation of earth/ soil,
- The slopes shall be stabilised and retaining wall shall be provided wherever required,
- In case of rock blasting, controlled blasting techniques shall be followed,
- Excavated material shall be stored properly for reuse/ refill for disposal and
- The diversion drains during construction shall be connected with natural drains.

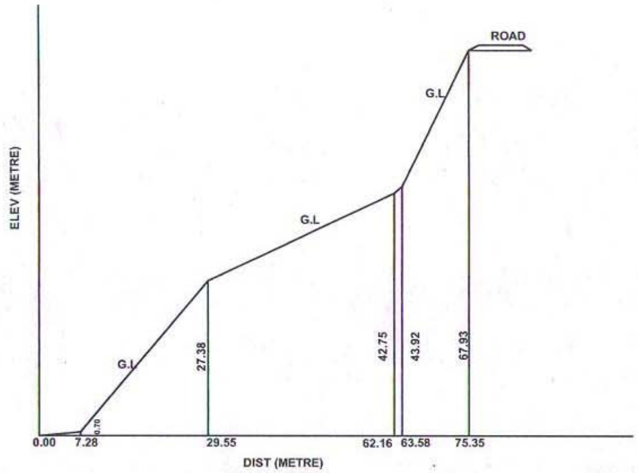
The provision of cost for construction of approach roads has been kept in Civil/Engineering costs.

Figure 6.1
Cross Section of Muck Disposal Site (S_1)

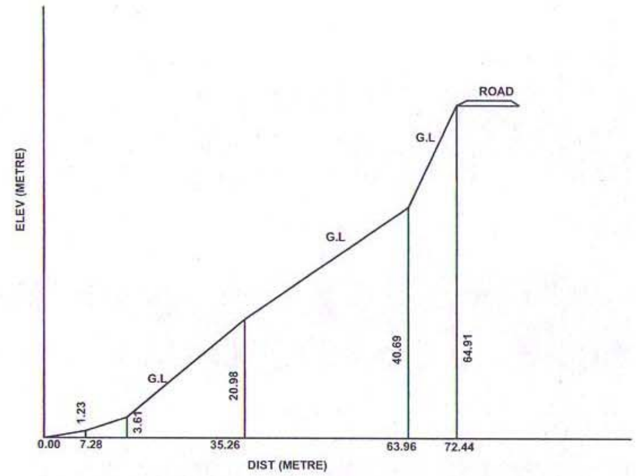


CHAPTER - 6 6.8 ENVIRONMENTAL MANAGEMENT PLAN

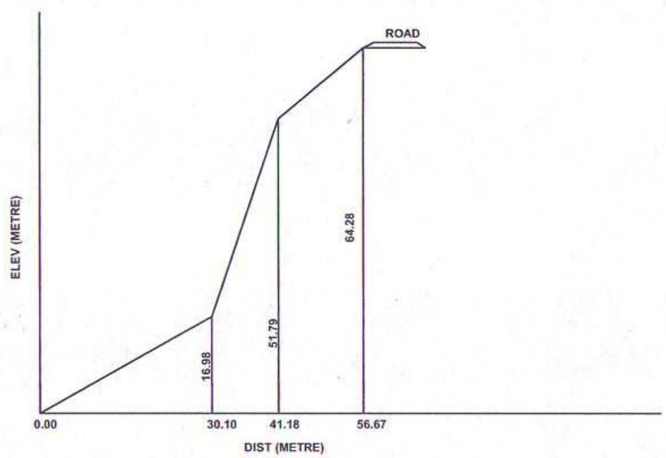
Figure 6.2
Cross Section of Muck Disposal Site (S_2)



SECTION AT A-A (DA-2)



SECTION AT C-C (DA-2)



SECTION AT B-B (DA-2)

Figure 6.3
Cross Section of Muck Disposal Site (S_3)

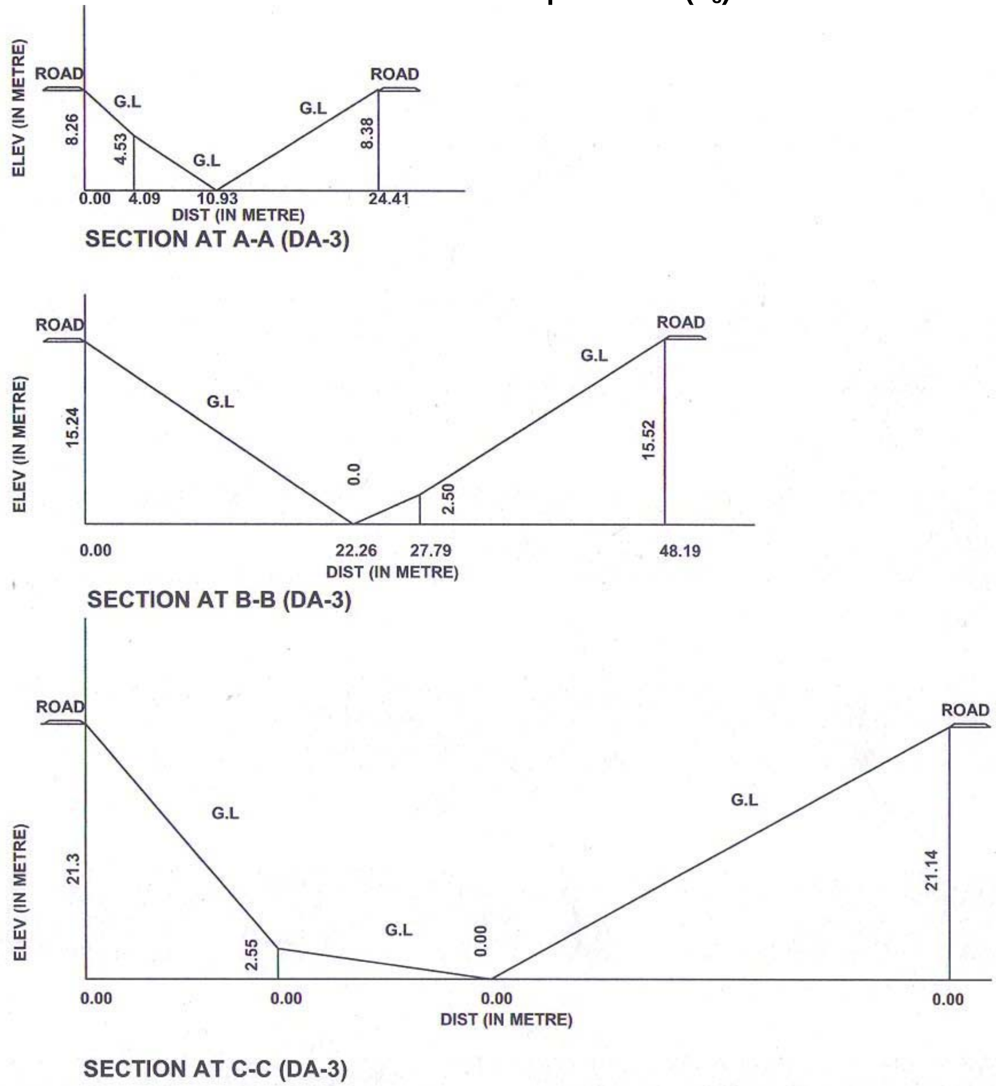
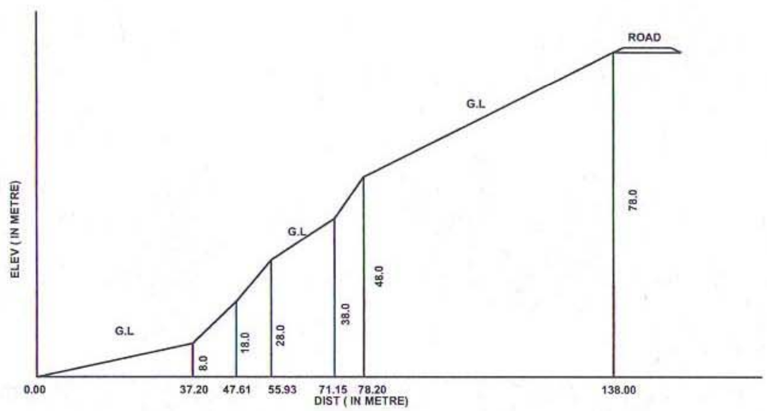
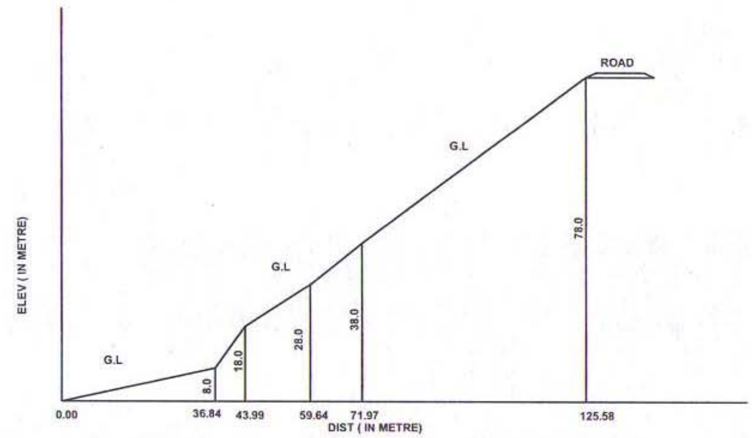


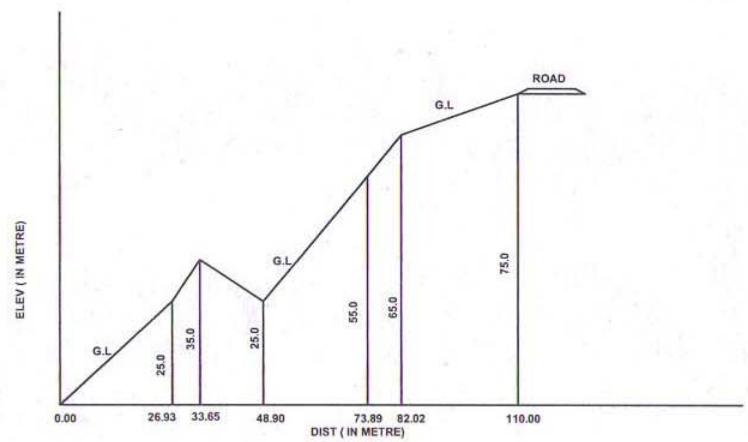
Figure 6.4
Cross Section of Muck Disposal Site (S_4)



SECTION AT A-A (DS-4)



SECTION AT B-B (DS-4)



SECTION AT C-C (DS-4)

6.2.2.4 Side Slope Stabilization of Excavation and Quarry Sites

To control erosion from and collapsing of side slopes of excavations and quarries, following measures need be taken.

- The quarrying operation should be controlled and permitted in specified area earmarked for such purpose.

- Design of excavations i.e. side slope, benching depth of excavation shall be approved by the construction supervision engineer before starting the work. No unauthorized excavation should be allowed. Engineering measures like application of boulder crates at critical locations would be applied to stabilize the slope of excavation if needed. A provision of Rs 10 lakhs has been kept for this head.

- On completion of the excavations the excavated surface shall be dressed neatly and covered with plantation, wherever possible.

6.2.2.5 Measures to control indiscriminate felling of Trees

Efforts would be made to minimize the cutting of trees for various construction activities. An inventory of trees required to be cut shall be prepared showing the details of each tree to obtain necessary prior approval.

Construction of the proposed project would increase human activities during construction and operation of the project, which would increase pressure on local natural resources if no adequate measures are provided for. Encroachment on nearby forest reserves and subsequent forest degradation can be avoided by arranging adequate supply of alternative fuels.

Requirement of fuel for workers camp will have to be met through supply of fossil fuel to avoid encroachment on forest area during construction phase. It is estimated that about average 3000 people will be working during the peak construction period. Generally 1 LPG cylinder is required per month for four people for cooking. The requirement of LPG thus works out to 9000 cylinders per annum and approximately 45000 cylinders during the entire construction period. Considering that one cylinder costs Rs.300 at site, the cost involvement is Rs. 135 lakhs. It is proposed to provide 50 % subsidy through the project proponent for compulsory provision of LPG in workers camp. The users and the contractor can share the balance cost. A provision of Rs. 67.5 lakhs has been kept for this head.

6.2.2.6 Air Pollution Control

During construction period the impact on air quality will be mainly due to increase in SPM along haul roads and emission from vehicles and construction machinery. Though during construction there will be insignificant impact on ambient air quality, nevertheless certain mitigation measures which shall be adopted to reduce the air pollution are presented below:

- Every day the haul road at the construction site shall be inspected and the debris left by the tractor - trolleys shall be removed as early as possible.

- As the vehicular movement may lead to fugitive dust in the area, hence provisions shall be made for sprinkling of water on the roads at least once a day during the entire construction period. Idling of delivery trucks / tractors and other construction equipments should not be permitted during the periods when they are unloaded or are not in active use.

- Stone crushers, which have installed pollution control device and have taken a certificate to that effect from the state pollution control board, shall only be allowed to operate.

- Concrete batching plant should be located at or near the project site so that the requirement of transit mixers/ delivery trucks is minimized.

- Operation time of each construction machinery should be optimized through modifications in the work schedule.

- As soon as the construction activity is over the surplus earth should be utilized to fill up the low-lying areas, if any.

- All stationary machines/DG sets emitting the pollutants shall be inspected weekly for maintenance and should be fitted with exhaust pollution control devices.

6.2.2.7 Noise Control

During the construction phase, there would be a temporary increase in ambient noise levels due to construction machinery operation and movement of construction vehicles. Though the industrial countries have specified limits for occupational noise exposure, the permissible noise exposure limit for industrial workers is primarily concerned with harmful effects of noise and its objective is to protect the hearing of majority of working people. The American Conference on Government of Industrial Hygienists (ACGIH), USA, has prescribed the permissible noise exposure limits for industrial workers as given in **Table 6.3.**

TABLE 6.3
NOISE LEVEL STANDARDS FOR OCCUPATIONAL EXPOSURE

EXPOSURE TIME IN HOURS/DAY	LIMIT IN dB(A)
8	90
4	93
2	96
½	99
¼	102
1/8	105
1/16	111
1/32	115

Exposure to continuous and intermittent noise levels louder than 115-dB (A) should not be permitted. Following mitigation/ management measures shall be adopted during construction period:

- Special acoustic enclosures should be provided for individual noise generating construction equipment like DG sets. The Special acoustic enclosures may be provided by way of noise shields.

- For protection of construction workers, earplugs should be provided to those workers who will be working very close to noise generation source.

Acoustic material and other protection device should conform to the user guidelines specified by MoEF. Noise control measures to be adopted for various construction machinery/sites shall be provided in the conditions of particular application of work contracts.

6.2.2.8 Water Supply and Wastewater Treatment Facility for Workers Camps

About 3000 people are likely to work at site during the peak construction period, which will create significant stress on different facts of environment. Following issues need to be addressed:

- Water Supply and Sewage Disposal, and
- Solid Waste Management

It is estimated that water requirement for the workers camps will be about 210,000 litres/day, which will be collected from nearby stream and treated through filtration and chlorination. About 80% of the water supply will be generated as sewage/ wastewater, which need be treated before disposal.

One community latrine could be provided per 20 people. The sewage from community latrine would be treated through septic tank and disposed off through soak pits. For each 500 persons one septic tank would be provided. The drinking water facilities and sewage disposal sites should be located away from each other. About Rs 83.0 lakhs will be required for these facilities as reported in **Table 6.4.**

TABLE 6.4
COST OF WATER SUPPLY AND SANITATION FACILITIES

S. NO.	DESCRIPTION	RATE (RS/ UNIT)	NUMBERS	COST (RS. LAKHS)
1	Water treatment and supply facility (1 modules of 0.21 KLD capacity)	20,00,000	1	20.0
2	Community latrine	20,000	150	30.0
3	Septic Tanks including connection	5,00,000	6	30.0
4	Soak Pit including disposal	50,000	6	3.0
			TOTAL	**83.0**

6.2.2.9 Solid Waste Management for Labour Camps

The past experience of such projects indicates that about 0.35 kg/ person/ day of solid waste is generated from the labour camps, which means that the total solid waste generation will be about 3000 x 0.35 kg = 1050 kg/ day, for which adequate collection, conveyance and disposal facilities shall be provided. One garbage collection bin of about 20 litre capacity with handle and cover would be provided among eight workers every two and a half years, in addition four community bins at different locations would be provided for effective collection of the waste. The cost of these facilities including maintenance for 60 months works out to about Rs. 54.95 lakhs as summarised in **Table 6.5**.

TABLE 6.5
COST OF DOMESTIC SOLID WASTE MANAGEMENT FACILITIES

S. NO.	DESCRIPTION	CALCULATION	COST (IN RUPEES)
1.	Solid waste collection bins for individual worker @Rs 100/bin Community bins at six locations @Rs 20000/bin	750x 100 6 x 20,000	75,000 1,20,000
2	Transportation: Initial cost of one covered truck Running/maintenance cost of truck for 60 months @30000 per month	16,00,000 18,00,000	16,00,000 18,00,000
3	Disposal Site Development cost	L.Sum	7,20,000
4	Manpower cost of 5 person @ 6000 per person for 60 months	5x60x6,000	18,00,000
		TOTAL	**54,95,000**

6.2.2.10 Health Delivery System

Health centre facility would be provided for the workers during construction period. According to the criteria of Ministry of Health and World Health Organisation, two Health Centre (HC) with one doctor and minimum of five health personnel, (nurses, compounders etc.) for each HC would be required. Cost of the health facilities works out to Rs. 83.60 Lakhs as estimated in **Table 6.6**

TABLE 6.6
HEALTH DELIVERY SYSTEM

S. NO.	DESCRIPTION	COST (IN RUPEES)
1.	Building 100 sqm @ Rs.8000/sqm	Rs.8,00,000
2	Manpower (1 doctor,2 nurses,1 compounder and two support staff) for 60 months @ Rs. 60,000/month	Rs.2,88,0000
3	Equipment and medicine LS	Rs.5,00,000
4	Total for 1 health centre	Rs. 41,80,000
	Total for 2 health centres	Rs.83,60,000

Up gradation of PHC at Chamoli would further add to the health delivery system in the project area, since all the facilities would be available for the workers and the local people as well.

6.2.2.11 Precautions Towards Depletion of Water Resources in the Vicinity of Tunnel

It is also proposed to measure the minimum discharge of the streams crossing the tunnel alignment and depth of ground water table in the villages near the tunnel before starting the tunnel excavation work. The observations will be used to see the impact of tunneling on the water sources. In case, there is any indication of adverse impact on the water resources, the project authorities should take immediate action for alternative arrangement of water for the affected population. Immediate measure under the scheme will be lifting of water directly from river Alakhnanda to the affected villages to maintain the minimum water supply to the affected areas.

6.2.2.12 Land Slides/slips stabilization:

Steeply sloping banks are liable to landslides, which can largely be controlled by provision of suitable drainage. The basic principle is to intercept and divert as much water as possible, before it arrives at a point, where it becomes a nuisance. The other erosion hazard is that of surface erosion of the bank, which is best controlled by vegetation. However, in a steeply sloping terrain, difficulty lies in growing vegetation on steeply sloping banks.

Engineering solutions such as surface drainage, sub-surface drainage, toe protection and rock bolting can be used. Landslides can be stabilized by several methods-engineering or bio-engineering measures alone or a combination of these. Some of the method are:

a. Constructions of masonry check wall and undertaking of vegetative measures.
b. Planting of shrubs, grass and quick growing species and carryout soil conservation measures to treat the sliding/eroding slip areas. Choice of species will be depending upon the site/field.

6.2.2.13 Safety Precautions in Tunnel Construction

The project authorities must recognize the causes of safety hazards in tunnel construction and establish programs, rules, regulations, guidelines and whatever else might be necessary to reduce accidents. Measures, which can provide guidelines for preparation of a comprehensive safety program achieving better safety performance for underground works are; deployment of a full time safety engineer, who will also prepare a safety program tailored to the project; emergency measures should include tunnel evacuation plan and procedures independent of the tunnel power supply; tunnel personnel should wear protective headgear, footwear and any other special garments that applicable code requires; specific working areas in underground construction can have their own unique hazards that personnel should be made aware of; weatherproof first aid kits should be provided at appropriate locations; tunnels should be provided with mechanically induced reversible flow primary ventilation for all work areas and there should be detailed guidelines for handling and storage of explosives.

6.2.2.14 Catchment Area Treatment

Details of a comprehensive catchment area treatment plan, which includes biological and engineering measures, have been presented in **Chapter-7.**

6.2.2.15 Cultural Upliftment Assistance

The region has rich cultural heritage. During the construction and operation period of this project, construction workers / labour force and staff personnel will be staying at project site. The project will serve as a platform for cultural exchanges. The project will bring diverse cultural events and will lead to cultural upliftment of the area. To maintain the cultural heritage/events and promote awareness a provision of Rs. 10 lakhs has been provided in the estimate to be appropriately utilised by cultural department of local administration.

6.2.2.16 Training and Extension

The training and extension programmes need to be conducted for Engineers of UJVNL officers. These programmes should also be extended for the local population for their active participation in the project implementation. Apart from training, such programmes should include guidelines for safety, measures of disaster prevention, action required in case of emergency, fire protection, environmental risk analysis etc. The cost involved for such a programme is presented in **Table 6.7**

TABLE 6.7
COST OF ENVIRONMENTAL TRAINING PROGRAMMES

S. NO.	ITEM	COST (RUPEES)
1	Curriculum Development and Course Preparation; 3 months @ Rs 20000 per month	60,000
2	2 Extension Officer for 1 year each @ Rs15000 per month	3,60,000
3	Demonstration/presentation aids	50,000
4	Transportation and Miscellaneous	30,000
	TOTAL	**5,00,000**

6.2.3 OPERATION PERIOD MITIGATION

6.2.3.1 Deforestation (Mitigation)

There is local movement of residents of nearby villages, who collect the forest produce for domestic use and graze their cattle in the nearby area. The requirements of fuel wood for heating and cooking can be replaced by cheap electricity generated by hydropower projects, ultimately reducing deforestation.

6.2.3.2 Water Supply and Sanitation in Colony

The public health facilities, such as water supply, sanitation and toilets are much needed at project location. Central Public Health and Environmental Engineering Organisation (CPHEEO) has recommended 70 litres of water per day per person for office accommodation. Water should be treated before use upto statutory drinking water standards. It is estimated that 118 officials will be working for the project during operation. Water demand of about 8,260 litres per day is estimated during project operation for offices. There would be approximately 118 permanent residential units in the project area for the operation of the facility. Assuming four occupants per dwelling unit the water demand (considering 135 lpd/capita) shall be 63,720 liters/day. Hence the total demand will be about 0.072 MLD.

The surface water test results indicate that it needs preliminary treatment like chlorination and sedimentation before use.

Collection and safe disposal of wastes from human activities are among the most important problems of environmental health. The wastewater from staff colony and office accommodation (about 0.058 mld) would be treated in aerated lagoon and secondary sedimentation tank to achieve the effluent standards for application on land. The effluent after treatment can be used for horticulture within the colony and powerhouse area. Cost of water treatment as well as wastewater treatment shall make part of the engineering estimate.

6.2.3.3 Refuse Disposal for Colony

Refuse includes many different substances such as garbage, rubbish, sweepings and ash. Health problem may arise since some of the refuse is attractive to insects and rodents. Refuse disposal programme should include storage, collection and disposal. The power generation process does not generate any solid waste however; about 75.2 kg/day of solid waste would be generated from residential colony and office accommodation. The solid waste first needs to be collected in properly designed collection containers equipped with side handles to facilitate handling. The containers used for garbage storage should not exceed 50 litres capacity and should preferably be equipped with lockable cover. To avoid odour and accumulation of fly-supporting materials, garbage containers should be washed at frequent intervals. The solid waste could be finally converted to compost and reused for horticulture. Cost of these works shall make part of the engineering estimate.

6.3 DAM BREAK ANALYSIS & DISASTER MANAGEMENT PLAN

At the Scoping stage of proposed Bowala Nandprayag (BN) HE project at river valley appraisal committee of Ministry of Environment and Forests (MoEF) which considered the case in July/August 2008, it was observed by MoEF vide their letter no J-12011/11/2003-IA.I dated 09.09.2008 that in event of a dam break of Vishnugad Pipalkoti HE project, the flood wave so generated could cause danger to proposed Bowala Nandprayag barrage. The committee observed that an examination of the dam break study of Vishnugad Pipalkoti (VP) project reveals the flood surge level as 1060.57 m at 15.8 km downstream of VP dam (Page 17 of Dam Break Analysis Report of THDC, conducted by WAPCOS, Refer **Annexure 6.2**) and also as BN project has a barrage as headworks the consequence of dam break upstream with water level expected to rise to 1044 m 18 km downstream of VP dam will endanger/destroy the barrage.

In view of these observations, a review of Dam Break Analysis Report of Vishnugad Pipalkoti Project was carried out and since it covered a reach of only till about the proposed location of Bowala Nandprayag barrage, it was revised for downstream reach also with the help of additional river cross-sections taken during the course of study.

6.3.1 DAM BREAK MODELLING

Since the storage at Bowala Nandprayag HE project is very small i.e. 0.11 Mcum, the same model set-up of Vishnugad Pipalkoti HE project has been used. Since the reach covered was only till about 20 km downstream, the model reach has now been extended upto 124.5 km downstream. Dambreak modeling of Vishnugad Pipalkoti dam has not considered proposed Bowala barrage downstream, hence river cross-section has been reset accordingly considering Bowala barrage at downstream. (**Figure 6.5**)

Full reservoir level and maximum water level for Bowala project have been considered as 1034 m and 1034.5 m respectively. Storage is very small and has been shown below in form of elevation capacity table **(Table 6.8):**

TABLE 6.8
ELEVATION CAPACITY VALUES FOR BOWALA PROJECT

Elevation in m	Cumulative Volume behind barrage in Mm^3
1022	0
1026	0.02
1027	0.04
1028	0.06
1030	0.08
1034	0.11

As per the dam break analysis report, Gross storage at FRL of Vishnugad Pipalkoti project is 3.63 Mcum and is a concrete gravity dam.

The present study works out determination of the flood flow from the Vishnugad Pipalkoti dam due to its breach, and routing the same along the river channel on the downstream, to estimate the maximum flood levels at various locations on the downstream. The initial reach of 20 km was covered as per earlier report of dam break analysis of Vishnugad Pipalkoti project without considering proposed Bowala project. The same model set up using the NWS DAMBRK model has been extended upto 124.5 km downstream of VP project and also model set up considers proposed Bowala project in downstream with insignificant storage capacity. Manning's coefficient has been considered varying between 0.055 to 0.070 replacing 0.4 used as manning's coefficient in VP dam break analysis. All other input parameters have been taken as same in the model setup those used in VP dam break analysis report. The model has been re run and all input data considered and outputs including flood hydrographs generated at a few select locations are shown at **Annexure 6.1**

The following tables (**Table 6.9 and 6.10**) gives the maximum elevation, maximum flow, time to maximum elevation and maximum velocity at select distances and smaller various distances downstream of the dam up 124.5 km downstream of VP dam.

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TABLE 6.9
PROFILE OF CRESTS AND TIMES AT SELECT LOCATIONS FOR RIVER BELOW VP DAM

Distance from Dam in km	Maximum Elevation (m)	Maximum Flow in cumec	Time to maximum elevation in hr	Max velocity in m/s
5.113	1183.13	6337	0.525	2.96
10.048	1085.98	6039	0.013	5.96
15.029	1037.19	5912	4.3	2.05
18.596	**1029.93**	**5898**	**4.55**	**7.57**
30.527	884.62	5898	5.212	7.39
35.292	841.2	5898	5.062	6.46
40.116	805.72	5898	5.212	6.5
46.49	768.2	5898	5.825	3.83
50.889	755.38	5897	6.25	4.46
55.355	741.83	5897	6.5	4.73
59.887	730.8	5897	7.362	3.6
70.456	714.75	5897	7.887	3.61
80.713	692.45	5896	8.175	4.3
90.76	669.83	5896	8.587	4.08
100.778	647.57	5895	8.737	4.19
119.874	598.75	5888	8.75	4.85
124.473	586.33	5884	8.75	5.47

It can be observed from the latest corrected results that water levels with these corrected parameters at proposed Bowala barrage location downstream stretch remains below top of Bowala barrage i.e. 1034.0 m. Average river bed level at site is 1022 m. Hence in view of this modified modelling results, the flood waves doesn’t pose any danger to this barrage and Bowala project would be safe functionally.

FIGURE 6.5
UPSTREAM VIEW OF PROPOSED BOWALA PROJECT

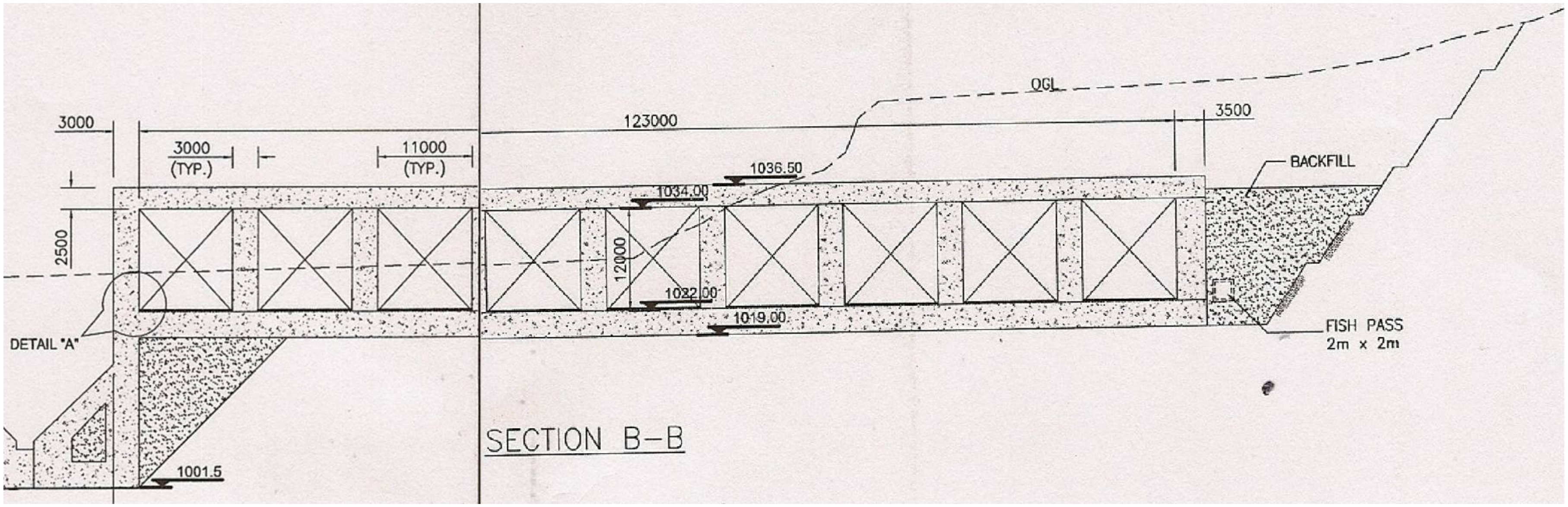


TABLE 6.10

PROFILE OF CRESTS AND TIMES FOR RIVER BELOW VP DAM

Distance from Dam in km	Maximum Elevation (m)	Maximum Flow in cumec	Time to maximum elevation in hr	Max velocity in m/s
0	1229.29	8192	0.238	3.33
0.154	1228.13	8133	0.238	3.26
0.308	1226.98	8084	0.25	3.19
0.462	1225.83	8032	0.25	3.13
0.617	1224.68	7968	0.263	3.06
0.771	1223.54	7905	0.263	3
0.925	1222.4	7830	0.275	2.95
1.079	1221.27	7766	0.275	2.89
1.233	1220.14	7673	0.287	2.84
1.387	1219.02	7616	0.287	2.79
1.541	1217.9	7522	0.3	2.74
1.695	1216.78	7451	0.312	2.7
1.85	1215.66	7378	0.312	2.65
2.004	1214.55	7284	0.325	2.61
2.158	1213.44	7209	0.337	2.57
2.312	1212.33	7140	0.35	2.52
2.466	1211.23	7059	0.35	2.49
2.62	1210.13	6973	0.362	2.45
2.774	1209.03	6898	0.375	2.41
2.929	1207.93	6833	0.387	2.37
3.083	1206.83	6766	0.4	2.34
3.237	1205.74	6697	0.412	2.31
3.391	1204.65	6627	0.425	2.27
3.545	1203.61	6570	0.425	2.2
3.699	1202.06	6535	0.437	2.67
3.856	1199.94	6505	0.45	2.7
4.013	1197.83	6485	0.462	2.73
4.171	1195.73	6466	0.462	2.76
4.328	1193.62	6444	0.475	2.79
4.485	1191.52	6419	0.487	2.82
4.642	1189.42	6392	0.5	2.85
4.799	1187.32	6373	0.512	2.89

Distance from Dam in km	Maximum Elevation (m)	Maximum Flow in cumec	Time to maximum elevation in hr	Max velocity in m/s
4.956	1185.22	6357	0.512	2.92
5.113	1183.13	6337	0.525	2.96
5.27	1181.04	6313	0.537	3.01
5.427	1178.97	6291	0.55	3.03
5.585	1176.84	6277	0.55	3.13
5.742	1174.9	6258	0.562	3.03
5.899	1172.48	6239	0.575	3.51
6.056	1169.66	6233	0.575	3.54
6.213	1166.84	6224	0.587	3.57
6.37	1164.03	6206	0.6	3.61
6.527	1161.21	6204	0.6	3.65
6.684	1158.4	6191	0.612	3.68
6.841	1155.59	6180	0.612	3.73
6.998	1152.79	6174	0.625	3.76
7.156	1149.97	6156	0.637	3.82
7.313	1147.19	6154	0.637	3.84
7.47	1144.36	6141	0.65	3.93
7.627	1141.62	6134	0.65	3.91
7.784	1138.72	6126	0.662	4.1
7.941	1136.14	6111	0.675	3.89
8.098	1132.97	6109	0.675	4.47
8.248	1129.32	6099	0.675	4.58
8.398	1125.84	6098	0.687	4.44
8.548	1122.15	6090	0.687	4.62
8.698	1118.73	6087	0.7	4.38
8.848	1114.96	6081	0.712	4.69
8.998	1111.64	6077	0.712	4.3
9.148	1107.75	6071	0.712	4.8
9.298	1104.59	6064	0.725	4.18
9.448	1100.49	6062	0.737	5
9.598	1097.59	6053	0.725	3.99
9.748	1093.3	6054	0.013	5.34
9.898	1090.67	6044	0.737	3.78
10.048	1085.98	6039	0.013	5.96
10.198	1083.88	6029	0.75	3.63
10.36	1077.76	6033	0.025	6.25

Distance from Dam in km	Maximum Elevation (m)	Maximum Flow in cumec	Time to maximum elevation in hr	Max velocity in m/s
10.523	1074.99	6021	0.762	2.63
10.685	1069.84	6019	0.05	4.83
10.848	1067.01	6012	0.787	2.09
11.01	1062.07	6005	0.063	4.47
11.173	1059.26	5994	0.812	1.76
11.335	1054.37	6002	0.088	4.42
11.498	1051.61	6013	0.837	1.53
11.651	1050.92	6004	0.85	1.55
11.805	1050.24	5996	0.862	1.56
11.958	1049.55	5990	0.887	1.58
12.112	1048.87	5984	0.9	1.6
12.265	1048.19	5978	0.912	1.61
12.419	1047.51	5974	0.925	1.63
12.572	1046.83	5970	0.937	1.65
12.726	1046.16	5967	0.962	1.67
12.879	1045.49	5964	0.975	1.69
13.033	1044.82	5961	0.987	1.72
13.186	1044.15	5959	1	1.74
13.34	1043.49	5957	1.012	1.76
13.494	1042.83	5956	1.037	1.79
13.647	1042.18	5954	1.05	1.82
13.801	1041.53	5952	1.062	1.84
13.954	1040.89	5951	1.075	1.87
14.108	1040.25	5950	1.1	1.9
14.261	1039.63	5948	1.125	1.93
14.415	1039.02	5946	3.838	1.96
14.568	1038.46	5942	3.825	1.99
14.722	1037.96	5936	3.875	2.01
14.875	1037.53	5926	4.038	2.04
15.029	1037.19	5912	4.3	2.05
15.182	1036.92	5898	4.475	2.05
15.336	1036.7	5898	4.463	2.03
15.49	1036.52	5898	4.45	1.99
15.643	1036.36	5898	4.438	1.96
15.797	1036.22	5898	4.513	1.96
15.952	1036.09	5898	4.613	1.94

Distance from Dam in km	Maximum Elevation (m)	Maximum Flow in cumec	Time to maximum elevation in hr	Max velocity in m/s
16.108	1035.97	5898	4.513	1.92
16.263	1035.86	5898	4.563	1.9
16.419	1035.75	5898	4.525	1.88
16.574	1035.64	5898	4.538	1.87
16.73	1035.53	5898	4.55	1.86
16.885	1035.42	5898	4.588	1.86
17.041	1035.31	5898	4.575	1.88
17.196	1035.19	5898	4.65	1.91
17.352	1035.06	5898	4.638	1.99
17.507	1034.92	5898	4.625	2.11
17.663	1034.75	5898	4.588	2.26
17.818	1034.56	5898	4.575	2.45
17.974	1034.32	5898	4.563	2.72
18.129	1034.01	5898	4.7	3.08
18.285	1033.54	5898	4.688	3.62
18.44	1032.73	5898	4.688	4.54
18.596	**1029.93**	**5898**	**4.55**	**7.57**
19.116	1023.09	5898	4.563	7.51
19.636	1016.26	5898	4.575	7.48
20.156	1009.43	5898	4.588	7.48
20.676	1002.65	5898	4.6	7.47
21.195	995.87	5898	4.613	7.48
21.715	989.15	5898	4.625	7.48
22.235	982.43	5898	4.638	7.5
22.755	975.78	5898	4.65	7.47
23.275	969.09	5898	4.663	7.51
23.795	962.54	5898	4.663	7.46
24.315	955.87	5898	4.675	7.54
24.835	949.48	5898	4.688	7.39
25.355	942.75	5898	4.7	7.59
25.874	936.64	5898	4.712	7.23
26.394	929.65	5898	4.85	7.74
28.461	908.39	5898	4.875	6.26
30.527	884.62	5898	5.212	7.39
32.593	864.21	5898	4.975	5.73
35.292	841.2	5898	5.062	6.46

Distance from Dam in km	Maximum Elevation (m)	Maximum Flow in cumec	Time to maximum elevation in hr	Max velocity in m/s
37.992	820.86	5898	5.137	6.4
40.116	805.72	5898	5.212	6.5
42.241	793.62	5898	5.825	5.07
44.365	777.46	5898	5.412	6.65
46.49	768.2	5898	5.825	3.83
48.69	761.8	5897	6.175	4.16
50.889	755.38	5897	6.25	4.46
53.089	748.7	5897	6.312	4.83
55.355	741.83	5897	6.5	4.73
57.621	735.14	5897	6.712	4.57
59.887	730.8	5897	7.362	3.6
62.001	727.53	5897	7.35	3.62
64.115	724.33	5897	7.9	3.63
66.229	721.17	5897	7.887	3.62
68.342	718.01	5897	7.762	3.61
70.456	714.75	5897	7.887	3.61
72.57	711.21	5897	7.9	3.69
74.684	706.78	5897	8.012	4.09
76.693	701.96	5897	8.237	4.22
78.703	697.16	5896	8.187	4.29
80.713	692.45	5896	8.175	4.3
82.722	687.84	5896	8.225	4.27
84.732	683.29	5896	8.687	4.22
86.741	678.78	5896	8.65	4.17
88.751	674.29	5896	8.575	4.12
90.76	669.83	5896	8.587	4.08
92.77	665.38	5896	8.612	4.04
94.78	660.88	5896	8.675	4.02
96.779	656.36	5896	8.725	4.08
98.779	651.92	5896	8.75	4.13
100.778	647.57	5895	8.737	4.19
102.778	643.34	5895	8.75	4.26
104.777	639.07	5895	8.75	4.41
106.777	634.03	5894	8.75	4.89
108.937	628.2	5894	8.75	4.85
111.096	622.36	5893	8.75	4.82

Distance from Dam in km	Maximum Elevation (m)	Maximum Flow in cumec	Time to maximum elevation in hr	Max velocity in m/s
113.256	616.51	5892	8.75	4.78
115.415	610.68	5891	8.75	4.74
117.575	604.93	5890	8.75	4.66
119.874	598.75	5888	8.75	4.85
122.174	592.58	5886	8.75	5.11
124.473	586.33	5884	8.75	5.47

Values in bold depict data at proposed Bowala barrage location. The particulars of the data used are given in **Annexure 6.1**

6.3.2 DISCUSSIONS ON RESULTS

The DAMBRK results consist of following important tables and profiles:

i. Reservoir depletion table
(It includes the outflow hydrograph at dam site)
ii. Water surface and discharge profile from dam site to desired location (up to approx 124.5 km in this case)
iii. Flood level at desired locations
iv. Time lag between time of maximum breach at dam site and at desired locations.

Based on output obtained from model results, the following observations could be derived:

- Dam Break modeling for Vishnugad Pipalkoti HE project has been carried out using manning's coefficient as 0.4 and also the model has been run only for 20 km i.e. approximately only till Bowala project without considering proposed Bowala barrage .

- In the present case, the same model set up has been used with a correct manning's coefficient. Since it was required to get DMP prepared for Bowala project as well, additional river cross sections to cover downstream reach of Bowala have been considered. River cross sections and other relevant data required for Bowala modelling has been provided by the client.

- Correct model set up for Bowala and Vishnugad together covers a reach of 124.5 km d/s of Vishnugad project which is adequate for DMP preparation.

- Now based on latest corrected results, it can be observed that water levels with these corrected parameters at proposed Bowala barrage location downstream stretch remains below top of Bowala barrage i.e. 134.0 m. Average river bed level at site is 1022 m. Hence in view of this modified modelling results, the flood waves doesn't pose any danger to this barrage and Bowala project would be safe functionally.

- It can be highlighted here that since pondage behind Bowala is very insignificant of 0.11 miliion cu m, it won't have any effect on peak flood. It will pass almost unaltered in event of a failure. Even pondage behind Vishnugad project is 3.6 million cu m and with corrected manning's coefficient values and attenuation in d/s reach of 20 km, dam break flood peak subsides substantially so as not to cause any danger to Bowala project.

6.3.3 PREPARATION OF INUNDATION MAP

An inundation map is a map depicting the d/s areas vulnerable to inundation by the dam break flood. The DAMBRK model computes maximum flood elevation at each original or interpolated cross-section. In present case, the cross-sections are available up to 124.5 km d/s of dam. The profile of water levels below the dam at all cross-sections (original and interpolated) is given as **Table 6.10**. From this profile, at locations below the dam & their subsequent markings on the topographic maps, it can be seen which areas are likely to be submerged in case of dam break.

The input control parameters for dam break flood forecasting are given in **Annexures-6.1** and the reservoir depletion tables including the outflow hydrograph at dam site have also been appended there.

It is clear from the **Figure 6.6** that in case of dam break, though there would be inundation of lower areas however no settlement will be affected. The floods generated, however, may lead to a number of landslides and slips downstream of dam causing damage to roads, etc. and also blocking of river itself endangering the life or property.

6.3.4 DISASTER MANAGEMENT PLAN

From the result it is evident that up to about 124.5 km d/s of the Vishnugad Pipalkoti dam, time required in reaching the flood wave elevation to the maximum is of the order of 8.5 – 9.0 hr. Since the time available is short, it doesn't leave much possibility of any rescue or evacuation and hence the Disaster Management Plan should concentrate on preventive actions.

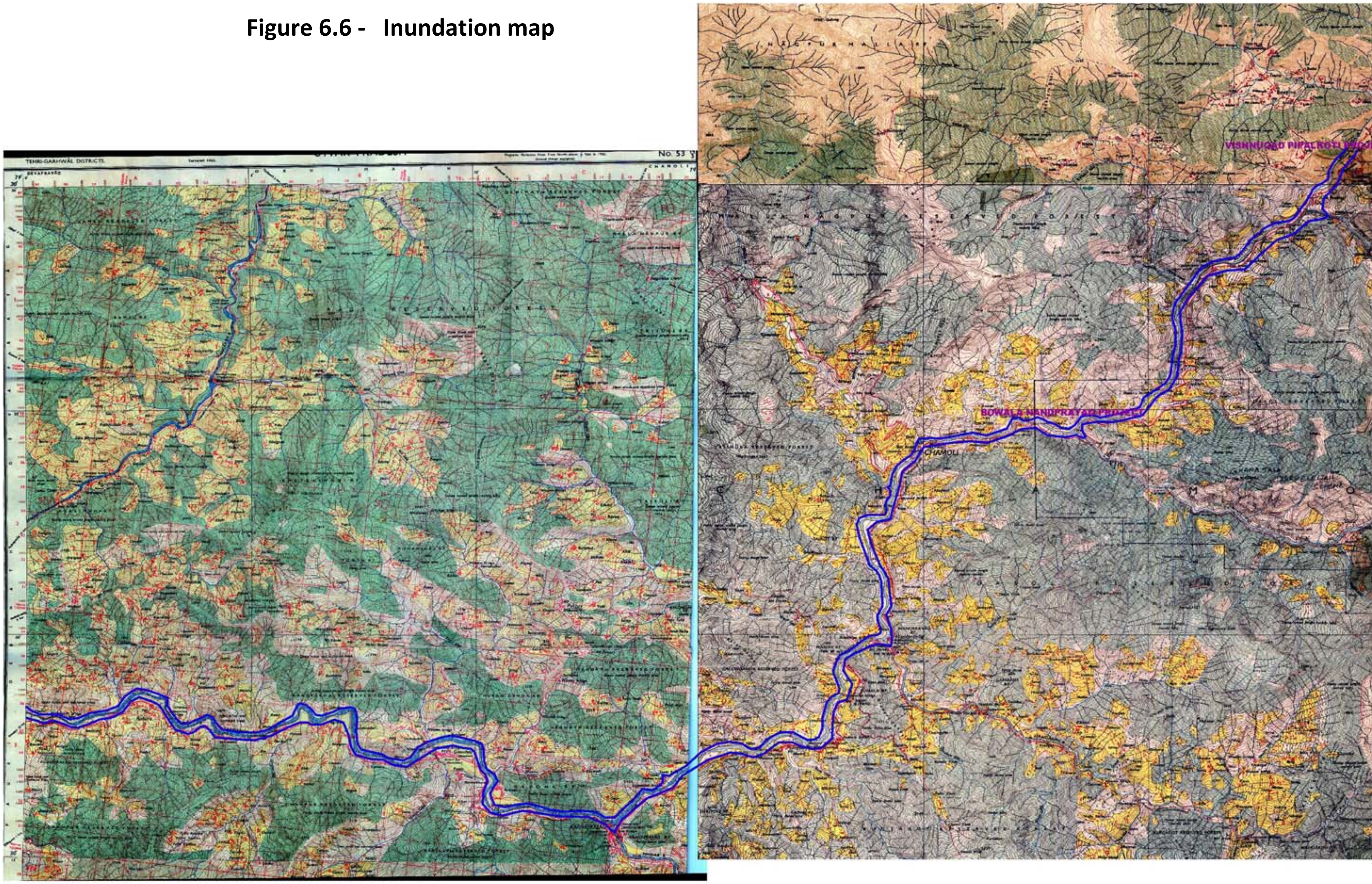
Surveillance and monitoring programmes are required to be implemented during design and investigation, construction, first reservoir filling, early operation period and operation & maintenance phases of the life cycle of dam. It is desirable that all gates, electricity, public announcement system, power generator backups etc are thoroughly checked before arrival of the monsoon. As it is clear from the results that u/s water level has significant effect on the dam break flood, the following flood conditions may be considered for different level of alertness:

1) If u/s water level reaches at top of the dam, it may be considered as an emergency. At this point only a few minutes are available for taking any action. All the staff from the dam site should be alerted to move to a safe place. The district administration and the corporation's head office shall be informed about the possibility of dam failure.

2) If u/s water level rises above the dam top and dam begins to fail, it may be considered as a disaster condition. At this stage, nothing can be done. Information in this regard should be given to the head office and district administration.

    i) If upstream water level is at or below FRL and flood is of the order of 20% to 30% of PMF, it may be considered as **normal flood** condition and normal routine may be maintained.

Figure 6.6 - Inundation map



ii) If upstream water level is rising above FRL, it may be considered as **Level-1 emergency**. In this condition gates must be kept fully operational. All concerned officials should be alerted so that they may reach at the dam site to take suitable actions. Preventive actions may be carried out simultaneously. A suitable warning and notification procedure may be laid. The local officials should be informed about the situation.

iii) If upstream water level reaches above MWL and still rising, it may be considered as **Level-2 emergency.** All communication systems and safety measures should be operational now. Public announcement system or centralized siren system may be used. A flood warning may be issued to the public downstream so that they may reach a higher and safe place.

iv) If upstream water level reaches at the top of the dam, it may be considered as **Level-3 emergency**. At this point only a few minutes are available for taking any action. All the staff from the dam site should be alerted to move to a safe place. The district level office and the corporation's head office should be informed about the possibility of dam failure.

v) If upstream water level is rising above the dam top and dam has started to fail. It may be considered as a **disaster** condition. Any information in this regard should be immediately provided to civil administration for necessary rescue operations.

The following measures can be taken to avoid the loss of lives and property:

- To establish an effective Dam Safety Surveillance and monitoring program including rapid analysis and interpretation of instrumentation and observation data; periodic inspection and safety reviews/evaluation by an independent panel of experts.
- To formulate and implement an Emergency Action Plan to minimize to the maximum extent possible, the probable loss of life and damage to property in the event of failure of dam.

6.3.4.1 Surveillance

The surveillance and monitoring programs are required to be implemented during design and investigation, construction, early operation period and operation and maintenance phases of the life cycle of the dam. An affective flood forecasting system is required by establishing hourly gauge reading at suitable upstream locations with real time communication at the top. An effective dam safety surveillance, monitoring and observation along with periodic inspection, safety reviews and evaluation must be put in place. These programs will be implemented in five phases in the life cycle of a dam *viz*.,

i) design and investigation phase,
ii) construction phase,
iii) first reservoir filling,
iv) early operation period, and
v) operation and maintenance phase.

6.3.4.2 Emergency Action Plan

An emergency is defined as a condition of serious nature which develops unexpectedly and endangers downstream property and human life and requires immediate attention. Emergency Action Plan shall include all potential indicators of likely failure of the dam, since the primary concern is for timely and reliable identification and evaluation of potential emergency.

This plan presents warning and notification procedures to be followed in case of potential failure of the dam. The purpose is to provide timely warning to nearby residents and alert key personnel responsible for taking action in case of an emergency.

6.3.4.3 Administrative and Procedural Aspects

The Administrative and Procedural Aspects of Emergency Action Plan consists of a flowchart depicting the names, addresses and telephone numbers of the responsible officials. In order of hierarchy, the following system will usually be appropriate. In the event of potential emergency, the observer at the site is required to report it to the Engineer-in-charge through a wireless system, if available, or by the fastest communication system available. The Engineer-in-charge shall be responsible for contacting the Civil Administration, *viz*. Deputy Commissioner. In order to oversee all the operations required to tackle the emergency situations, a centralized control room would be set up by the project authorities at Bowala.

Each person would be made aware of his/her responsibilities/ duties and the importance of work assigned under the Emergency Action Plan. All the villages falling under the flood prone zone or on the margins would be connected through wireless communication system with backup of standby telephone lines. A centralized siren alert system would be installed at all the Village Panchayats so that in the event of a warning all villagers can be alerted through sirens rather than informing everybody through messengers which is not feasible in such emergency situations.

6.3.4.4 Preventive Action

Once the likelihood of an emergency situation is suspected, action has to be initiated to prevent a failure. The point at which each situation reaches an emergency status shall be specified and at that stage the vigilance and surveillance shall be upgraded. At this stage, a thorough inspection of the dam shall be carried out to locate any visible signs of distress.

The anticipated need of equipment shall be evaluated and if these are not available at the dam site, the exact locations and availability of these equipments shall be identified. A plan shall be drawn on priority for inspection of the dam. The dam, its sluices and non-overflow sections will be properly illuminated.

6.3.4.5 Communication System

An efficient communication system and a downstream warning system is absolutely essential for the success of an emergency plan especially in the present case because of inadequacy of time. The difference between a high flood and a dam break situation shall be made clear to the downstream people. All of the villages falling under the flooding zone or on margins are required to be connected through wireless system backed by stand-by telephone lines. A centralized siren system is to be installed at Panchayats so that in event of a warning, all villagers can be alerted, through messengers which may not be possible in this case.

6.3.4.6 Merits of Satellite Communication System

Keeping the disaster scenario in mind, any terrestrial system such as land lines, etc. is likely to be the first casualty in earthquakes or floods. The restoration of such systems is time consuming. Moreover the maintenance of such lines becomes a great problem in emergency even for the technical personnel who are required to reach the site of fault, which may be struck by the disaster. So the system cannot be put back into operation soon. The fault repairs and restoration of communication services are usually not possible for a considerable period of time after the calamity has struck. Moreover, it is critical that the communication systems are restored at the earliest so that relief/medical teams and other personnel can be arranged at the earliest possible time. All the subsidiary help depends solely on the communication system. As this criteria is paramount, existing systems such as telephones and telex, etc. are practically of little use in case of such events and situations. Similarly, microwave links are expected to be down due to collapse of towers, etc. Restoration of towers and alignment of equipment is again a time consuming activity.

Keeping in view the urgency of services and their dependability during emergency relevant to the disaster conditions, satellite based systems present an ideal solution. The satellite based system usually comprises following components.

i) A small dish of approximately one meter diameter
ii) Associated radio equipment
iii) A power source

The deployment of the system is not dependent on the restoration of land routes. The existing satellite based communication systems are designed in such a manner that they are able to withstand fairly high degree of demanding environmental conditions. Secondly, the restoration of the satellite based system can be undertaken by carrying maintenance personnel and equipment by helicopters at a very short notice. Even the fresh systems could be inducted in a matter of an hour or so because most of these are designed for transportability by air. The deployment takes usually less than an hour. The power requirements are not large and can be met by sources such as UPS/batteries/ generators.

6.3.4.7 Financial Outlay for Installation of VSAT Communication System

The cost of deployment and maintenance of a telecommunication system in disaster prone areas is not as important as the availability, reliability and quick restoration of the system. The cost of both satellite bandwidth and the ground components of the satellite communication system has been decreasing rapidly like that of V-SAT (Very Small Aperture Terminal) based systems supporting a couple of voice and data channels. Some highly superior communication systems in VSAT without time delay are marketed by National agencies like HECL, HFCL and HCL Comet. There are two different types of systems with the above mentioned capabilities available in the market viz. SCPCDAMA and TDMA. However, the first one named SCPCDAMA has been recommended for the project. Two such systems would be installed first V SAT is in the upstream catchment of River and second one in Bowala town. The estimated cost of installation of such a communication system has been given in **Table 6.1**.

6.3.4.8 Evacuation Plans

Emergency Action Plan includes evacuation plans and procedures for implementation based on local needs. These are:

- Demarcation/prioritization of areas to be evacuated.
- Notification procedures and evacuation instructions.
- Safe routes, transport and traffic control.
- Shelter areas
- Functions and responsibilities of members of evacuation team.

The flood prone zone in the event of break of VP dam shall be marked properly at the village locations with adequate factor of safety. As the flood wave takes sufficient time in reaching these villages, its populace shall be informed well in time through wireless and sirens etc. so that people may climb on hills or to some elevated place beyond the flood zone which has been marked.

The Evacuation Team would comprise of:

i) D.M./ his Nominated Officer (To peacefully relocate the people to places at higher elevation with state administration)
ii) Engineer-in-Charge of the Project (Team Leader)
iii) S.P./Nominated Police Officer (To maintain law and order)
iv) C.M.O. of the area (To tackle morbidity of affected people)
v) Sarpanch/ Affected Village Representative to execute the resettlement operation with the aid of state machinery and project proponents
vi) Sub-committees at village level

The Engineer-in-Charge will be responsible for the entire operation including prompt determination of the flood situation from time to time. Once the red alert is declared the whole state machinery will come into swing and will start evacuating people in the inundation areas delineated in the inundation map. For successful execution, annually Demo exercise will be done. DM is to monitor the entire operation.

6.3.4.9 Notifications

Notification procedures are an integral part of any emergency action plan. Separate procedures shall be established for slowly and rapidly developed situations and failure. Notifications will include communications of either an alert situation or an alert situation followed by a warning situation. An alert situation will indicate that although failure or flooding is not imminent, a more serious situation can occur unless conditions improve. A warning situation will indicate that flooding is imminent as a result of an impending failure of the dam. It will normally include an order for evacuation of delineated inundation areas. For a regular watch on the flood level situation, it is necessary that two or more people man the flood cell so that an alternative person is available for notification round the clock.

In addition, a few guidelines to be generally followed by the inhabitants of flood prone areas, which form part of public awareness for disaster mitigation include:

- Listen to the radio for advance information and advice.
- Disconnect all electrical appliances and move all valuable personal and household goods and all clothing out of reach of flood water.
- Move vehicles, farm animals and movable goods to the highest ground nearby.
- Move all dangerous pollutants and insecticides out of reach of water.
- Do not enter flood waters on foot, if it can be avoided.

6.3.5 Cost Estimates for Disaster Management

The estimated total cost of execution of disaster management plan including the equipment would be **Rs. 80.00 lakh** and it is given in **Table 6.11**.

6.4 EPILOGUE

Impacts as discussed on natural resources, terrestrial and aquatic ecology of the area could be mitigated with available know-how in technology. The key issue is that the project would cause social upliftment of affected people and improvement in ecological environment in addition to the economic gains. Based on environmental base line data, prediction of positive and negative impacts and assessment, it could be concluded that the project will bring benefit at regional level. After incorporation of environmental management plans, the environmental sustainability will be further improved. In a nutshell, it could be concluded that the project is environmentally sustainable and eco-friendly.

TABLE 6.11
ESTIMATED COST OF SETTING UP OF A SATELLITE COMMUNICATION SYSTEM

S. No.	Product	Amount (Rs. in lakh)
A.	Setting up of V-SAT communication system	
1.	Product Name: SCPCDAMA (2 sites) @ Rs.11.00 lakh/ site a) Antenna 1 x 2.4 M b) RF 1 x 2 W c) Modem 1 x 1No.	22.00
2.	Generators 2 Nos. (2 KVA)	5.00
3.	UPS 2 Nos. (2 KVA)	3.00
4.	Installation and maintenance of system, maintenance and running cost of UPS, generators, etc. @ 10% of the total cost for 5 years	15.00
5	Band Width cost of the V –SAT arrangement @ 2.0 lakh per year per terminal = Rs 2.0 * 2 * 5 = Rs. 20 lakh for 2 terminals	20.00
	Sub-Total (A)	65.00
B.	Installation of alert systems, Setting up of control room, etc.	10.00
C.	Notification and publication procedures, miscellaneous, etc.	5.00
	Total (A+B+C) (Rs. in lakh)	**80.00**

Annexure 6-1

Dam Break Analysis of Vishnugad Pipalkothi HEP

ANNEXURE 6-1

ANALYSIS OF THE DOWNSTREAM FLOOD HYDROGRAPH

PRODUCED BY THE DAM BREAK OF

THDC PROJECT

ON

VISHNUGAD PIPALKOTHI PROJECT

ANALYSIS BY

RITES LIMITED

BASED ON PROCEDURE DEVELOPED BY
DANNY L. FREAD, PH.D., SR. RESEARCH HYDROLOGIST

QUALITY CONTROL TESTING AND OTHER SUPPORT BY
JANICE M. LEWIS, RESEARCH HYDROLOGIST

HYDROLOGIC RESEARCH LABORATORY
W23, OFFICE OF HYDROLOGY
NOAA, NATIONAL WEATHER SERVICE
SILVER SPRING, MARYLAND 20910

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***                        ***
***  SUMMARY OF INPUT DATA  ***
***                        ***
******************************
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INPUT CONTROL PARAMETERS FOR THDC PROJECT

PARAMETER	VARIABLE	VALUE
NUMBER OF DYNAMIC ROUTING REACHES	KKN	1
TYPE OF RESERVOIR ROUTING	KUI	0
MULTIPLE DAM INDICATOR	MULDAM	0
PRINTING INSTRUCTIONS FOR INPUT SUMMARY	KDMP	3
NO. OF RESERVOIR INFLOW HYDROGRAPH POINTS	ITEH	15
INTERVAL OF CROSS-SECTION INFO PRINTED OUT WHEN JNK=9	NPRT	0
FLOOD-PLAIN MODEL PARAMETER	KFLP	0
METRIC INPUT/OUTPUT OPTION	METRIC	1

TABLE OF ELEVATION VS VOLUME

VOLUME (M CUM) SA(K)	ELEVATION (M) HSA(K)
3.6	1267.00
2.3	1260.00
.9	1250.00
.6	1247.00
.5	1245.00
.2	1240.00
.1	1235.00
.0	1225.00

THDC PROJECT RESERVOIR AND BREACH PARAMETERS

PARAMETER	UNITS	VARIABLE	VALUE
LENGTH OF RESERVOIR	KM	RLM	2.03
ELEVATION OF WATER SURFACE	M	YO	1269.00
SIDE SLOPE OF BREACH		Z	.01
ELEVATION OF BOTTOM OF BREACH	M	YBMIN	1225.00

WIDTH OF BASE OF BREACH	M	BB	50.00
TIME TO MAXIMUM BREACH SIZE	HOUR	TFH	.25
ELEVATION (MSL) OF BOTTOM OF DAM	M	DATUM	1225.00
VOLUME-SURFACE AREA PARAMETER		VOL	1.00
ELEVATION OF WATER WHEN BREACHED	M	HF	1269.00
ELEVATION OF TOP OF DAM	M	HD	1269.00
ELEVATION OF UNCONTROLLED SPILLWAY CREST	M	HSP	.00
ELEVATION OF CENTER OF GATE OPENINGS	M	HGT	1233.00
DISCHARGE COEF. FOR UNCONTROLLED SPILLWAY		CS	.00
DISCHARGE COEF. FOR GATE FLOW		CG	25.00
DISCHARGE COEF. FOR UNCONTROLLED WEIR FLOW		CDO	57.00
DISCHARGE THRU TURBINES	CMS	QT	20.00

DHF(INTERVAL BETWEEN INPUT HYDROGRAPH ORDINATES) = 1.00 HRS.

TEH(TIME AT WHICH COMPUTATIONS TERMINATE)= 15.0000 HRS.

BREX(BREACH EXPONENT) = .000

MUD(MUD FLOW OPTION) = 0

IWF(TYPE OF WAVE FRONT TRACKING) = 0

KPRES(WETTED PERIMETER OPTION) = 0

KSL(LANDSLIDE PARAMETER) = 0

DFR(WINDOW FOR CRITICAL FROUDE NO. IN MIX FLOW ALGORITHM)= .050

INFLOW HYDROGRAPH TO THDC PROJECT
****

2106.00	2070.00	1992.50	41913.20	1829.98	1742.79	1650.99	1553.80
1450.08	1338.37	1216.40	41080.63	925.59	739.30	483.40	

TIME OF INFLOW HYDROGRAPH ORDINATES

.0000	1.0000	2.0000	3.0000	4.0000	5.0000	6.0000	7.0000
8.0000	9.0000	10.0000	11.0000	12.0000	13.0000	14.0000	

CROSS-SECTIONAL PARAMETERS FOR VISHNUGAD PIPALKOTI
BELOW THDC PROJECT

PARAMETER	VARIABLE	VALUE
NUMBER OF CROSS-SECTIONS	NS	20
MAXIMUM NUMBER OF TOP WIDTHS	NCS	5
NUMBER OF CROSS-SECTIONAL HYDROGRAPHS TO PLOT	NTT	6
TYPE OF OUTPUT OTHER THAN HYDROGRAPH PLOTS	JNK	4
CROSS-SECTIONAL SMOOTHING PARAMETER	KSA	0
DOWNSTREAM SUPERCRITICAL OR NOT	KSUPC	0
NO. OF LATERAL INFLOW HYDROGRAPHS	LQ	0
NO. OF POINTS IN GATE CONTROL CURVE	KCG	0

NUMBER OF CROSS-SECTION WHERE HYDROGRAPH DESIRED
(MAX NUMBER OF HYDROGRAPHS = 6)
****

2 5 8 12 16 20

CROSS-SECTIONAL VARIABLES FOR VISHNUGAD PIPALKOTI
BELOW THDC PROJECT

PARAMETER	UNITS	VARIABLE
LOCATION OF CROSS-SECTION	KM	XS(I)
ELEVATION(MSL) OF FLOODING AT CROSS-SECTION	M	FSTG(I)
ELEV CORRESPONDING TO EACH TOP WIDTH	M	HS(K,I)
TOP WIDTH CORRESPONDING TO EACH ELEV (ACTIVE FLOW PORTION)	M	BS(K,I)
TOP WIDTH CORRESPONDING TO EACH ELEV (OFF-CHANNEL PORTION)	M	BSS(K,I)
NUMBER OF CROSS-SECTION		I
NUMBER OF ELEVATION LEVEL		K

CROSS-SECTION NUMBER 1
****

XS(I) = .000 FSTG(I) = .00

HS ...	1225.0	1680.0	1720.0	1760.0	1800.0
BS ...	574.0	631.0	746.0	804.0	918.0
BSS ...	.0	.0	.0	.0	.0

```
 CROSS-SECTION NUMBER  2
*************************

 XS(I) =     3.700   FSTG(I) =     .00


 HS  ...   1200.0  1880.0  1920.0  1960.0  2000.0
 BS  ...   1190.0  1464.0  1722.0  1951.0  2066.0
 BSS ...       .0      .0      .0      .0      .0



 CROSS-SECTION NUMBER  3
*************************

 XS(I) =     5.900   FSTG(I) =     .00


 HS  ...   1170.0  1320.0  1360.0  1400.0  1440.0
 BS  ...    718.0   631.0   517.0   459.0   344.0
 BSS ...       .0      .0      .0      .0      .0



 CROSS-SECTION NUMBER  4
*************************

 XS(I) =     8.100   FSTG(I) =     .00


 HS  ...   1130.0  1680.0  1720.0  1760.0  1800.0
 BS  ...    460.0   574.0   804.0  1349.0  1435.0
 BSS ...       .0      .0      .0      .0      .0



 CROSS-SECTION NUMBER  5
*************************

 XS(I) =    10.200   FSTG(I) =     .00


 HS  ...   1080.0  1880.0  1920.0  1960.0  2000.0
 BS  ...    459.0   861.0  1693.0  1837.0  2009.0
 BSS ...       .0      .0      .0      .0      .0



 CROSS-SECTION NUMBER  6
*************************

 XS(I) =    11.500   FSTG(I) =     .00


 HS  ...   1050.0  1280.0  1320.0  1360.0  1400.0
 BS  ...   2440.0  2640.0  3042.0  3099.0  3272.0
 BSS ...       .0      .0      .0      .0      .0
```

CROSS-SECTION NUMBER 7
****

XS(I) = 15.800 FSTG(I) = .00

HS ...	1030.0	1280.0	1320.0	1360.0	1400.0
BS ...	574.0	718.0	861.0	1549.0	1722.0
BSS ...	.0	.0	.0	.0	.0

CROSS-SECTION NUMBER 8
****

XS(I) = 18.500 FSTG(I) = .00

HS ...	1025.0	1280.0	1320.0	1360.0	1400.0
BS ...	75.0	746.0	832.0	1091.0	1435.0
BSS ...	.0	.0	.0	.0	.0

CROSS-SECTION NUMBER 9
****

XS(I) = 19.000 FSTG(I) = .00

HS ...	1020.0	1025.0	1028.0	1031.0	1034.0
BS ...	76.0	76.0	76.0	76.0	76.0
BSS ...	.0	.0	.0	.0	.0

CROSS-SECTION NUMBER 10
****

XS(I) = 26.400 FSTG(I) = .00

HS ...	915.1	920.0	930.0	950.0	970.0
BS ...	.0	40.0	100.0	170.0	220.0
BSS ...	.0	.0	.0	.0	.0

CROSS-SECTION NUMBER 11
****

XS(I) = 32.600 FSTG(I) = .00

HS ...	849.3	860.0	870.0	875.0	880.0
BS ...	.0	100.0	180.0	235.0	265.0
BSS ...	.0	.0	.0	.0	.0

CROSS-SECTION NUMBER 12
****

XS(I) = 38.000 FSTG(I) = .00

HS ...	803.6	810.0	820.0	830.0	835.0
BS ...	.0	55.0	80.0	150.0	200.0
BSS ...	.0	.0	.0	.0	.0

CROSS-SECTION NUMBER 13
****

XS(I) = 46.500 FSTG(I) = .00

HS ...	749.5	760.0	770.0	775.0	780.0
BS ...	.0	90.0	190.0	260.0	300.0
BSS ...	.0	.0	.0	.0	.0

CROSS-SECTION NUMBER 14
****

XS(I) = 53.100 FSTG(I) = .00

HS ...	729.2	740.0	760.0	770.0	790.0
BS ...	.0	80.0	130.0	150.0	200.0
BSS ...	.0	.0	.0	.0	.0

CROSS-SECTION NUMBER 15
****

XS(I) = 59.900 FSTG(I) = .00

HS ...	710.0	720.0	730.0	740.0	750.0
BS ...	.0	90.0	130.0	150.0	190.0
BSS ...	.0	.0	.0	.0	.0

CROSS-SECTION NUMBER 16
****

XS(I) = 74.700 FSTG(I) = .00

HS ...	684.8	690.0	700.0	710.0	730.0
BS ...	.0	45.0	80.0	150.0	190.0
BSS ...	.0	.0	.0	.0	.0

```
 CROSS-SECTION NUMBER 17
*************************

 XS(I) =    94.800   FSTG(I) =     .00


 HS  ...    643.8   650.0   670.0   690.0   700.0
 BS  ...       .0    90.0   160.0   200.0   250.0
 BSS ...       .0      .0      .0      .0      .0



 CROSS-SECTION NUMBER 18
*************************

 XS(I) =   106.800   FSTG(I) =     .00


 HS  ...    613.4   620.0   630.0   650.0   670.0
 BS  ...       .0    60.0    75.0   150.0   220.0
 BSS ...       .0      .0      .0      .0      .0



 CROSS-SECTION NUMBER 19
*************************

 XS(I) =   117.600   FSTG(I) =     .00


 HS  ...    583.2   590.0   600.0   610.0   620.0
 BS  ...       .0    50.0    80.0   120.0   150.0
 BSS ...       .0      .0      .0      .0      .0



 CROSS-SECTION NUMBER 20
*************************

 XS(I) =   124.500   FSTG(I) =     .00


 HS  ...    565.0   570.0   580.0   590.0   595.0
 BS  ...       .0    50.0    60.0    70.0   100.0
 BSS ...       .0      .0      .0      .0      .0



 MANNING N ROUGHNESS COEFFICIENTS FOR THE GIVEN REACHES
        (CM(K,I),K=1,NCS) WHERE I = REACH NUMBER
********************************************************

 REACH  1 ...  .080   .080   .080   .080   .080

 REACH  2 ...  .080   .080   .080   .080   .080

 REACH  3 ...  .080   .080   .080   .080   .080

 REACH  4 ...  .080   .080   .080   .080   .080
```

REACH 5	...	.080	.080	.080	.080	.080
REACH 6	...	.060	.060	.060	.060	.060
REACH 7	...	.060	.060	.060	.060	.060
REACH 8	...	.055	.055	.055	.055	.055
REACH 9	...	.055	.055	.055	.055	.055
REACH 10	...	.060	.060	.060	.060	.060
REACH 11	...	.060	.060	.060	.060	.060
REACH 12	...	.060	.060	.060	.060	.060
REACH 13	...	.060	.060	.060	.060	.060
REACH 14	...	.060	.060	.060	.060	.060
REACH 15	...	.060	.060	.060	.060	.060
REACH 16	...	.060	.060	.060	.060	.060
REACH 17	...	.060	.060	.060	.060	.060
REACH 18	...	.060	.060	.060	.060	.060
REACH 19	...	.060	.060	.060	.060	.060

CROSS-SECTIONAL VARIABLES FOR VISHNUGAD PIPALKOTHI
BELOW THDC PROJECT

PARAMETER	UNITS	VARIABLE
MINIMUM COMPUTATIONAL DISTANCE USED BETWEEN CROSS-SECTIONS	KM	DXM(I)
CONTRACTION - EXPANSION COEFFICIENTS BETWEEN CROSS-SECTIONS		FKC(I)

REACH NUMBER	DXM(I)	FKC(I)
1	.150	.000
2	.150	.000
3	.150	.000
4	.150	.000
5	.150	.000
6	.150	.000

7	.150	.000
8	.500	.000
9	2.000	.000
10	2.000	.000
11	2.000	.000
12	2.000	.000
13	2.000	.000
14	2.000	.000
15	2.000	.000
16	2.000	.000
17	2.000	.000
18	2.000	.000
19	2.000	.000

DOWNSTREAM FLOW PARAMETERS FOR VISHNUGAD PIPALKOTI
BELOW THDC PROJECT

PARAMETER	UNITS	VARIABLE	VALUE
MAX DISCHARGE AT DOWNSTREAM EXTREMITY	CMS	QMAXD	.0
MAX LATERAL OUTFLOW PRODUCING LOSSES	CMS /M	QLL	.000
INITIAL SIZE OF TIME STEP	HOUR	DTHM	.0000
DOWNSTREAM BOUNDARY PARAMETER	M	YDN	.000000
SLOPE OF CHANNEL DOWNSTREAM OF DAM	%	SOM	.68
THETA WEIGHTING FACTOR		THETA	.00
CONVERGENCE CRITERION FOR STAGE	M	EPSY	.010000
TIME AT WHICH DAM STARTS TO FAIL	HOUR	TFI	.00

COMPUTATIONS WILL USE THE FOLLOWING DXM VALUES

.150 .150 .150 .150 .150 .150 .150 .500 2.000 2.000 2.000
2.000 2.000 2.000 2.000 2.000 2.000 2.000 2.000

TOTAL NUMBER OF CROSS SECTIONS (ORIGINAL+INTERPOLATED) (N) = 171 (MAXIMUM
ALLOWABLE = 200

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***                          ***
***  SUMMARY OF OUTPUT DATA  ***
***                          ***
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CROSS-SECTION NO.	KM	BOTTOM ELEVATION M	REACH NO.	REACH LENGTH KM	SLOPE %
1	.00	1225.00			
2	3.70	1200.00	1	3.70	.68
3	5.90	1170.00	2	2.20	1.36
4	8.10	1130.00	3	2.20	1.82
5	10.20	1080.00	4	2.10	2.38
6	11.50	1050.00	5	1.30	2.31
7	15.80	1030.00	6	4.30	.47
8	18.50	1025.00	7	2.70	.19
9	19.00	1017.60	8	.50	1.48
10	26.40	915.15	9	7.40	1.38
11	32.60	849.27	10	6.20	1.06
12	38.00	803.62	11	5.40	.85
13	46.50	749.54	12	8.50	.64
14	53.10	729.21	13	6.60	.31
15	59.90	710.04	14	6.80	.28
16	74.70	684.85	15	14.80	.17
17	94.80	643.79	16	20.10	.20
18	106.79	613.41	17	12.00	.25
19	117.59	583.21	18	10.80	.28
20	124.49	564.97	19	6.90	.26

DEFINITION OF VARIABLES IN RESERVOIR DEPLETION TABLE

PARAMETER	UNITS	VARIABLE
**	*******	******
TIME STEP FROM START OF ANALYSIS		I
ITERATIONS NECESSARY TO SOLVE FLOW EQUATIONS		K
ELAPSED TIME FROM START OF ANALYSIS	HOUR	TTP(I)
TOTAL OUTFLOW FROM DAM	CMS	Q(I)
ELEVATION OF WATER SURFACE AT DAM	M	H2
ELEVATION OF BOTTOM OF BREACH	M	YB
EST DEPTH OF FLOW IMMEDIATELY DOWNSTREAM	M	D
SUBMERGENCE COEFFICIENT		SUB
VELOCITY CORRECTION		VCOR

TOTAL VOLUME DISCHARGED FROM TIME OF BREACH	MILLION CU M	OUTVOL
BREACH WIDTH	M	BB
RECTANGULAR BREACH DISCHARGE COEFFICIENT		COFR
INFLOW TO RESERVOIR	CMS	QI(I)
BREACH OUTFLOW	CMS	QBRECH
SPILLWAY OUTFLOW	CMS	QSPIL

RESERVOIR DEPLETION TABLE

I	K	TTP(I)	Q(I)	H2	YB	D	SUB	VCOR	OUTVOL	BB	COFR	QI(I)	QBRECH	QSPIL
***	**	******	********	*******	*******	*******	****	****	*********	****	****	*****	******	*****
1	0	.000	386	1269.00	1269.00	1225.77	1.00	1.00	.0	.0	3.10	2106.	0.	387.
2	2	.005	388	1269.02	1268.12	1225.78	1.00	1.00	.0	1.0	3.10	2106.	1.	387.
3	2	.010	396	1269.07	1267.24	1225.79	1.00	1.00	.0	2.0	3.10	2106.	9.	388.
4	1	.015	413	1269.11	1266.36	1225.80	1.00	1.00	.0	3.0	3.10	2105.	24.	389.
5	1	.020	439	1269.16	1265.48	1225.84	1.00	1.00	.0	4.0	3.10	2105.	49.	391.
6	1	.025	477	1269.21	1264.60	1225.88	1.00	1.00	.0	5.0	3.10	2105.	85.	392.
7	1	.030	528	1269.25	1263.72	1225.93	1.00	1.00	.0	6.0	3.10	2105.	135.	394.
8	1	.035	593	1269.29	1262.84	1226.00	1.00	1.00	.1	7.0	3.10	2105.	198.	396.
9	1	.040	673	1269.33	1261.96	1226.08	1.00	1.00	.1	8.0	3.10	2105.	276.	397.
10	1	.045	768	1269.37	1261.08	1226.17	1.00	1.00	.1	9.0	3.10	2104.	371.	398.
11	1	.050	881	1269.41	1260.20	1226.27	1.00	1.00	.1	10.0	3.10	2104.	482.	399.
12	2	.055	1010	1269.44	1259.32	1226.38	1.00	1.00	.1	11.0	3.10	2104.	611.	400.
13	2	.060	1158	1269.47	1258.44	1226.49	1.00	1.00	.1	12.0	3.10	2104.	758.	401.
14	2	.065	1324	1269.49	1257.56	1226.62	1.00	1.00	.2	13.0	3.10	2104.	924.	401.
15	2	.070	1508	1269.51	1256.68	1226.75	1.00	1.00	.2	14.0	3.10	2103.	1109.	399.
16	2	.075	1712	1269.53	1255.80	1226.89	1.00	1.00	.2	15.0	3.10	2103.	1315.	398.
17	2	.080	1936	1269.53	1254.92	1227.03	1.00	1.00	.2	16.0	3.10	2103.	1541.	396.
18	2	.085	2180	1269.53	1254.04	1227.18	1.00	1.00	.3	17.0	3.10	2103.	1787.	393.
19	2	.090	2445	1269.53	1253.16	1227.34	1.00	1.00	.3	18.0	3.10	2103.	2055.	391.
20	2	.095	2731	1269.52	1252.28	1227.50	1.00	1.00	.4	19.0	3.10	2103.	2343.	388.
21	2	.100	3038	1269.49	1251.40	1227.66	1.00	1.00	.4	20.0	3.10	2102.	2653.	385.
22	2	.105	3366	1269.46	1250.52	1227.83	1.00	1.00	.5	21.0	3.10	2102.	2984.	382.
23	2	.110	3716	1269.42	1249.64	1228.01	1.00	1.00	.5	22.0	3.10	2102.	3337.	379.
24	2	.115	4086	1269.37	1248.76	1228.18	1.00	1.00	.6	23.0	3.10	2102.	3710.	376.
25	2	.120	4477	1269.31	1247.88	1228.36	1.00	1.00	.7	24.0	3.10	2102.	4105.	373.
26	2	.125	4889	1269.24	1247.00	1228.54	1.00	1.00	.8	25.0	3.10	2102.	4520.	370.
27	2	.130	5323	1269.16	1246.12	1228.73	1.00	1.00	.9	26.0	3.10	2101.	4955.	368.
28	2	.135	5778	1269.06	1245.24	1228.92	1.00	1.00	1.0	27.0	3.10	2101.	5411.	367.
29	2	.140	6252	1268.95	1244.36	1229.11	1.00	1.00	1.1	28.0	3.10	2101.	5886.	367.
30	2	.145	6745	1268.83	1243.48	1229.30	1.00	1.00	1.2	29.0	3.10	2101.	6380.	366.
31	2	.150	7257	1268.69	1242.60	1229.49	1.00	1.00	1.3	30.0	3.10	2101.	6892.	365.
32	2	.155	7786	1268.54	1241.72	1229.68	1.00	1.00	1.5	31.0	3.10	2100.	7422.	364.
33	2	.160	8332	1268.37	1240.84	1229.88	1.00	1.00	1.6	32.0	3.10	2100.	7968.	364.
34	2	.165	8893	1268.19	1239.96	1230.07	1.00	1.00	1.8	33.0	3.10	2100.	8531.	363.
35	2	.170	9470	1267.99	1239.08	1230.27	1.00	1.00	1.9	34.0	3.10	2100.	9109.	362.
36	2	.175	10062	1267.77	1238.20	1230.46	1.00	1.00	2.1	35.0	3.10	2100.	9702.	361.
37	2	.180	10666	1267.54	1237.32	1230.66	1.00	1.00	2.3	36.0	3.10	2100.	10307.	359.
38	2	.185	11283	1267.29	1236.44	1230.85	1.00	1.00	2.5	37.0	3.10	2099.	10925.	358.
39	2	.190	11910	1267.01	1235.56	1231.04	1.00	1.00	2.7	38.0	3.10	2099.	11554.	357.
40	2	.195	12547	1266.72	1234.68	1231.24	1.00	1.00	2.9	39.0	3.10	2099.	12193.	355.
41	2	.200	13193	1266.41	1233.80	1231.43	1.00	1.00	3.1	40.0	3.10	2099.	12840.	353.
42	2	.205	13847	1266.08	1232.92	1231.61	1.00	1.00	3.4	41.0	3.10	2099.	13495.	352.
43	2	.210	14506	1265.73	1232.04	1231.80	1.00	1.00	3.6	42.0	3.10	2098.	14157.	350.
44	2	.215	15170	1265.36	1231.16	1231.99	1.00	1.00	3.9	43.0	3.10	2098.	14823.	348.

45	2	.220	15837	1264.96	1230.28	1232.17	1.00	1.00	4.2	44.0	3.10	2098.	15492.	346.
46	2	.225	16506	1264.55	1229.40	1232.35	1.00	1.00	4.5	45.0	3.10	2098.	16163.	343.
47	2	.230	17175	1264.11	1228.52	1232.53	1.00	1.00	4.8	46.0	3.10	2098.	16835.	341.
48	2	.235	17843	1263.65	1227.64	1232.70	1.00	1.00	5.1	47.0	3.10	2098.	17505.	338.
49	2	.240	18508	1263.16	1226.76	1232.87	1.00	1.00	5.4	48.0	3.10	2097.	18173.	336.
50	2	.245	19169	1262.65	1225.88	1233.04	1.00	1.00	5.8	49.0	3.10	2097.	18837.	333.
51	2	.250	19823	1262.12	1225.00	1233.20	1.00	1.00	6.1	50.0	3.10	2097.	19495.	329.
52	2	.255	19396	1261.57	1225.00	1233.10	1.00	1.00	6.5	50.0	3.10	2097.	19071.	326.
53	2	.260	18977	1261.04	1225.00	1232.99	1.00	1.00	6.8	50.0	3.10	2097.	18654.	324.
54	2	.265	18567	1260.52	1225.00	1232.89	1.00	1.00	7.1	50.0	3.10	2096.	18246.	321.
55	2	.270	18166	1260.00	1225.00	1232.78	1.00	1.00	7.5	50.0	3.10	2096.	17849.	318.
56	2	.275	17773	1259.49	1225.00	1232.68	1.00	1.00	7.8	50.0	3.10	2096.	17459.	315.
57	2	.280	17385	1258.98	1225.00	1232.58	1.00	1.00	8.1	50.0	3.10	2096.	17074.	312.
58	2	.285	17003	1258.48	1225.00	1232.48	1.00	1.00	8.4	50.0	3.10	2096.	16695.	309.
59	2	.290	16627	1257.98	1225.00	1232.38	1.00	1.00	8.7	50.0	3.10	2096.	16322.	306.
60	2	.295	16255	1257.49	1225.00	1232.28	1.00	1.00	9.0	50.0	3.10	2095.	15953.	303.
61	2	.300	15889	1256.99	1225.00	1232.18	1.00	1.00	9.3	50.0	3.10	2095.	15590.	299.
62	2	.305	15529	1256.50	1225.00	1232.09	1.00	1.00	9.6	50.0	3.10	2095.	15233.	296.
63	2	.310	15173	1256.02	1225.00	1231.99	1.00	1.00	9.9	50.0	3.10	2095.	14881.	293.
64	2	.315	14823	1255.54	1225.00	1231.89	1.00	1.00	10.1	50.0	3.10	2095.	14534.	290.
65	2	.320	14479	1255.06	1225.00	1231.79	1.00	1.00	10.4	50.0	3.10	2094.	14192.	287.
66	2	.325	14139	1254.58	1225.00	1231.70	1.00	1.00	10.7	50.0	3.10	2094.	13855.	284.
67	2	.330	13805	1254.11	1225.00	1231.60	1.00	1.00	10.9	50.0	3.10	2094.	13524.	281.
68	2	.335	13475	1253.64	1225.00	1231.51	1.00	1.00	11.2	50.0	3.10	2094.	13198.	278.
69	2	.340	13151	1253.17	1225.00	1231.41	1.00	1.00	11.4	50.0	3.10	2094.	12877.	275.
70	2	.345	12832	1252.71	1225.00	1231.32	1.00	1.00	11.6	50.0	3.10	2094.	12561.	271.
71	2	.350	12518	1252.26	1225.00	1231.23	1.00	1.00	11.9	50.0	3.10	2093.	12250.	268.
72	2	.355	12209	1251.80	1225.00	1231.13	1.00	1.00	12.1	50.0	3.10	2093.	11944.	265.
73	2	.360	11905	1251.35	1225.00	1231.04	1.00	1.00	12.3	50.0	3.10	2093.	11643.	262.
74	2	.365	11606	1250.90	1225.00	1230.95	1.00	1.00	12.5	50.0	3.10	2093.	11347.	259.
75	2	.370	11311	1250.46	1225.00	1230.86	1.00	1.00	12.7	50.0	3.10	2093.	11056.	255.
76	2	.375	11022	1250.02	1225.00	1230.77	1.00	1.00	12.9	50.0	3.10	2093.	10770.	252.
77	2	.380	10729	1249.57	1225.00	1230.68	1.00	1.00	13.1	50.0	3.10	2092.	10481.	249.
78	2	.385	10421	1249.09	1225.00	1230.58	1.00	1.00	13.3	50.0	3.10	2092.	10176.	245.
79	2	.390	10092	1248.58	1225.00	1230.47	1.00	1.00	13.5	50.0	3.10	2092.	9852.	241.
80	2	.395	9734	1248.01	1225.00	1230.35	1.00	1.00	13.7	50.0	3.10	2092.	9498.	237.
81	2	.400	9329	1247.36	1225.00	1230.22	1.00	1.00	13.8	50.0	3.10	2092.	9097.	232.
82	2	.405	8871	1246.62	1225.00	1230.06	1.00	1.00	14.0	50.0	3.10	2091.	8646.	226.
83	2	.410	8404	1245.85	1225.00	1229.90	1.00	1.00	14.2	50.0	3.10	2091.	8185.	219.
84	2	.415	7959	1245.10	1225.00	1229.75	1.00	1.00	14.3	50.0	3.10	2091.	7747.	213.
85	2	.420	7541	1244.38	1225.00	1229.59	1.00	1.00	14.4	50.0	3.10	2091.	7335.	206.
86	2	.425	7154	1243.70	1225.00	1229.45	1.00	1.00	14.6	50.0	3.10	2091.	6954.	200.
87	2	.430	6795	1243.07	1225.00	1229.32	1.00	1.00	14.7	50.0	3.10	2091.	6601.	194.
88	2	.435	6462	1242.47	1225.00	1229.19	1.00	1.00	14.8	50.0	3.10	2090.	6275.	188.
89	2	.440	6154	1241.90	1225.00	1229.07	1.00	1.00	14.9	50.0	3.10	2090.	5972.	182.
90	2	.445	5869	1241.37	1225.00	1228.95	1.00	1.00	15.0	50.0	3.10	2090.	5693.	177.
91	2	.450	5605	1240.87	1225.00	1228.85	1.00	1.00	15.1	50.0	3.10	2090.	5434.	172.
92	2	.455	5360	1240.40	1225.00	1228.74	1.00	1.00	15.2	50.0	3.10	2090.	5195.	166.
93	2	.460	5133	1239.96	1225.00	1228.65	1.00	1.00	15.3	50.0	3.10	2089.	4972.	161.

94	2	.465	4920	1239.54	1225.00	1228.56	1.00	1.00	15.4	50.0	3.10	2089.	4764.	156.
95	2	.470	4719	1239.14	1225.00	1228.47	1.00	1.00	15.5	50.0	3.10	2089.	4568.	151.
96	2	.475	4528	1238.75	1225.00	1228.38	1.00	1.00	15.6	50.0	3.10	2089.	4382.	147.
97	2	.480	4349	1238.39	1225.00	1228.30	1.00	1.00	15.7	50.0	3.10	2089.	4207.	142.
98	2	.485	4179	1238.04	1225.00	1228.22	1.00	1.00	15.8	50.0	3.10	2089.	4043.	137.
99	2	.490	4020	1237.70	1225.00	1228.15	1.00	1.00	15.8	50.0	3.10	2088.	3888.	133.
100	2	.495	3871	1237.38	1225.00	1228.08	1.00	1.00	15.9	50.0	3.10	2088.	3743.	128.
101	2	.500	3731	1237.08	1225.00	1228.01	1.00	1.00	16.0	50.0	3.10	2088.	3608.	124.
102	2	.505	3599	1236.80	1225.00	1227.95	1.00	1.00	16.0	50.0	3.10	2088.	3481.	119.
103	2	.510	3465	1236.50	1225.00	1227.88	1.00	1.00	16.1	50.0	3.10	2088.	3351.	114.
104	2	.517	3328	1236.20	1225.00	1227.81	1.00	1.00	16.2	50.0	3.10	2087.	3220.	109.
105	2	.523	3191	1235.89	1225.00	1227.74	1.00	1.00	16.3	50.0	3.10	2087.	3088.	104.
106	1	.531	3055	1235.59	1225.00	1227.67	1.00	1.00	16.3	50.0	3.10	2087.	2957.	98.
107	2	.539	2922	1235.28	1225.00	1227.60	1.00	1.00	16.4	50.0	3.10	2087.	2830.	92.
108	2	.547	2794	1234.98	1225.00	1227.53	1.00	1.00	16.5	50.0	3.10	2086.	2708.	86.
109	2	.557	2674	1234.70	1225.00	1227.47	1.00	1.00	16.6	50.0	3.10	2086.	2595.	80.
110	2	.568	2565	1234.44	1225.00	1227.41	1.00	1.00	16.7	50.0	3.10	2086.	2492.	73.
111	2	.580	2467	1234.21	1225.00	1227.35	1.00	1.00	16.8	50.0	3.10	2085.	2401.	67.
112	2	.593	2382	1234.01	1225.00	1227.30	1.00	1.00	16.9	50.0	3.10	2085.	2321.	61.
113	2	.607	2310	1233.83	1225.00	1227.26	1.00	1.00	17.1	50.0	3.10	2084.	2254.	56.
114	2	.623	2249	1233.69	1225.00	1227.22	1.00	1.00	17.2	50.0	3.10	2084.	2199.	51.
115	2	.640	2201	1233.57	1225.00	1227.20	1.00	1.00	17.3	50.0	3.10	2083.	2155.	46.
116	2	.659	2163	1233.48	1225.00	1227.17	1.00	1.00	17.5	50.0	3.10	2082.	2121.	43.
117	2	.680	2135	1233.42	1225.00	1227.16	1.00	1.00	17.6	50.0	3.10	2082.	2096.	39.
118	2	.703	2114	1233.37	1225.00	1227.14	1.00	1.00	17.8	50.0	3.10	2081.	2078.	37.
119	2	.728	2100	1233.33	1225.00	1227.13	1.00	1.00	18.0	50.0	3.10	2080.	2065.	35.
120	2	.756	2091	1233.31	1225.00	1227.13	1.00	1.00	18.2	50.0	3.10	2079.	2057.	34.
121	2	.786	2084	1233.30	1225.00	1227.12	1.00	1.00	18.4	50.0	3.10	2078.	2052.	33.
122	2	.820	2080	1233.29	1225.00	1227.12	1.00	1.00	18.7	50.0	3.10	2076.	2048.	33.
123	1	.857	2078	1233.28	1225.00	1227.12	1.00	1.00	19.0	50.0	3.10	2075.	2046.	32.
124	1	.898	2075	1233.28	1225.00	1227.12	1.00	1.00	19.3	50.0	3.10	2074.	2044.	32.
125	1	.942	2073	1233.27	1225.00	1227.12	1.00	1.00	19.6	50.0	3.10	2072.	2042.	32.
126	1	.992	2072	1233.27	1225.00	1227.12	1.00	1.00	20.0	50.0	3.10	2070.	2040.	32.
127	1	1.046	2069	1233.26	1225.00	1227.12	1.00	1.00	20.4	50.0	3.10	2066.	2038.	31.
128	2	1.105	2065	1233.25	1225.00	1227.11	1.00	1.00	20.8	50.0	3.10	2062.	2035.	31.
129	1	1.171	2060	1233.24	1225.00	1227.11	1.00	1.00	21.3	50.0	3.10	2057.	2030.	30.
130	1	1.243	2054	1233.23	1225.00	1227.11	1.00	1.00	21.8	50.0	3.10	2051.	2026.	29.
131	1	1.322	2048	1233.21	1225.00	1227.10	1.00	1.00	22.4	50.0	3.10	2045.	2020.	28.
132	1	1.410	2041	1233.20	1225.00	1227.10	1.00	1.00	23.1	50.0	3.10	2038.	2015.	27.
133	1	1.506	2034	1233.18	1225.00	1227.09	1.00	1.00	23.8	50.0	3.10	2031.	2008.	26.
134	1	1.611	2026	1233.16	1225.00	1227.09	1.00	1.00	24.6	50.0	3.10	2023.	2002.	25.
135	1	1.727	2017	1233.14	1225.00	1227.08	1.00	1.00	25.4	50.0	3.10	2014.	1994.	23.
136	1	1.855	2007	1233.12	1225.00	1227.08	1.00	1.00	26.3	50.0	3.10	2004.	1986.	21.
137	1	1.996	1996	1233.10	1225.00	1227.07	1.00	1.00	27.3	50.0	3.10	1993.	1977.	19.
138	4	2.150	5334	1240.35	1225.00	1228.73	1.00	1.00	29.4	50.0	3.10	7989.	5169.	166.
139	3	2.320	10644	1249.44	1225.00	1230.65	1.00	1.00	34.3	50.0	3.10	14776.	10397.	248.
140	3	2.507	16269	1257.50	1225.00	1232.29	1.00	1.00	43.3	50.0	3.10	22242.	15967.	303.
141	3	2.713	23135	1266.17	1225.00	1234.00	1.00	1.00	57.9	50.0	3.10	30455.	22788.	347.
142	3	2.939	31474	1275.59	1225.00	1235.82	1.00	1.00	80.2	50.0	3.10	39488.	31089.	385.

143	3	3.188	35513	1279.84	1225.00	1236.64	1.00	1.00	110.2	50.0	3.10	34370.	35111.	402.
144	4	3.462	30299	1274.32	1225.00	1235.58	1.00	1.00	142.6	50.0	3.10	23395.	29919.	380.
145	4	3.763	19389	1261.57	1225.00	1233.10	1.00	1.00	169.6	50.0	3.10	11321.	19063.	326.
146	4	4.095	5836	1241.31	1225.00	1228.94	1.00	1.00	184.6	50.0	3.10	1822.	5661.	176.
148	0	4.82	386											
149	0	5.22	386											
150	0	5.67	386											
151	0	6.15	386											
152	0	6.68	386											
153	0	7.27	386											
154	0	7.92	386											
155	0	8.63	386											
156	0	9.41	386											
157	0	10.27	386											
158	0	11.21	386											
159	0	12.25	386											
160	0	13.40	386											
161	0	14.65	386											
162	0	16.04	386											

PARAMETER	UNITS	VARIABLE	VALUE
INITIAL FLOW	CMS	Q(1)	387.
MAX FLOW	CMS	QM	35513.
FINAL FLOW	CMS	Q(NU)	387.
TIME TO MAX FLOW	HRS	TP	3.19
NUMBER OF TIME STEPS		NNU	162

TIME PARAMETERS OF OUTFLOW HYDROGRAPH IMMEDIATELY DOWNSTREAM OF DAM

PARAMETER	UNITS	VARIABLE	VALUE
TIME TO FAILURE	HR	TFH	.250
TIME TO START OF RISING LIMB OF HYDROGRAPH	HR	TFO	2.938
TIME TO PEAK	HR	TP	3.188
TIME STEP SIZE	HR	DTHI	.013

ROUTING COMPLETED.

PROFILE OF CRESTS AND TIMES FOR VISHNUGAD PIPALKOTI
BELOW THDC PROJECT

DISTANCE FROM DAM KM	MAX ELEV M	MAX FLOW CMS	TIME MAX ELEV-HRS	MAX VEL M/S
.154	1234.48	35444	3.188	5.61
.308	1233.22	35384	3.201	5.49
.462	1231.96	35379	3.201	5.38
.617	1230.72	35349	3.201	5.28
.771	1229.48	35301	3.213	5.18
.925	1228.26	35281	3.213	5.09
1.079	1227.04	35260	3.213	5.01
1.233	1225.84	35222	3.226	4.93
1.387	1224.63	35197	3.226	4.85
1.541	1223.44	35177	3.238	4.78
1.695	1222.25	35141	3.238	4.71
1.850	1221.07	35119	3.238	4.64
2.004	1219.89	35097	3.251	4.58
2.158	1218.72	35059	3.251	4.52
2.312	1217.55	35046	3.263	4.46
2.466	1216.39	35018	3.263	4.41

2.620	1215.23	34993	3.263	4.36
2.774	1214.08	34973	3.276	4.31
2.929	1212.92	34944	3.276	4.27
3.083	1211.76	34928	3.288	4.23
3.237	1210.58	34901	3.288	4.20
3.391	1209.35	34890	3.288	4.21
3.545	1208.02	34871	3.301	4.29
3.699	1206.16	34862	3.301	4.75
3.856	1204.13	34849	3.313	4.80
4.013	1202.11	34838	3.313	4.85
4.171	1200.09	34828	3.326	4.90
4.328	1198.08	34815	3.326	4.96
4.485	1196.08	34807	3.338	5.01
4.642	1194.08	34792	3.338	5.07
4.799	1192.10	34787	3.338	5.13
4.956	1190.12	34773	3.351	5.20
5.113	1188.16	34765	3.351	5.27
5.270	1186.21	34755	3.363	5.33
5.427	1184.27	34743	3.363	5.41
5.585	1182.34	34737	3.363	5.50
5.742	1180.36	34725	3.376	5.63
5.899	1177.63	34723	3.376	6.36
6.056	1174.90	34719	3.376	6.42
6.213	1172.17	34710	3.388	6.48
6.370	1169.45	34709	3.388	6.54
6.527	1166.74	34704	3.388	6.60
6.684	1164.03	34695	3.401	6.67
6.841	1161.33	34694	3.401	6.74
6.998	1158.64	34690	3.401	6.81
7.156	1155.97	34682	3.413	6.89
7.313	1153.30	34680	3.413	6.96
7.470	1150.64	34676	3.413	7.04
7.627	1148.00	34668	3.426	7.13
7.784	1145.37	34664	3.426	7.21
7.941	1142.95	34662	3.426	7.17
8.098	1139.01	34658	3.426	8.34
8.248	1135.44	34653	3.438	8.34
8.398	1131.87	34654	3.438	8.34
8.548	1128.30	34653	3.438	8.34
8.698	1124.72	34649	3.438	8.34
8.848	1121.16	34644	3.438	8.33
8.998	1117.56	34636	3.438	8.35
9.148	1114.04	34625	3.438	8.31
9.298	1110.39	34613	3.469	8.38
9.448	1106.95	34613	3.469	8.25
9.598	1103.16	34618	3.469	8.45
9.748	1099.96	34621	3.469	8.12
9.898	1095.80	34622	3.469	8.68
10.048	1093.30	34620	3.469	7.71
10.198	1088.01	34616	3.469	9.38
10.360	1082.13	34612	3.469	8.32
10.523	1078.31	34604	3.469	6.23
10.685	1073.34	34591	3.469	6.26
10.848	1069.84	34585	3.499	4.93
11.010	1064.88	34594	3.499	5.61
11.173	1061.96	34593	3.499	3.98
11.335	1056.50	34588	3.499	5.74
11.498	1054.73	34556	3.530	3.00
11.651	1054.10	34513	3.530	3.02
11.805	1053.48	34483	3.561	3.05
11.958	1052.93	34437	4.121	3.07

12.112	1052.77	34374	4.153	3.10
12.265	1052.67	34330	4.185	3.12
12.419	1052.59	34268	4.185	3.15
12.572	1052.54	34167	4.185	3.17
12.726	1052.49	34007	4.185	3.19
12.879	1052.46	33758	4.185	3.20
13.033	1052.43	33397	4.218	3.22
13.186	1052.41	32982	4.218	3.23
13.340	1052.39	32421	4.218	3.24
13.494	1052.37	31779	4.218	3.25
13.647	1052.35	31049	4.218	3.25
13.801	1052.34	30246	4.218	3.25
13.954	1052.32	29382	4.218	3.25
14.108	1052.31	28449	4.218	3.24
14.261	1052.29	27493	4.218	3.23
14.415	1052.28	26479	4.218	3.22
14.568	1052.27	25423	4.218	3.20
14.722	1052.25	24360	4.218	3.18
14.875	1052.23	23283	4.218	3.14
15.029	1052.22	22217	4.218	3.07
15.182	1052.20	21265	4.218	2.98
15.336	1052.18	20667	4.218	2.89
15.490	1052.15	20269	4.218	2.82
15.643	1052.13	20066	4.218	2.77
15.797	1052.09	19891	4.218	2.77
15.947	1052.06	19739	4.218	2.74
16.097	1052.03	19608	4.218	2.70
16.246	1052.00	19507	4.218	2.66
16.396	1051.96	19423	4.218	2.62
16.546	1051.92	19357	4.218	2.58
16.696	1051.87	19313	4.218	2.55
16.846	1051.82	19278	4.218	2.53
16.996	1051.75	19250	4.218	2.51
17.146	1051.68	19226	4.218	2.50
17.296	1051.59	19209	4.218	2.51
17.446	1051.47	19194	4.218	2.70
17.596	1051.33	19186	4.218	2.94
17.746	1051.15	19178	4.218	3.24
17.896	1050.90	19171	4.218	3.64
18.046	1050.55	19168	4.218	4.16
18.196	1050.00	19167	4.218	4.91
18.346	1049.01	19165	4.218	6.09
18.496	1046.46	19163	4.250	8.84
18.996	**1033.87**	**19160**	**4.218**	**15.50**
21.462	1004.09	19156	4.282	11.91
23.928	969.81	19149	4.315	12.67
26.394	937.99	19143	4.347	11.21
28.461	916.87	19135	4.379	9.07
30.527	892.46	19125	4.412	10.00
32.593	872.62	19109	4.476	7.82
35.292	851.72	19071	4.573	7.86
37.992	832.28	19021	4.670	8.08
40.116	815.93	18999	4.703	8.32
42.241	803.36	18952	4.800	6.85
44.365	785.58	18942	4.800	8.80
46.490	779.03	18738	5.091	5.07
48.689	773.68	18450	5.188	5.60
50.889	767.68	18284	5.253	6.06
53.089	760.46	18199	5.317	7.05
55.355	753.13	18109	5.414	6.95
57.621	746.82	17921	5.608	6.68

59.887	742.89	17639	5.705	5.51
62.001	739.49	17372	5.802	5.46
64.115	736.04	17129	5.867	5.38
66.229	732.56	16911	5.964	5.31
68.342	729.00	16715	6.061	5.26
70.456	725.34	16548	6.126	5.23
72.570	721.47	16401	6.191	5.28
74.684	717.10	16271	6.288	5.52
76.693	712.68	16147	6.385	5.57
78.703	708.09	16015	6.482	5.67
80.713	703.29	15883	6.546	5.75
82.722	698.38	15761	6.643	5.79
84.732	693.52	15650	6.740	5.79
86.741	688.71	15549	6.805	5.77
88.751	683.98	15452	6.902	5.71
90.760	679.33	15353	6.967	5.64
92.770	674.79	15246	7.064	5.57
94.780	670.43	15124	7.161	5.46
96.779	666.17	14986	7.290	5.52
98.779	662.09	14840	7.387	5.59
100.778	658.10	14702	7.452	5.64
102.778	654.07	14582	7.517	5.66
104.777	649.75	14486	7.614	5.75
106.777	644.47	14408	7.678	6.25
108.937	638.43	14328	7.775	6.20
111.096	632.38	14253	7.840	6.16
113.256	626.32	14179	7.937	6.11
115.415	620.45	14084	8.099	6.08
117.575	615.47	13936	8.261	5.86
119.874	610.70	13728	8.390	6.10
122.174	606.33	13502	8.554	6.38
124.473	602.17	13276	8.656	6.79

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    DISCHARGE HYDROGRAPH FOR   VISHNUGAD PIPALKOTI ... STATION NUMBER 25
                  BELOW       THDC PROJECT   AT KM       3.70
GAGE ZERO = 1200.00 M        MAX ELEVATION REACHED BY FLOOD WAVE = 1206.16 M
                  MAX STAGE =    6.16 M        AT TIME =    3.301 HOURS
                  MAX FLOW =    34863 CMS      AT TIME =    3.301 HOURS

   TIME  STAGE     FLOW
    HR    M         CMS  0     10000     20000     30000     40000     50000
     .0     .4      387  *         .         .         .         .         .
     .1     .4      400  *         .         .         .         .         .
     .2     .5      537  .*        .         .         .         .         .
     .3     .9     1550  . *       .         .         .         .         .
     .4    1.7     4676  .    *    .         .         .         .         .
     .5    2.6     8696  .        *.         .         .         .         .
     .6    2.8     9636  .         *         .         .         .         .
     .7    2.5     8089  .       * .         .         .         .         .
     .8    2.0     5179  .    *    .         .         .         .         .
     .9    1.5     3551  .   *     .         .         .         .         .
    1.0    1.3     2636  .  *      .         .         .         .         .
    1.1    1.2     2203  . *       .         .         .         .         .
    1.2    1.1     2097  . *       .         .         .         .         .
    1.3    1.1     2062  . *       .         .         .         .         .
    1.4    1.1     2069  . *       .         .         .         .         .
    1.5    1.1     2064  . *       .         .         .         .         .
    1.6    1.1     2059  . *       .         .         .         .         .
    1.7    1.1     2052  . *       .         .         .         .         .
    1.8    1.1     2045  . *       .         .         .         .         .
    1.9    1.1     2037  . *       .         .         .         .         .
    2.0    1.1     2033  . *       .         .         .         .         .
    2.1    1.1     2058  . *       .         .         .         .         .
    2.2    1.2     2309  . *       .         .         .         .         .
    2.3    1.3     2896  .  *      .         .         .         .         .
    2.4    1.8     4954  .    *    .         .         .         .         .
    2.5    2.5     8433  .       * .         .         .         .         .
    2.6    3.3    12769  .         .  *      .         .         .         .
    2.7    3.9    16964  .         .      *  .         .         .         .
    2.8    4.5    20836  .         .         .*        .         .         .
    2.9    5.0    24540  .         .         .    *    .         .         .
    3.0    5.4    28593  .         .         .        *.         .         .
    3.1    5.8    31710  .         .         .         . *       .         .
    3.2    6.0    33604  .         .         .         .   *     .         .
    3.3    6.2    34862  .         .         .         .    *    .         .
    3.4    6.1    33800  .         .         .         .   *     .         .
    3.5    5.9    32038  .         .         .         . *       .         .
    3.6    5.6    29812  .         .         .         *         .         .
    3.7    5.3    26729  .         .         .      *  .         .         .
    3.8    4.9    23444  .         .         .  *      .         .         .
    3.9    4.4    20134  .         .         *         .         .         .
    4.0    4.0    16724  .         .      *  .         .         .         .
    4.1    3.5    13373  .         .  *      .         .         .         .
    4.2    2.9    10247  .         *         .         .         .         .
    4.3    2.5     7608  .       * .         .         .         .         .
    4.4    2.1     5731  .     *   .         .         .         .         .
    4.5    1.8     4425  .   *     .         .         .         .         .
    4.6    1.5     3400  .  *      .         .         .         .         .
    4.7    1.3     2555  .  *      .         .         .         .         .
    4.8    1.1     1881  . *       .         .         .         .         .
    4.9     .9     1374  .*        .         .         .         .         .
    5.0     .7     1012  .*        .         .         .         .         .
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    DISCHARGE HYDROGRAPH FOR   VISHNUGAD PIPALKOTI ... STATION NUMBER    67
                  BELOW       THDC PROJECT   AT KM      10.20
GAGE ZERO = 1080.00 M        MAX ELEVATION REACHED BY FLOOD WAVE = 1088.01 M
                  MAX STAGE =    8.01 M         AT TIME =    3.469 HOURS
                  MAX FLOW =    34617 CMS       AT TIME =    3.469 HOURS

   TIME  STAGE      FLOW
    HR    M          CMS  0     10000     20000     30000     40000     50000
     .0     .8       387  *         .         .         .         .         .
     .2     .8       387  *         .         .         .         .         .
     .4     .8       389  *         .         .         .         .         .
     .6     .9       517  .*        .         .         .         .         .
     .8    2.3      3344  .  *      .         .         .         .         .
    1.0    3.7      7957  .       * .         .         .         .         .
    1.2    3.1      5263  .    *    .         .         .         .         .
    1.4    2.3      2870  .  *      .         .         .         .         .
    1.6    2.0      2277  . *       .         .         .         .         .
    1.8    1.9      2071  . *       .         .         .         .         .
    2.0    1.9      2049  . *       .         .         .         .         .
    2.2    1.9      2057  . *       .         .         .         .         .
    2.4    1.9      2079  . *       .         .         .         .         .
    2.6    2.2      2731  .  *      .         .         .         .         .
    2.8    3.8      8613  .        *.         .         .         .         .
    3.0    6.1     20670  .         .         .*        .         .         .
    3.2    7.3     29179  .         .         .        *.         .         .
    3.4    7.9     34029  .         .         .         .   *     .         .
    3.6    7.8     33303  .         .         .         .  *      .         .
    3.8    7.3     29203  .         .         .        *.         .         .
    4.0    6.6     23356  .         .         .  *      .         .         .
    4.2    5.7     17426  .         .      *  .         .         .         .
    4.4    4.9     11958  .         . *       .         .         .         .
    4.6    3.9      7746  .       * .         .         .         .         .
    4.8    3.1      5140  .    *    .         .         .         .         .
    5.0    2.5      3530  .   *     .         .         .         .         .
    5.2    2.1      2417  . *       .         .         .         .         .
    5.4    1.8      1659  . *       .         .         .         .         .
    5.6    1.5      1161  .*        .         .         .         .         .
    5.8    1.3       838  .*        .         .         .         .         .
    6.0    1.1       629  .*        .         .         .         .         .
    6.2    1.0       496  *         .         .         .         .         .
    6.4     .9       421  *         .         .         .         .         .
    6.6     .9       400  *         .         .         .         .         .
    6.8     .9       391  *         .         .         .         .         .
    7.0     .8       389  *         .         .         .         .         .
    7.2     .8       388  *         .         .         .         .         .
    7.4     .8       387  *         .         .         .         .         .
    7.6     .8       387  *         .         .         .         .         .
    7.8     .8       387  *         .         .         .         .         .
    8.0     .8       387  *         .         .         .         .         .
    8.2     .8       387  *         .         .         .         .         .
    8.4     .8       387  *         .         .         .         .         .
    8.6     .8       387  *         .         .         .         .         .
    8.8     .8       387  *         .         .         .         .         .
    9.0     .8       387  *         .         .         .         .         .
    9.2     .8       387  *         .         .         .         .         .
    9.4     .8       387  *         .         .         .         .         .
    9.6     .8       387  *         .         .         .         .         .
    9.8     .8       387  *         .         .         .         .         .
   10.0     .8       387  *         .         .         .         .         .
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DISCHARGE HYDROGRAPH FOR   VISHNUGAD PIPALKOTI ... STATION NUMBER   121
                    BELOW       THDC PROJECT   AT KM      18.50
  GAGE ZERO = 1025.00 M        MAX ELEVATION REACHED BY FLOOD WAVE = 1046.46 M
                    MAX STAGE =   21.46 M         AT TIME =    4.250 HOURS
                    MAX FLOW =    19164 CMS       AT TIME =    4.218 HOURS

     TIME  STAGE     FLOW
      HR    M         CMS  0      5000     10000     15000     20000     25000
       .0    1.5      387  .*        .         .         .         .         .
       .2    1.5      387  .*        .         .         .         .         .
       .4    1.5      387  .*        .         .         .         .         .
       .6    1.5      387  .*        .         .         .         .         .
       .8    1.5      387  .*        .         .         .         .         .
      1.0    1.5      387  .*        .         .         .         .         .
      1.2    1.5      389  .*        .         .         .         .         .
      1.4    1.7      494  .*        .         .         .         .         .
      1.6    3.6     1611  .  *      .         .         .         .         .
      1.8    5.7     3138  .     *   .         .         .         .         .
      2.0    6.2     3314  .      *  .         .         .         .         .
      2.2    6.0     3145  .     *   .         .         .         .         .
      2.4    5.6     2916  .     *   .         .         .         .         .
      2.6    5.3     2700  .    *    .         .         .         .         .
      2.8    5.1     2529  .    *    .         .         .         .         .
      3.0    4.9     2423  .    *    .         .         .         .         .
      3.2    5.2     2670  .    *    .         .         .         .         .
      3.4   11.2     8835  .         .       * .         .         .         .
      3.6   16.8    14004  .         .         .       * .         .         .
      3.8   19.5    17155  .         .         .         .   *     .         .
      4.0   21.0    18664  .         .         .         .      *  .         .
      4.2   21.5    19157  .         .         .         .       * .         .
      4.4   21.3    18889  .         .         .         .       * .         .
      4.6   20.6    18077  .         .         .         .     *   .         .
      4.8   19.5    16921  .         .         .         .   *     .         .
      5.0   18.4    15604  .         .         .         .*        .         .
      5.2   17.1    14216  .         .         .       * .         .         .
      5.4   15.8    12802  .         .         .    *    .         .         .
      5.6   14.4    11388  .         .         . *       .         .         .
      5.8   13.1    10002  .         .         *         .         .         .
      6.0   11.8     8675  .         .      *  .         .         .         .
      6.2   10.6     7427  .         .    *    .         .         .         .
      6.4    9.5     6277  .         .  *      .         .         .         .
      6.6    8.3     5239  .         *         .         .         .         .
      6.8    7.3     4316  .        *.         .         .         .         .
      7.0    6.3     3515  .      *  .         .         .         .         .
      7.2    5.4     2834  .     *   .         .         .         .         .
      7.4    4.7     2267  .    *    .         .         .         .         .
      7.6    4.0     1806  .   *     .         .         .         .         .
      7.8    3.4     1441  .  *      .         .         .         .         .
      8.0    3.0     1157  . *       .         .         .         .         .
      8.2    2.6      941  . *       .         .         .         .         .
      8.4    2.2      779  . *       .         .         .         .         .
      8.6    2.0      657  .*        .         .         .         .         .
      8.8    1.8      568  .*        .         .         .         .         .
      9.0    1.6      504  .*        .         .         .         .         .
      9.2    1.5      460  .*        .         .         .         .         .
      9.4    1.5      432  .*        .         .         .         .         .
      9.6    1.5      415  .*        .         .         .         .         .
      9.8    1.5      405  .*        .         .         .         .         .
     10.0    1.5      398  .*        .         .         .         .         .
```

```
     DISCHARGE HYDROGRAPH FOR   VISHNUGAD PIPALKOTI ... STATION NUMBER   130
                  BELOW       THDC PROJECT   AT KM      37.99
GAGE ZERO =  803.62 M        MAX ELEVATION REACHED BY FLOOD WAVE =  832.28 M
                  MAX STAGE =   28.66 M        AT TIME =    4.670 HOURS
                  MAX FLOW =    19021 CMS      AT TIME =    4.638 HOURS

   TIME  STAGE     FLOW
    HR    M         CMS  0      5000     10000     15000     20000     25000
    1.0    6.1      387  .*        .         .         .         .         .
    1.2    6.1      387  .*        .         .         .         .         .
    1.4    6.1      387  .*        .         .         .         .         .
    1.6    6.1      387  .*        .         .         .         .         .
    1.8    6.1      387  .*        .         .         .         .         .
    2.0    6.2      392  .*        .         .         .         .         .
    2.2    6.9      610  .*        .         .         .         .         .
    2.4   10.1     1808  .   *     .         .         .         .         .
    2.6   12.8     3131  .     *   .         .         .         .         .
    2.8   13.0     3180  .     *   .         .         .         .         .
    3.0   12.8     2976  .     *   .         .         .         .         .
    3.2   12.5     2771  .     *   .         .         .         .         .
    3.4   12.2     2600  .    *    .         .         .         .         .
    3.6   12.1     2519  .    *    .         .         .         .         .
    3.8   14.8     4562  .        *.         .         .         .         .
    4.0   23.3    12303  .         .         .    *    .         .         .
    4.2   26.7    16508  .         .         .         .  *      .         .
    4.4   28.1    18370  .         .         .         .      *  .         .
    4.6   28.6    19002  .         .         .         .       * .         .
    4.8   28.6    18817  .         .         .         .       * .         .
    5.0   28.1    18085  .         .         .         .     *   .         .
    5.2   27.5    17024  .         .         .         .   *     .         .
    5.4   26.6    15799  .         .         .         . *       .         .
    5.6   25.7    14455  .         .         .        *.         .         .
    5.8   24.7    13110  .         .         .     *   .         .         .
    6.0   23.7    11789  .         .         .   *     .         .         .
    6.2   22.5    10498  .         .         .*        .         .         .
    6.4   21.3     9215  .         .       * .         .         .         .
    6.6   20.1     8039  .         .     *   .         .         .         .
    6.8   18.8     6986  .         .   *     .         .         .         .
    7.0   17.6     6024  .         . *       .         .         .         .
    7.2   16.3     5136  .         *         .         .         .         .
    7.4   15.1     4300  .        *.         .         .         .         .
    7.6   14.1     3604  .      *  .         .         .         .         .
    7.8   13.1     3007  .     *   .         .         .         .         .
    8.0   12.1     2493  .    *    .         .         .         .         .
    8.2   11.3     2077  .   *     .         .         .         .         .
    8.4   10.5     1736  .  *      .         .         .         .         .
    8.6    9.9     1460  .  *      .         .         .         .         .
    8.8    9.3     1225  . *       .         .         .         .         .
    9.0    8.7     1034  . *       .         .         .         .         .
    9.2    8.2      881  . *       .         .         .         .         .
    9.4    7.8      759  . *       .         .         .         .         .
    9.6    7.5      662  .*        .         .         .         .         .
    9.8    7.2      586  .*        .         .         .         .         .
   10.0    6.9      527  .*        .         .         .         .         .
   10.2    6.7      483  .*        .         .         .         .         .
   10.4    6.6      458  .*        .         .         .         .         .
   10.6    6.5      443  .*        .         .         .         .         .
   10.8    6.4      432  .*        .         .         .         .         .
   11.0    6.4      423  .*        .         .         .         .         .
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     DISCHARGE HYDROGRAPH FOR   VISHNUGAD PIPALKOTI ... STATION NUMBER   147
                  BELOW       THDC PROJECT   AT KM      74.68
GAGE ZERO =  684.85 M        MAX ELEVATION REACHED BY FLOOD WAVE =  717.10 M
                  MAX STAGE =   32.25 M        AT TIME =    6.288 HOURS
                  MAX FLOW =    16272 CMS      AT TIME =    6.158 HOURS

   TIME  STAGE     FLOW
    HR    M         CMS  0      5000     10000     15000     20000     25000
   2.60    6.9      387  .*        .         .         .         .         .
   2.85    6.9      387  .*        .         .         .         .         .
   3.10    6.9      387  .*        .         .         .         .         .
   3.35    6.9      387  .*        .         .         .         .         .
   3.60    6.9      390  .*        .         .         .         .         .
   3.85    6.9      388  .*        .         .         .         .         .
   4.10    7.0      402  .*        .         .         .         .         .
   4.35    7.5      524  .*        .         .         .         .         .
   4.60   10.6     1293  .  *      .         .         .         .         .
   4.85   12.7     1866  .   *     .         .         .         .         .
   5.10   16.6     3822  .       * .         .         .         .         .
   5.35   23.7     8745  .         .      *  .         .         .         .
   5.60   28.8    13372  .         .         .      *  .         .         .
   5.85   31.1    15556  .         .         .         .*        .         .
   6.10   32.1    16249  .         .         .         . *       .         .
   6.35   32.2    16070  .         .         .         . *       .         .
   6.60   31.9    15363  .         .         .         .*        .         .
   6.85   31.2    14362  .         .         .        *.         .         .
   7.10   30.4    13205  .         .         .     *   .         .         .
   7.35   29.4    11979  .         .         .   *     .         .         .
   7.60   28.3    10757  .         .         . *       .         .         .
   7.85   27.2     9582  .         .        *.         .         .         .
   8.10   26.0     8504  .         .      *  .         .         .         .
   8.35   24.9     7532  .         .    *    .         .         .         .
   8.60   23.7     6658  .         .  *      .         .         .         .
   8.85   22.4     5844  .         . *       .         .         .         .
   9.10   21.2     5108  .         *         .         .         .         .
   9.35   20.0     4454  .        *.         .         .         .         .
   9.60   18.8     3875  .       * .         .         .         .         .
   9.85   17.6     3368  .      *  .         .         .         .         .
  10.10   16.4     2923  .     *   .         .         .         .         .
  10.35   15.3     2521  .    *    .         .         .         .         .
  10.60   14.3     2155  .   *     .         .         .         .         .
  10.85   13.4     1859  .   *     .         .         .         .         .
  11.10   12.6     1615  .  *      .         .         .         .         .
  11.35   11.9     1412  .  *      .         .         .         .         .
  11.60   11.2     1240  . *       .         .         .         .         .
  11.85   10.6     1096  . *       .         .         .         .         .
  12.10   10.1      972  . *       .         .         .         .         .
  12.35    9.6      868  . *       .         .         .         .         .
  12.60    9.2      778  . *       .         .         .         .         .
  12.85    8.8      703  .*        .         .         .         .         .
  13.10    8.5      640  .*        .         .         .         .         .
  13.35    8.2      588  .*        .         .         .         .         .
  13.60    8.0      546  .*        .         .         .         .         .
  13.85    7.8      511  .*        .         .         .         .         .
  14.10    7.6      484  .*        .         .         .         .         .
  14.35    7.4      463  .*        .         .         .         .         .
  14.60    7.3      445  .*        .         .         .         .         .
  14.85    7.2      432  .*        .         .         .         .         .
```

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DISCHARGE HYDROGRAPH FOR   VISHNUGAD PIPALKOTI ... STATION NUMBER   171
                    BELOW       THDC PROJECT   AT KM     124.47

  GAGE ZERO =  564.97 M        MAX ELEVATION REACHED BY FLOOD WAVE =  602.17 M
                    MAX STAGE =   37.19 M        AT TIME =    8.656 HOURS
                    MAX FLOW =    13276 CMS      AT TIME =    8.390 HOURS

     TIME  STAGE     FLOW
      HR    M         CMS  0      5000     10000     15000     20000     25000
      5.0    6.2      387  .*        .         .         .         .         .
      5.2    6.2      387  .*        .         .         .         .         .
      5.4    6.2      387  .*        .         .         .         .         .
      5.6    6.2      387  .*        .         .         .         .         .
      5.8    6.2      387  .*        .         .         .         .         .
      6.0    6.2      387  .*        .         .         .         .         .
      6.2    6.2      387  .*        .         .         .         .         .
      6.4    6.2      389  .*        .         .         .         .         .
      6.6    6.3      396  .*        .         .         .         .         .
      6.8    6.3      422  .*        .         .         .         .         .
      7.0    6.2      390  .*        .         .         .         .         .
      7.2   15.2     3826  .       * .         .         .         .         .
      7.4   22.9     7843  .         .     *   .         .         .         .
      7.6   28.2     9995  .         .         *         .         .         .
      7.8   32.2    11513  .         .         .  *      .         .         .
      8.0   34.7    12560  .         .         .    *    .         .         .
      8.2   36.1    13112  .         .         .     *   .         .         .
      8.4   36.9    13276  .         .         .      *  .         .         .
      8.6   37.2    13161  .         .         .     *   .         .         .
      8.8   37.1    12849  .         .         .     *   .         .         .
      9.0   36.8    12402  .         .         .    *    .         .         .
      9.2   36.4    11870  .         .         .   *     .         .         .
      9.4   35.8    11291  .         .         .  *      .         .         .
      9.6   35.0    10689  .         .         .*        .         .         .
      9.8   34.2    10080  .         .         *         .         .         .
     10.0   33.3     9478  .         .        *.         .         .         .
     10.2   32.4     8895  .         .       * .         .         .         .
     10.4   31.3     8337  .         .      *  .         .         .         .
     10.6   30.1     7804  .         .     *   .         .         .         .
     10.8   28.8     7304  .         .    *    .         .         .         .
     11.0   27.3     6850  .         .   *     .         .         .         .
     11.2   25.0     6509  .         .  *      .         .         .         .
     11.4   22.8     5880  .         . *       .         .         .         .
     11.6   21.0     5286  .         .*        .         .         .         .
     11.8   19.7     4776  .         *         .         .         .         .
     12.0   18.6     4338  .        *.         .         .         .         .
     12.2   17.7     3951  .       * .         .         .         .         .
     12.4   16.9     3600  .      *  .         .         .         .         .
     12.6   16.1     3280  .      *  .         .         .         .         .
     12.8   15.3     2993  .     *   .         .         .         .         .
     13.0   14.7     2741  .    *    .         .         .         .         .
     13.2   14.1     2517  .    *    .         .         .         .         .
     13.4   13.5     2316  .    *    .         .         .         .         .
     13.6   13.0     2136  .   *     .         .         .         .         .
     13.8   12.5     1974  .   *     .         .         .         .         .
     14.0   12.0     1827  .   *     .         .         .         .         .
     14.2   11.6     1694  .  *      .         .         .         .         .
     14.4   11.2     1573  .  *      .         .         .         .         .
     14.6   10.8     1463  .  *      .         .         .         .         .
     14.8   10.5     1364  .  *      .         .         .         .         .
```

Annexure 6-2

Dam Break Analysis of Vishnugad Pipalkothi HE Project carried out earlier

1. INTRODCUTION

Tehri Hydro Development Corporation Ltd. (THDC) proposes to commission Vishnugad Pipalkoti Hydro-electric Power Project on river Alaknanda, a major tributary of river Ganga. The project is situated in district Chamoli, Uttaranchal. The dam is located at village Helong in Joshimath Tehsil whereas power house is located at village Hat in Chamoli Tehsil.

River Alaknanda is a major tributary of river Ganga, originating from the glacial regions of Himalayas. The river has tremendous scope for development of hydro-power, which needs to be harnessed to meet the ever-growing demand for power. At present, various hydropower schemes are indifferent stages of development on river Alaknanda. Vishnugad Pipalkoti too is one of the various hydropower schemes envisaged in this region. The proposed site is located close to village Helong and is situated at a distance of 250 km from Rishikesh. The project envisages a drop in water level from 1231 m to 1027 m over a river stretch of about 31 km from village Helong to village Birahi.

The Vishnugad Pipalkoti hydroelectric project as mentioned earlier, is situated on river Alaknanda and aim to divert the water of river Alaknanda through a water conductor system to an underground power house located near village Hat. The project aims to generate (4x111) 444 MW of hydropower. The project vicinity map is enclosed as Figure-1.

2. PROJECT DESCRIPTION

The Vishnugad Pipalkoti Hydro-electric Project is envisaged as a runoff the river scheme, involving construction of a 65 m high diversion dam high across river Alaknanda river, near Village Helong. The project site is located about 250 km from Rishikesh. The project utilizes the drop in water level between out fall of Tapovan-Vishnugad Project and Birahi Alaknanda confluence. At the diversion site, a discharge of about 228.86 cumecs shall pass through a tunnel of 13.4 km length and 8.8 m dia (horse shoe shaped) which leads the discharge to the under ground power house proposed to be located near village Hat, about 3 km from Pipalkoti. The tail race discharge will be diverted in river Alaknanda through a tunnel of 3.07 km length and 8.8 m Horse shoe shaped diameter. The power station utilizes a gross head of 237 m with an installed capacity of (4x111) 444 MW.

The salient features of the project are listed in Table-1 and the project layout map is enclosed as Figuree-1.

TABLE-1

Salient features of Vishnugad Pipalkoti Hydro-electric Power Project

1.	**LOCATION**	
	State	Uttaranchal
	District	Chamoli
	River	Alaknanda
	Dam site	Near Village Helong (E – 79^0 29'30") (N - 30^0 30'50")
	Power House site (underground)	Near Village Hat (E – 79^0 24'56") (N - 30^0 25'31")
2.	**HYDROLOGY**	
	Catchment Area at Dam Site	4672 km^2
	Annual mean flow	5682.6 Mcum
	Submergence area	24.5 ha
	Design Flood	SPF 6700 m^3/sec (For Design) PMF10840 m^3/sec (For Checking)
	Diversion Flood (1: 25 yr Non-monsoon flood)	725 m^3/sec
3.	**RESERVOIR**	
	Full Reservoir Level	E L 1267 m
	Maximum Water level	E L 1269 m (PMF)
	Minimum Draw Down level	E L 1252.5 m
	Gross storage at FRL	3.63 Mcum
	Storage at MDDL	1.16 Mcum
	Live storage	2.47 Mcum
	Surface Area at FRL	24.5 ha
4.	**DIVERSION ARRANGEMENT**	
	A. Diversion Tunnel	
	Location	Left Bank
	Length	490 m
	Diameter	10 m, circular
	Design Discharge	1074 m^3/sec
	Gates	10 m x 10 m, vertical lift fixed wheel
	Invert level at entry	1228 m

U/S Coffer Dam:

Type	Colcrete
Length	60 m
Height	15 m
Top Elevation	EL 1242 m

B. **D/S Coffer Dam:**

Type	Rock fill\
Length	46 m
Height	6 m
Top Elevation	EL 1229 m

5. DIVERSION DAM

Type of Dam	Concrete, gravity dam
Height of dam above deepest foundation level	65 m
Top of dam	El 1270 m
River bed level	El 1225 m
Foundation level	El 1205 m
Length	89.3 m (NOF 32.3 m, OF 57.0 m)

6. SPILLING ARRANGEMENT

A. **Sluices**

No.	4
Design Flood	8004 m^3 /sec
Size of sluice	6.6 m (W) x 15 m (H) (4 nos. 6.6 m x 15 m)
Type of gate	Radial Stoplog (1 no. 6.6 m x 22.5 m)
Crest level of sluice	1233 m

B. **Diversion cum Spillway Tunnel** Diameter 10 m (Φ), Circular

Invert level at Entry	1249 m
Length	490 m
Design discharge	1074 m^3/sec
Gate	2+1 no., 4.1 m x 10 m (Vertical lift fixed wheel Gate)

C. **Spill Tunnel (12 m Φ)**

Size	12 m Φ, Circular
Invert level at Entry	1245 m
Length	250 m
Design Discharge	1618 m^3/sec
Gate	2+1 no., 4.8 m x 12 m (Vertical lift fixed wheel Gate)

D. **Ogee spillway**

No.	1
Type of gate	vertical
Size	4 m x 3 m
Design flow	80 m^3 /sec
Crest EL	EL 1264 m

7. POWER INTAKE

Location	Right Bank
Nos.	3
Type	straight intake with bell mouth
Maximum discharge	277.9 m^3/sec
Intake invert level	EL 1242.5 m
Size	6 m modified Horse shoe type
Gates	3 + 3 nos. 5.20 m x 6 m Vertical lift fixed wheel gate (Service gate + emergency gate)
Silt Flushing Tunnel (Below Intake)	
Size of Intake	3 nos. of 3m x 3m
Size of SFT ducts	3 nos. of 2m x 5m
Gate	3+3 nos. of 3m x 3m

8. DESILTING CHAMBER

No.	3
Size	350 m (L) x 16 m (W) x 20.6 m (H)
Particle size to be removed	0.2 mm & above
Gates	3 nos. 5.24 m x 6 m (H) Vertical lift fixed wheel
Gate Chamber	6 m (W) x 9 m (H) x 155 m (L)
Operation level	EL 1270 m

Silt Flushing Tunnel	
Size	3.6m x 4.0m (D shaped)
Flushing discharge	47.6 m^3/sec
Length	680 m
Gate	3 nos, 2.5m x 2.85m (vertical lift slide gate)
Gate chamber	4.8m x 4.8m x 118m
Operation level	EL 1233.5 m

9. **Head Race Tunnel**

Length	13.4 km
Diameter	8.8 m (Horse shoe)
Design discharge	228.86 m^3/sec
Velocity	3.56 m/sec
Bed Slope (average)	1:208
No. of adits	4

10. **UPSTREAM SURGE SHAFT**

Type	Restricted orifice type
Diameter	22/15 m (Φ)
Height (from HRT invert)	130 m
Top EL	1305 m
Orifice Level	1185 m
Orifice diameter	1.5 m
Tunnel invert	EL 1175 m
Maximum surge level	1304 m
Minimum surge level	1196.30 m
Pressure shaft gates	2 Nos., 4.2 m x 5.2 m

11. **BUTTERFLY VALVE CHAMBER**

Size	50 m (L) x 9.8 m (W) x 19 m (H)
Butterfly Valve	2 Nos., 5.2 m

12. PRESSURE SHAFT

Nos	2/4
Type	circular
Diameter	5.2 m /3.65 m
Length of each PS	351 m/36.7 m
Design velocity	5.39 m/sec

13. POWER HOUSE

Type	Underground
Size of P/H Cavern	127 m x 20.3 m x 50 m
Size of Transformer cavern	112 m x 16 m x 24.5 m
No. of units	4
Rated Unit capacity	111 MW
Installed capacity	4 x 111 MW = 444 MW
Gross head	237.0 m
Rated Head	212.46 m
Centre line of unit	EL 1022.0 m
Service bay level	EL 1041 m
Maximum flow through each unit	57.22 m^3/sec
Generator:	
Synchronous speed of Generator	250 rpm
Power factor, Generator voltage	0.9, 13.8 kV
Excitation system	Quick response static
Starting method (For PSSs)	
Transformers – Type, Nos.,	OFWF, 4, 3,
No. of phases	single phase
	46 MVA, 13.8/420 √3kV
Step-up voltage Capacity	400 kV
Energy generation (on 90% dependability basis)	1813.03 GWh

14. DOWN STREAM SURGE TANK

Type	Underground
Size	120 m (L) x 12 m (W) x 27 m (H)
Maximum Surge Level	1040.1 m
Minimum Surge level	1026.5 m

15. TAIL RACE TUNNEL

Size	8.8 m (Φ) (Horse shoe)
Length	3.07 km
Maximum TWL	1030.0 m (with all M/C running)
Minimum TWL	1027.2 (with 10% load)
TRT invert level	EL 1025 m

16. SWITCH YARD

Type of switchyard	GIS
No. of bays in the switchyard	8 bays
Voltage level	420 kV
Size of potyard	40 m x 60 m

17. POWER GENERATION

Firm power	74.69 MW
Design Energy	1813.03 GWh
Annual load factor (lean flow)	16.82%
Design Energy	1797.24 GWh

18. PROJECT COST

Civil works	Rs. 1353.30 crores
Electro-mechanical works	Rs. 533.43 crores
Total cost	Rs. 1886.73 crores

19. TARIFF

First year tariff	Rs. 2.06/kWh
Levelised tariff	Rs. 1.68/kWh

3. NEED FOR DAM BREAK ANALYSIS

More and more dams have come up or being constructed with the aim of using the available water resources optimally for developmental purpose or for protecting lives and properties from the fury of floods. With the assured water resources facility and flood protection provided by the dam, the encouragement for improving the overall economy of the country has led to various developmental activities in the downstream of the dam resulting in the settlement of large population and properties in the flood plains and adjoining areas. However, in the eventuality of any dam failure, the disaster would be catastrophic. Therefore, it is the responsibility of the organization(s) involved with the safety of the dams, to plan preventive measures so that in the eventuality of dam failure, the loss can be minimized to the extent possible.

One of the preventive measures in avoiding dam failure disaster is by issuing flood warning of the imminent flood to the public residing in the areas likely to be affected, as early as possible if there is a possibility of dam failure. However, it is quite difficult to conduct analysis and determine the warning time of the dam break flood at the time of disaster. Therefore, pre-determination of the warning time assuming various hypothetical dam break situations is an essential part of dam safety measures.

The dam failure study involves the following component steps:

i) Development or identification of the inflow hydrograph to the reservoir at the time of failure;
ii) Routing that hydrograph through the reservoir;
iii) Calculating the outflow hydrograph from the failed structure, and
iv) Modelling the movement of the flood wave downstream to determine travel time, maximum water level reached, inundated areas, etc.

4. MODEL FOR DAM BREAK ANALYSIS

For reasons of simplicity, generally, wide applicability and the uncertainty in the actual mechanism, the DAMBRK model has been used. The model uses failure time interval, terminal size and shape of the breach as the inputs. The possible shapes of the breach that can be accomplished by the DAMBRK model are rectangular, triangular and trapezoidal. DAMBRK model is capable of adopting either storage routing or dynamic routing methods for routing floods through reservoirs depending on the nature of flood wave movement in reservoirs at the time of failure.

After computing the hydrograph of the reservoir outflow, the time of occurrence of flooding in the downstream valley is determined by routing the outflow hydrograph through the valley.

The dynamic wave method based on the complete equations of unsteady flow is the appropriate technique to route the dam break flood hydrograph through the downstream valley. This method is derived from the original equations developed by St. Venant. DAMBRK model uses St. Venant's equations for routing dam break floods in channels.

5. METHODOLOGY

The National Weather Service's DAMBRK model developed by Dr. D.L. Fread has been used in the study. This model simulates the failure of a dam, computes the resultant outflow hydrograph and also simulates movement of the dam break flood wave through the downstream river valley. The model is built around three major capabilities, which are reservoir routing, breach simulation and river routing.

However, it does no rainfall-runoff analysis and storm inflow hydrographs to the upstream of reservoir must be developed external to the model. A brief description of the capabilities of the model is described in the following paragraphs.

Reservoir Routing

In this model the reservoir routing may be performed either by using storage routing or dynamic routing.

Storage routing

The storage routing is based on the law of conservation given as:

$$I - Q = \frac{dS}{dt} \qquad \ldots (1)$$

in which, I is the reservoir inflow, Q is the total reservoir outflow which include the flow from spillway, breach, overtopping flow and head independe discharge, and dS/dt is the time rate of change of reservoir storage volum Equation (1) can be expressed in finite difference form as:

$$(I + I')/2 - (Q + Q')/2 = \Delta S/\Delta t \qquad \ldots (2)$$

in which the prime (') superscript denotes values at the time $t - \Delta t$ and the notati approximates the differential. The term ΔS may be expressed as:

$$\Delta S = (As + A's)\,(h - h')/2 \qquad \ldots (3)$$

in which, As is the reservoir surface area coincidental with the elevation (h) and i function of h. The discharge Q which is to be evaluated from equation (2) i function of h and this unknown h is evaluated using Newton-Raphson itera technique and thus the estimation of discharge corresponding to h.

Dynamic Routing

The hydrologic storage routing technique, expressed by equation (2) implies that the water surface elevation within the reservoir is horizontal. This assumption is quite adequate for gradually occurring breaches with no substantial reservoir inflow hydrographs. However, when the breach is specified to form almost instantaneously so as to produce a negative wave within the reservoir, and/or the reservoir inflow hydrograph is significant enough to produce a positive wave progressing through the reservoir, a routing option which simulates the negative and/or positive wave occurring within the reservoir may be used in DAMBRK model. Such a technique is referred to as dynamic routing.

The routing principle is same as dynamic routing in river reaches and it is performed using St. Venant's equation. The movement of the dam break flood wave through the downstream river channel is simulated using the complete unsteady flow equations for one dimensional open channel flow, alternatively known as St. Venant's equations. These equations consist of the continuity equation:

$$\frac{\partial Q}{\partial t} + \frac{\partial (A + A_o)}{\partial t} = q \quad \ldots (4)$$

and the conservation of momentum equation:

$$\frac{\partial Q}{\partial t} + \frac{\partial (Q^2/A)}{\partial x} + g\,A\left(\frac{\partial h}{\partial x} + S_f + S_e\right) + L_c = 0 \quad \ldots (5)$$

where,

A = active cross-sectional flow area

A_o = inactive (off-channel storage) cross-sectional area
x = distance along the channel
q = lateral inflow or outflow per unit distance along the channel
g = acceleration due to gravity
Q = discharge
h = water surface elevation
S_f = friction slope
S_e = expansion-contraction loss slope
L_c = lateral inflow/outflow momentum effect due to assumed flow path of inflow being perpendicular to the main flow

The friction slope and expansion-contraction loss slope are evaluated by the following equation

$$S_f = \frac{n^2 \ Q^2}{2.21 \ A^2 \ R^{4/3}} \qquad \text{.... (6)}$$

and,

$$S_e = \frac{K \ \Delta(Q/A)^2}{2g \ \Delta x} \qquad \text{.... (7)}$$

Wherein,

n = Manning's roughness coefficient,

R = A/B where B is the top width of the active portion of the channel

K = Expansion-contraction coefficient varying from 0.1 to 0.3 for contraction and –0.5 to -1.0 expansion

$\Delta(Q/A)^2$ = Difference in $(Q/A)^2$ for cross sections at their end of a reach

The non-linear partial differential equations (4) and (5) are represented by a corresponding set of non-linear finite difference algebraic equations and they are solved by the Newton-Raphson method using weighted four point implicit scheme to evaluate Q and h. The initial conditions are given by known steady discharge at the dam, for which steady state non-uniform flow equation are used. The outflow hydrograph from the reservoir is the upstream boundary condition for the channel routing and the model is capable of dealing with fully supercritical flow or fully sub critical flow in the reach or the upstream reach having supercritical flow and downstream reach having sub critical flow. There is a choice of downstream boundary conditions such as internally calculated loop rating curve, user provided single valued rating curve, user provided time dependent water surface elevation, critical depth and dam which may pass flow via spillways, overtopping and/or breaching.

6. STATEMENT OF THE PROBLEM

The computation of flood wave resulting from a dam breach basically involves two scenarios which can be considered jointly or separately: (1) the outflow hydrograph from the reservoir; and (2) the routing of the flood wave downstream from the breached dam along the river channel and the flood plain. If breach outflow is independent of downstream conditions, or if their effect can be neglected, the reservoir outflow hydrograph is referred to as the free outflow hydrograph. In this case, the computation of the flood characteristics is divided into two distinct phases: (a) the determination of outflow hydrograph with or without the routing of the negative wave along the reservoir, and (b) the routing of flood wave downstream from the dam breach. In this study the problem of simulating the failure of dam in Vishnugad Pipalkoti hydroelectric project by computing the free outflow hydrograph from the breached dam using `storage routing technique' and routing this hydrograph along the downstream channel using `dynamic routing technique' with the aim of reproducing the maximum water level marks reached during the passage of flood wave is considered. The information regarding inflow hydrograph into the reservoir due to the storm at the time of failure, the structural and the hydraulic characteristics details of the dam, the time of failure, the channel cross sectional details, the maximum water level marks reached in the reservoir at the time of failure and those observed in the downstream reach of the dam due to the passage of flood wave etc. are available for the study.

7. AVAILABILITY OF DATA

The input data required for the National Weather Service's DAMBRK model can be categorised into two groups. The first data group pertains to the dam and inflow hydrograph into the reservoir and the second group pertains to the routing of the outflow hydrograph through the downstream valley. These are described in the following paragraphs.

First Data Group

With reference to the data group pertaining to the dam, the information on reservoir elevation-volume relationship, spillway details, elevation of bottom and top of dam, elevation of water surface in the reservoir at the beginning of analysis and at the time of failure, breach description data are required.

Second Data Group

The second group of data pertaining to the routing of the outflow hydrograph through the downstream valley consists of a description of cross-sections, hydraulic resistance coefficients and contraction-expansion coefficients of the reach, steady state flow in the river at the beginning of the simulation and the downstream boundary condition. The cross sections are specified by location mileage, and tables of top width and corresponding elevation. In this study, nine cross sectional details have been used down stream of the dam. Nine cross sections below the dam are at locations 0, 3.7, 5.9, 8.1,11.5, 15.8, 18.4 and 20 km respectively downstream from the dam site.

8. RESULTS

It can be inferred from the hydrographs below the dam that the attenuation of the outflow hydrograph from the breached dam is significant only in the initial reaches and rate of attenuation of the hydrographs decreases when the distance increases from the breached dam. This is because the effect of breach parameters on the hydrograph characteristics may be dominant immediately downstream of the dam and for reaches further downstream, the flow wave characteristics may be predominantly influenced by channel geometry.

The dam break analysis has been carried out for the worst condition in which it has been assumed that whole dam gets washed away. The output of dam break modeling analysis are enclosed as Annexure-I.

The water depth and water spread at various distances downstream of the dam are outlined in Table-2. The variation of flood level with distance is given in Figure-2.

TABLE-2

Water depth and spread downstream of dam in the event of dam break

Distance from dam (km)	Max. elevation above MSL (m)	River bed level (m)	Water depth (m)	Water spread width (m)
3.7	1200.00	1223.44	23.44	86.1
10.2	1080.00	1104.39	24.39	114.8
11.5	1050.00	1071.96	21.96	72.0
15.8	1030.00	1060.57	30.57	110.7
18.4	1010.00	1044.20	34.20	172.2
20.0	1000.00	1038.33	38.33	229.6

9. DISASTER MANAGEMENT PLAN

A lot of care needs to be taken during the design and construction of dams and there are several checks which makes it impossible for a dam to break. For this dam, several dam safety surveillance systems have been suggested to ensure that the dam never fails even under most adverse conditions. However, in case of a dam break, the measures which can be implemented to minimize loss of lives and property are as follows:

- To establish an effective Dam Safety Surveillance and monitoring programme including rapid analysis and interpretation of instrumentation and observation data periodic inspection and safety reviews/evaluation by an independent panel of experts.
- To formulate and implement an Emergency Action Plan to minimise, to the maximum extent possible, the probable loss of life and damage to property in the event of failure of dam.

Surveillance

Surveillance activities which is an important part of any Dam Safety Programme, are generally limited to post fill monitoring of performance and aging process of most of the dams. For the Vishnugad Pipalkoti hydroelectric project more rigorous and effective dam safety surveillance and monitoring programme, encompassing rapid analysis and interpretation of instrumentation and observation data alongwith periodic inspection and safety reviews and evaluation have been suggested. Such programmes will have to be implemented during the following five critical phases in the life cycle of a dam:

1. Design and Investigation Phase
2. Construction Phase
3. First Reservoir Filling
4. Early Operation Period
5. Operation and Maintenance Phase

Evaluation of the structural environmental response includes assessment of the hazards specific to the site. Many factors must be deduced indirectly. Such assessment should be assigned to professionals who understand potential problems.

Emergency Action Plan (EAP)

Dam safety programme as indicated above includes the formation of an Emergency Action Plan for the dam. An emergency is defined as a condition of serious nature which develops unexpectedly and endangers downstream property and human life and requires immediate attention. Emergency Action Plan should include all potential indicators of likely failure of the dam, since the primary concern is for timely and reliable identification and evaluation of existing or potential emergency.

This EAP presents warning and notification procedures to follow during the monsoon season in case of failure or potential failure of the dam. The objective is to provide timely warning to nearby residents and alert key personnel responsible for taking action in case of emergency.

Administration and Procedural Aspects

The administrative and procedural aspects of the Emergency Action Plan consist of a flow chart depicting the names and addresses of the responsible officials. In order of hierarchy, the following system will usually be appropriate. In the event that the failure is imminent or the failure has occurred or a potential emergency conditions is developing, the observer at the site is required to report it to the Junior Engineer/Assistant Engineer who will report to the Executive Engineer/ Superintending Engineer for their reporting to the Chief Engineer through a wireless system or by any available fastest communication system. The Engineer-in-charge is usually responsible for making cognizant with the developing situation to the Civil Administration viz. District Magistrate. Each personnel is to acknowledge his/her responsibilities under the EAP in an appropriate format at a priori.

The technical aspects of the EAP consist of preventive action to be taken with regards to the structural safety of the dam. The EAP is drawn at a priori for the regular inspection of the dam. For this purpose, providing an adequate and easy access to the dam site is a necessity. The dam, its sluices, and non-overflow sections should be properly illuminated for effective operations during night time. Whenever sinkholes, boils, increased leakages, movement of rock, gate failure, rapid rise or fall of the level in the reservoir, rise in the level of reservoir beyond the maximum working level, or wave overrun of the dam crest are observed, the personnel on patrol is required to inform immediately to the Junior Engineer (JE)/Assistant Engineer (AE) for initiation of the execution of EAP. They are required to inform the Engineer-in-charge and the local administrative authorities. It is desirable if the downstream inhabitants are warned using siren, if available, so as to make them aware of the likely imminent danger.

The other preventive measures may include availability of a sufficient number of sandbags at several selected downstream locations and logs (for holding and sandbags) and at the dam site, one tractor, one motor boat, lanterns and rope. Areas from where the labour can be mobilized should be chalked out at a priori. In addition to these, public participation in the process of execution of the EAP may further help in amelioration the adverse impacts of the likely disaster and for this, it is necessary that the public should be aware of its responsibilities.

Preventive Action

Once the likelihood of an emergency situation is suspected, action has to be initiated to prevent a failure. The point at which each situation reaches an emergency status shall be specified and at that stage the vigilance and surveillance shall be upgraded both in respect of time and level. At this stage a thorough inspection of the dam should be carried out to locate any visible sign(s) of distress.

Engineers responsible for preventive action should identify sources of equipment needed for repair, materials, labour and expertise for use during an emergency. The amount and type of material required for emergency repairs should be determined for each dam, depending upon its characteristsics, design, construction history and past behaviour. It is desirable to stockpile suitable construction materials at an appropriate site. The anticipated need of equipment should be evaluated and if these are not available at the dam site, the exact location and availability of these equipment should be determined and specified. The sources/agencies must have necessary instructions for assistance during emergency. Due to the inherent uncertainties about their effectiveness, preventive actions should usually be carried out simultaneously with appropriate notification on alert situation or a warning situation.

Communication System

An efficient communication system and a downstream warning system are absolutely essential for the success of an emergency preparedness plan. The difference between a high flood and a dam-break situation must be made clear to the downstream population.

Evacuation Plans

Emergency Action Plan includes evacuation plans and procedures for implementation based on local needs. These could be:

- Demarcation/prioritization of areas to be evacuated.
- Notification procedures and evacuation instructions.
- Safe routes, transport and traffic control.
- Safe areas/shelters.
- Functions and responsibilities of members of evacuation team.

Any precarious situation during floods will be communicated either by an alert situation or by an alert situation followed by a warning situation. An alert situation would indicate that although failure or flooding is not imminent, a more serious situation could occur unless conditions improve. A warning situation would indicate that flooding is imminent as a result of an impending failure of the dam. It would normally include an order for evacuation of delineated inundation areas.

Evacuation Team

It will comprise of following official/Representative:

i) D.M./his Nominated officer (To peacefully relocate the people to places at higher elevation with state administration)
ii) Engineer in charge of the Project (Team Leader)
iii) S.P./Nominated Police Officer (To maintain law and order)
iv) C.M.O. of the area (To tackle morbidity of affected people)
v) Sarpanch/Affected Village Representative to execute the resettlement operation with the aid of state machinery and project proponents.
vi) Sub committees at village level.

The Engineer-in-charge will be responsible for the entire operation including prompt determination of the flood situation time to time. Once the red alert is declared the whole state machinery will come into swing and will start evacuating people in the inundation areas delineated in the Inundation maps. For successful execution, annually Demo exercise will be done. DM is to monitor the entire operation.

10. PUBLIC AWARENESS FOR DISASTER MITIGATION

In addition, guidelines that have to be followed by the inhabitants of flood prone areas, in the event of a flood resulting from dam failure, which form part of public awareness for disaster mitigation may also include following :

i) Listen to the radio for advance information and advice.
ii) Disconnect all electrical appliances and move all valuable personal and household goods beyond the reach of floodwater, if one is warned or if one suspects that flood waters may enter the house.
iii) Move vehicles, farm animals and movable goods to the higher place nearby
iv) Keep sources of water pollution i.e. Insecticides out of the reach of water.
v) Turn off electricity and gas one has to leave the house.

vi) Lock all outside doors and windows if one has to leave the house.
vii) Do not enter floodwaters.

Notifications

Notification procedures are an integral part of any emergency action plan. Separate procedures should be established for slowly and rapidly developing situations and failure. Notifications would include communication of either an alert situation or an alert situation followed by a warning situation. An alert situation would indicate that although failure or flooding is not imminent, a more serious situation could occur unless conditions improve. A warning situation would indicate that flooding is imminent as a result of an impending failure of the dam. It would normally include an order for evacuation of delineated inundation areas.

Notification Procedures

Copies of the EAP that also includes the above described inundation map are displayed at prominent locations, in the rooms and locations of the personnel named in the notification chart. For a regular watch on the flood level situation, it is necessary that the flood cells be manned by two or more people so that an alternative person is available for notification round the clock. For speedy and unhindered communication, a wireless system is a preferable mode of communication. Telephones may be kept for back up, wherever available. It is also preferred that all the flood cells, if more than one, are tuned in the same wireless channel. It will ensure communication from the dam site to the control rooms. The communication can be established by messenger service in the absence of such modes of communication.

Management after receding of flood water

It is to be accepted that in the event of dam break, even with maximum efforts, the loss of human lives, livestock and property would be inevitable. Under such a scenario, a massive effort would be used by various government agencies to provide various relief measures to the evacuees. Formulation of a plan delineating such measures is beyond the scope of work of this document. However, some of the measures which need to be implemented are listed as below:

- Provision of various food items & shelter to the evacuees.
- Provision of fuel for various evacuees.
- Provision of adequate fodder supply.
- Arrangements for potable water supply.
- Commissioning of low cost sewage treatment & sanitation facilities, and disposal of treatment sewage.
- Approximate disposal of dead bodies human & livestock.
- Immunization programmes for prevention of outbreak of epidemics of various water related diseases.
- Adequate stocks of medicines of various diseases, especially water-related diseases.

Chapter –7

Catchment Area Treatment Plan

CHAPTER - 7
CATCHMENT AREA TREATMENT PLAN

7.1 CATCHMENT SCENARIO

Alakhnanda River is one of the major tributaries of the river Ganga. Alakhnanda joins Bhagirathi at Devprayag to form the sacred river Ganges. The Alakhnanda originates at a height of 3641 meters below Balakun peak 16 km upstream from Badrinath form the two glaciers of Bhagirath Kharak and Satopanth. The two glaciers rise from the eastern slopes of Chaukhamba (7140 Meters) peak, Badrinath peak and its satellite peaks. These peaks separates the Gangotri group of glaciers in the west. The major portion of the Alakhnanda basin falls in Chamoli district. From its source upto Hallang (58 Km), the valley is treated as upper Alakhnanda valley. The remaining part of the area is known as lower Alakhnanda valley. While moving from its source, the river flows in a narrow deep gorge between the mountain slopes of Alkapuri, from which it drives its name. All along its course, it drains its tributaries The directly draining catchment area of river Alakhnanda at proposed barrage site is 4381 hactare as per GIS study. Watershed wise details of the catchment have been presented in **Table 7.1**

TABLE 7.1
DETAILS OF CATCHMENT AREA

WATERSHED NUMBER	TOTAL AREA (HA)
W1	163.4
W2	241.5
W	73.3
W4	116.2
W5	193
W6	162.3
W7	138
W8	292.2
W9	261
W10	392.2
W11	235.8
W12	347.3
W13	174
W14	301.3
W15	164.9
W16	231
W17	221.6
W18	242
W19	430

7.2 CATCHMENT AREA TREATMENT AND ITS NEED

There is no significant sedimentation or siltation involved as Bowala Nand Prayag HEP is a runoff the river scheme. However, erosion observed in watershed area need considerable attention/mitigation. Soil erosion may be defined as detachment and transportation of soil. Various factors affecting erosion are soil characteristics, meteorological conditions such as total annual precipitation, snow fall, intensity of precipitation, wind velocity, exposure conditions such as extent and type of vegetation cover and the topography of the catchment. Controlling one or more factors responsible for erosion as mentioned above can control the process of soil erosion. Providing vegetation cover will have two fold effect in erosion control, the first is that it improves the soil matrix through reinforcing and second it reduces the intensity of run-off. Breaking of slopes through engineering measures the slopes and prevent mass movement of soil.

Bowala Nand Prayag HEP being runoff the river scheme, storage of water is not anticipated. A sedimentation tank has been provided in between the head regulator and tunnel intake. Silt load of size 0.20mm and above from water will be removed in the sedimentation tank to prevent the wear and tear of the turbine. Catchment area treatment results into less sediment load of water to be removed by sedimentation tank and less amount of silt discharge down stream of barrage back into the river. It, therefore, becomes imperative to take adequate preventive measures towards soil erosions at the planning stage itself.

The catchment area treatment (CAT) plan pertains to preparation of a management plan for treatment of erosion prone area of the catchment through biological and engineering measures, however, a comprehensive CAT plan should also include the social dimensions associated directly or indirectly with the catchment. A well-designed CAT plan should not only control the soil erosion but should also provide a life support system to the local population through their active involvement. An effective CAT plan of a hydropower project is a key factor to make the project eco-friendly and sustainable.

7.3 OBJECTIVES

The main aim of Catchment Area treatment Plan is to restore various potential and degraded ecosystems in the catchment area for minimizing the sediment flow for longevity of the reservoir storage capacity. For this purpose the action plan has been prepared with the following objectives:

- To facilitate the hydrological functioning of the catchment and to augment the quality of water of the river and its tributaries.
- Conservation of soil cover control of soil erosion, and consequent reduction of siltation in the reservoir of the project.
- Demarcation of the priority in the catchment for treatment on the basis of soil erosion intensity.
- Rehabilitation of degraded forest areas through afforestation and facilitating natural regeneration of plants.
- Mitigation of landslide, landslip and rock falls.
- Soil conservation through biological and engineering measures to reduce sediment load in river and tributaries incidentally improving the quality of water.
- To meet the fuel and fodder requirements of local people
- Employment generation and community participation
- Ecosystem conservation resulting from increased vegetal cover and water retaining properties of soil.

7.4 APPROACH AND METHODOLOGY

The directly draining catchment area of the Bowala Nand Pryag HEP works out to about 4381 ha. An image of this area taken from satellite has been presented as **Figure 7.1,** whereas the land use pattern is shown as **Figure 7.2**. Details of land use pattern of catchment directly draining is given in **Table 7.2.** It is observed that about 82.75% of this area is covered with vegetation (dense 48.35%, medium 22.50%, light 11.90%). Agricultural land makes 14.41%, whereas a mere 0.38% of this area is occupied by settlements. It will not be possible to treat this entire area because of the topographical and financial considerations. It would, therefore, be prudent to further prioritize the area for treatment, which contribute maximum silt load in the silt basin at barrage.

TABLE 7.2
LAND USE PATTERN OF DIRECTLY DRAINING CATCHMENT AREA

S.NO.	LAND USE CATEGORY	AREA (ha)	AREA (%)
1	Dense Vegetation (Crown Cover Density> 40%)	2118.1	48.35
2	Medium Vegetation (Crown Cover Density 10 – 40%)	986.3	22.50
3	Light Vegetation (Crown Cover Density < 10%)	521.8	11.90
4	Agricultural Land	632.3	14.41
5	Scrubs/Bushes	7.3	0.2
6	Barren Area	35.4	0.8
7	Water Bodies	63.8	1.46
8	Settlements/Built-up Area	16.0	0.38
	TOTAL	**4381**	**100**

7.4.1 Soil Erosion Estimation through GIS

Geographical Information Systems (GIS) are computerized resource data base systems that are referenced to some geographic coordinate system. A GIS is primarily used to store, manipulate, analyze and display various spatial data. In addition, GIS combine special hardware and software to perform numerous functions and operations on various spatial data layers residing in the database. It makes it capable of performing analysis of large database in relation to a set of established criteria. In this particular case, due to spatial variability of site parameters, GIS proved a very useful tool for soil erosion estimation. Following thematic maps have been used for delineating areas prone to soil erosion.

- Landuse/ Landcover map
- Slope map
- Soil map

Landuse/Landcover map has been derived using the latest cloud free satellite imageries. Data has been generated from Indian Remote Sensing (IRS) Satellite ID/P6, LISS III sensor procured from National Remote Sensing Agency. The data from LISS III sensor is of 23.5 m resolution (**Figure 7.2.)**

Slope Map has been generated through standard triangulation techniques using digitized counters at 40 m interval derived from Survey of India 1:50,000 scale topographic sheets. The platforms used are Arc View/ Mapinfo Professional/ ERDAS Imagine for the purpose. The raster slope map was converted to vector form for further use. The slope map of the area has been presented as **Figure 7.3.** The areas falling under various slope categories have been tabulated as indicated in **Table 7.3**. As seen from the table 69.1 % of the area has a slope of more than 50%, which reflects towards the ruggedness of the area.

Soil map has been digitized and produced using soil maps collected from National Bureau of Soil Survey & Land use Planning.

FIGURE 7.1
SATELLITE IMAGERY OF DIRECTLY DRAINING CATCHMENT AREA

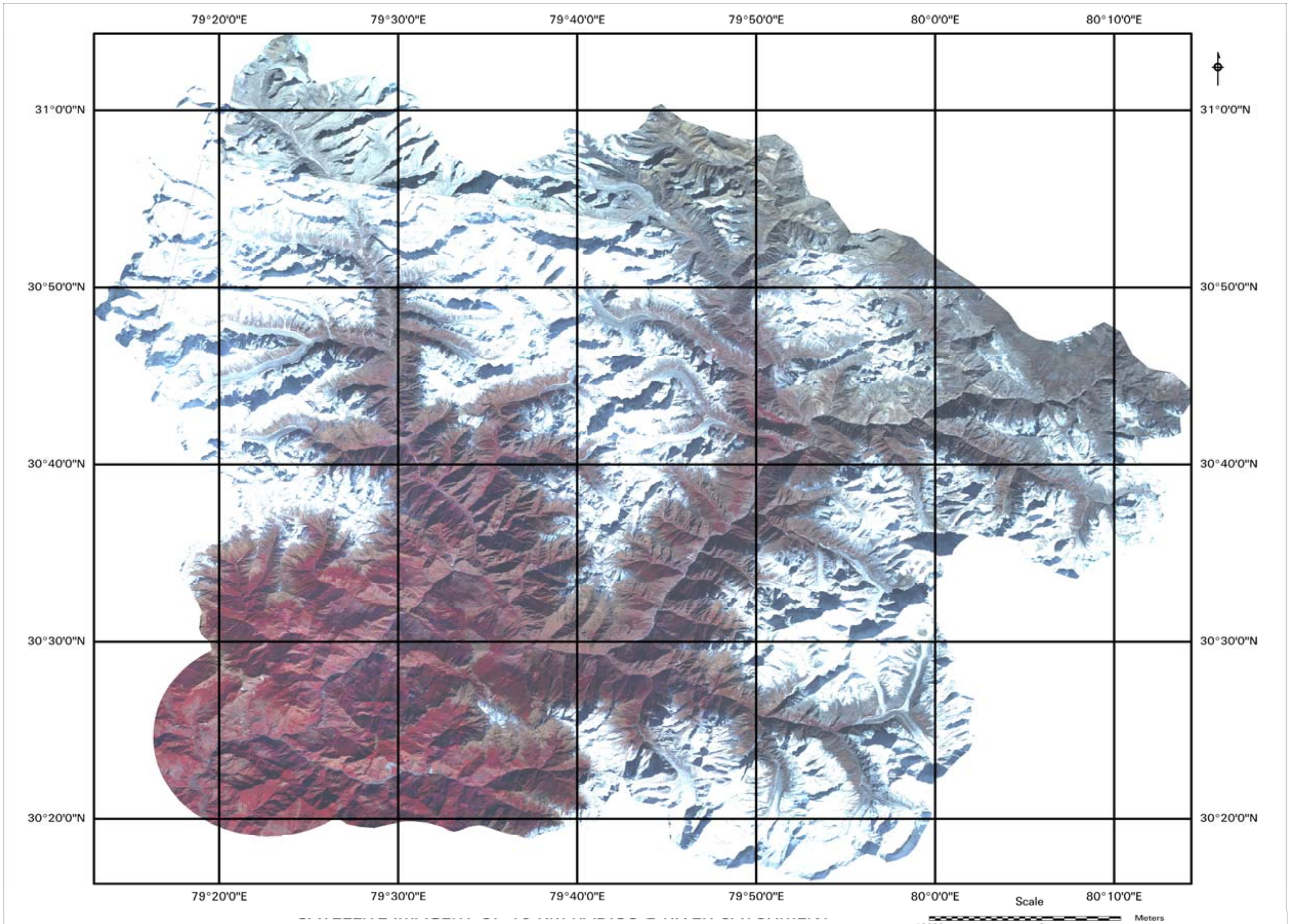


FIGURE 7.2
LANDUSE CLASSIFICATION OF DIRECTLY DRAINING CATCHMENT AREA

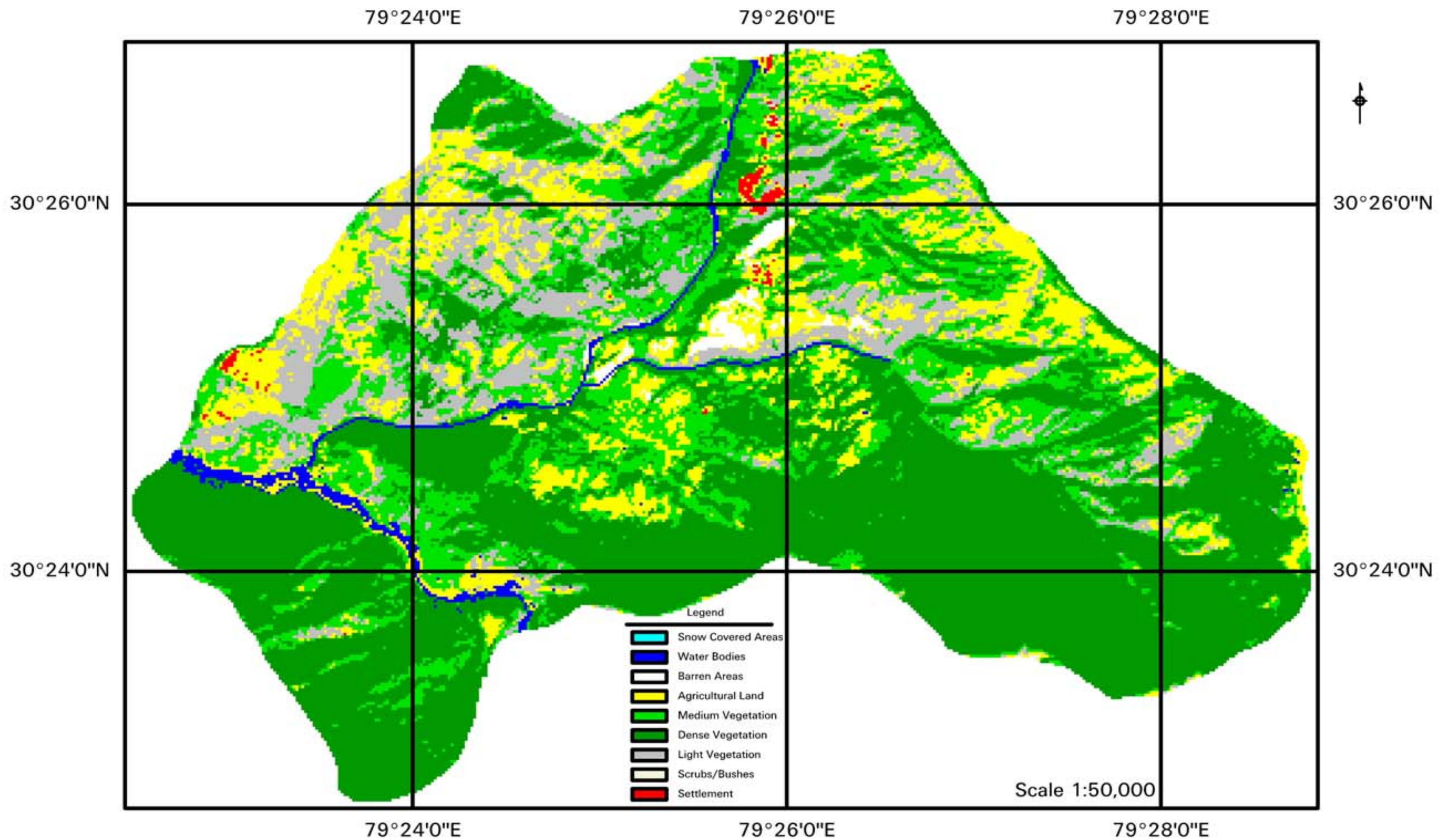


FIGURE 7.3
SLOPE MAP FOR DIRECTLY DRAINING CATCHMENT

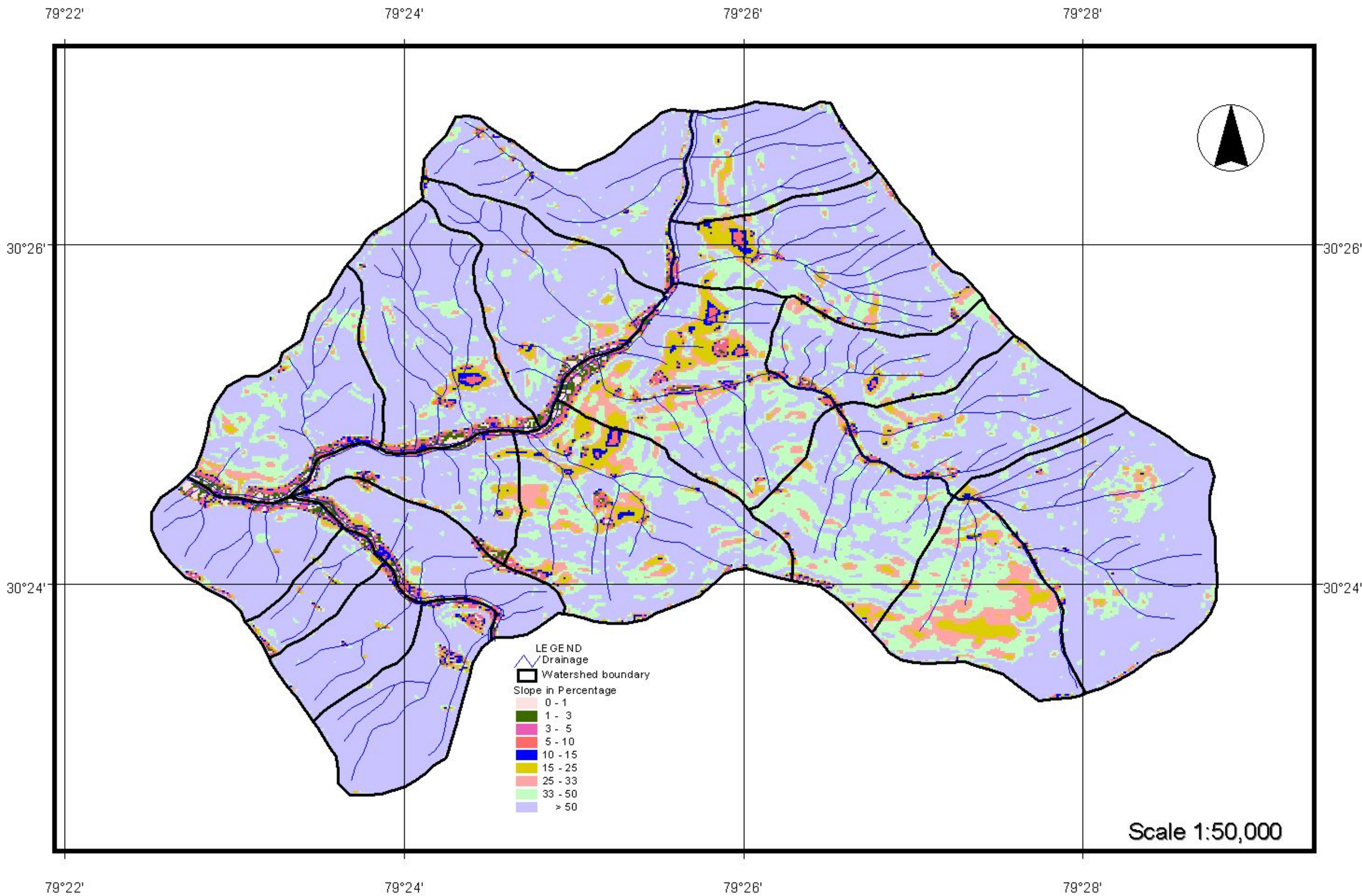


TABLE 7.3
SLOPE CATEGORIES OF CATCHMENT AREA

S.NO.	SLOPE CATEGORY (PERCENTAGE)	AREA (ha)	AREA (PERCENTAGE)
1	0-1	8.8	0.2
2	1-3	43.8	1.0
3	3-5	43.8	1.0
4	5-10	70	1.6
5	10-15	57	1.3
6	15-25	162	3.7
7	25-33	241	5.5
8	33-50	727	16.6
9	>50	3027.6	69.1
TOTAL		**4381**	**100**

7.4.2 USLE Modeling

The catchment area has been divided into small grids of 20mX20m. The vector layer so generated of 20m-grid size was updated by Landuse/Landcover details, soil information and slope values in Mapinfo Professional software using different maps as generated above. Soil loss has then been calculated in tons/acre/annum for each grid using Universal Soil Loss Equation (USLE) through information derived for updated grid with the help of a customized computer software program. A thematic map has been prepared using these calculated soil erosion values for delineating areas prone to soil erosion in the study catchment and presented as **Figure 7.4**.

7.4.3 Sediment Yield Index (SYI)

SYI provides comparative erodibility criteria of watersheds in terms of high, medium, low and very low but does not provide absolute silt yield. SYI has been calculated based on the methodology developed by All India Soil & Land Use Survey (AIS & LUS). Each erosion unit was assigned a weightage that indicate the relative erosion intensity. A factor k, rated as an inertia factor signifying equilibrium between erosion and deposition is assigned a value of 10. Any addition to this factor is indicative of erosion roughly in proportion to the added factor whereas the subtraction is suggestive of deposition possibilities. SYI values for each sub-watershed marked within the catchment were calculated using assigned weightages. A map of prioritization of different sub-watersheds has been prepared highlighting priority categories and given as **Figure 7.5**. The Silt Yield Index (SYI) values with the degree of priority have been indicated in **Table 7.4**.

TABLE 7.4
SILT YIELD INDEX CATAGORIES

S.NO.	SYI VALUES	PRIORITY
1	> 1300	Very high
2	1200-1299	High
3	1100-1199	Medium
4	1000-1099	Low
5	< 1000	Very low

FIGURE 7.4
SOIL EROSION INTENSITY MAP OF DIRECTLY DRAINING CATHMENT AREA

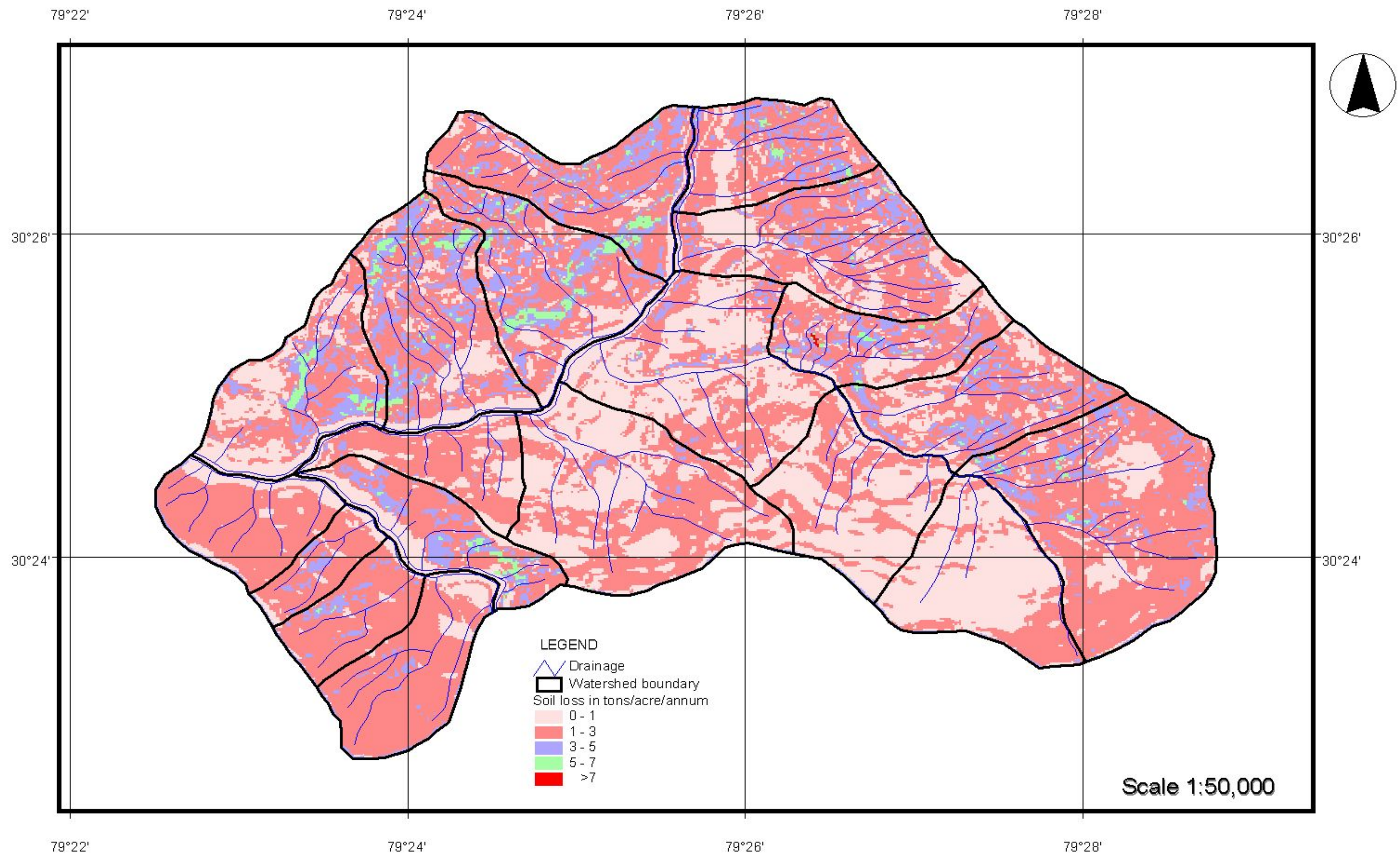
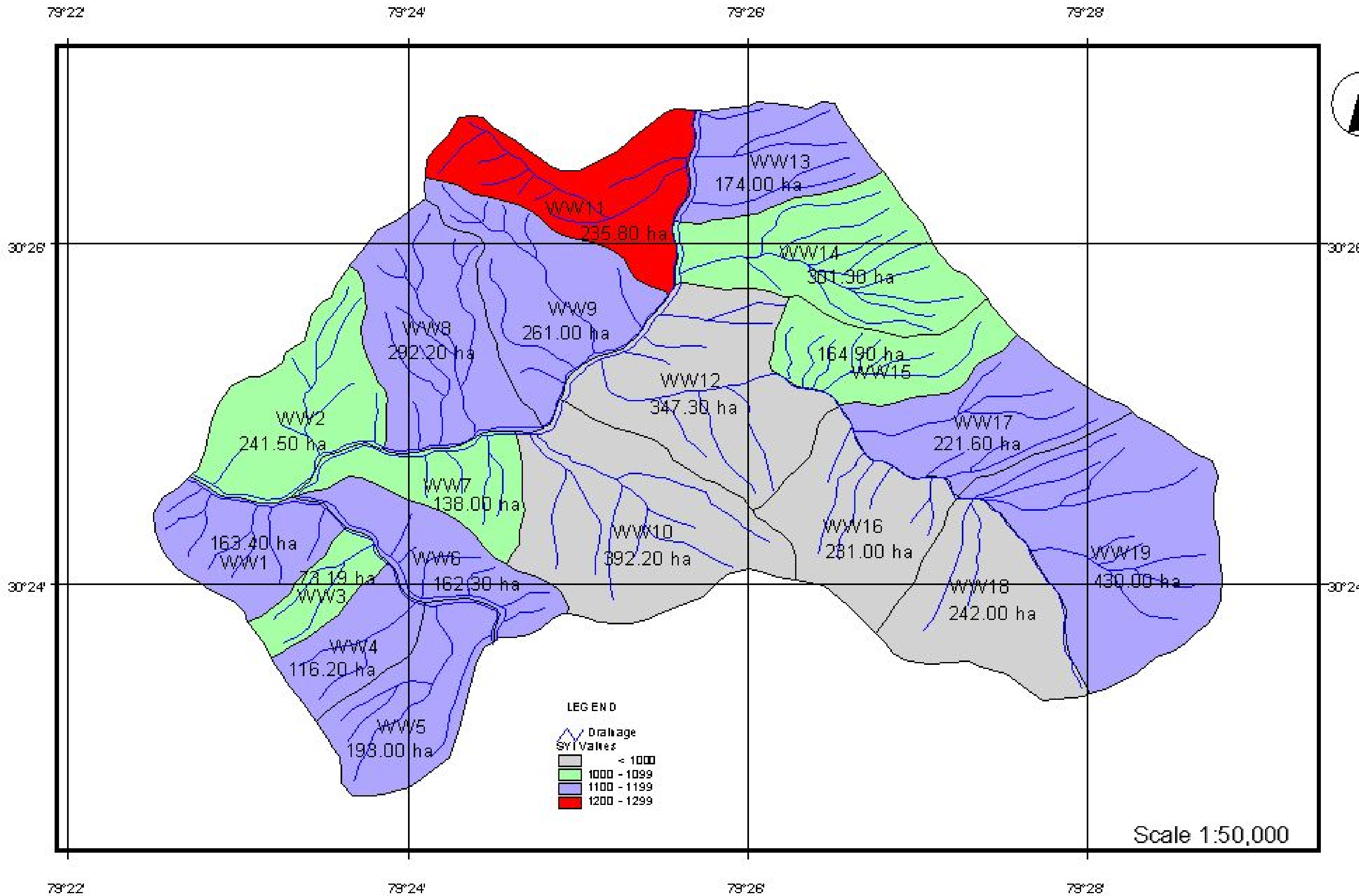


FIGURE 7.5
PRIROTISATION OF SUB WATERSHED



7.4.4 Prioritization of Sub-watersheds

Prioritization of each sub-watershed has been done on the basis of SYI index, which shall make the basis for selection of area for treatment of the catchment. **Table 7.5** presents the sub water shed details, such as area, SYI value and the priority assigned for treatment.

TABLE 7.5
PRIORATISATION OF SUB-WATER SHEDS ON THE BASIS OF SYI INDEX

SUB-WATERSHED	AREA IN HA	SYI VALUE	PRIORITY
WW1	163.4	1110	Medium
WW2	241.5	1088	Low
WW3	73.3	1097	Low
WW4	116.2	1171	Medium
WW5	193	1124	Medium
WW6	162.3	1143	Medium
WW7	138	1000	Low
WW8	292.2	1172	Medium
WW9	261	1176	Medium
WW10	392.2	937	Very low
WW11	235.8	1200	High
WW12	347.3	926	Very Low
WW13	174	1141	Medium
WW14	301.3	1061	Low
WW15	164.9	1096	Low
WW16	231	887	Very Low
WW17	221.6	1102	Medium
WW18	242	882	Very Low
WW19	430	1125	Medium
Total	**4381**		

7.5 CATCHMENT AREA TREATMENT MEASURES

Execution of CAT plan is the responsibility of District Forest Division. Outlines of CAT plan suggesting the project components, execution mechanism, physical and financial targets including the cost estimate etc. have been outlined in the following paragraphs. The treatment measures, phasing of works and the cost estimate suggested below shall provide broader guidelines for designing a CAT plan by the forest division for execution.

The treatment measures have been designed keeping in view the ecological as well as social dimensions of the project. The treatment measures emphasize on conservation of the catchment through plantation and supporting engineering works. It envisages an active participation of the local community.

7.5.1 Biological Measures

In order to reduce the erosion of soil and its transport, it is suggested to undertake the following biological measures

7.5.1.1 Plantation Works in Degraded Forest Area

It is proposed to carry out plantation over an area of 350 hectare in the degraded forest area. The area earmarked for plantation in each of the sub-water sheds is given in **Table 7.6**. Delineation of plantation area from these sub watersheds is on the basis of SYI value and the total area of the sub watershed. Actual patches for plantation shall be earmarked physically by the CAT implementing agency accordingly at the time of execution, depending on the accessibility as well as treatability of the area. The plantation would help in reducing the silting of reservoir in addition to the multi objective of soil conservation, water recharge and eco-restoration of the degraded area.

TABLE 7.6
PLANTATION WORKS IN PROTECTED FOREST AREA

SL. NO.	MICRO WATERSHED NO.	TOTAL AREA (ha)	AREA OF PLANTATION EARMARKED (ha)
1.	W1	163.4	25
2.	W4	116.2	18
3	W5	193	29
4.	W6	162.3	24
5.	W8	292.2	44
6.	W9	261	39
7.	W11	235.8	47
8.	W13	174	26
9.	W17	221.6	33
10.	W19	430	65
	TOTAL	**2249.5**	**350**

7.5.1.2 Fodder Plantation

To overcome the problem of scarce availability of the fodder, it is proposed to bring a substantial area under fodder plantation with suitable fast growing species.

7.5.1.3 Plantation of Horticulture Crops

Under this treatment plan suitable horticultural crop species and Citrus species shall be planted in select areas adjacent to the villages. These plants would be distributed to families residing in villages within the catchment with the objective of supplementing their income.

7.5.1.4 Pasture Development

As there are degraded patches of pastures in the area, this measure will be adopted to encourage development of new and healthy pasture areas for the use of cattle. Under this treatment suitable species of grasses and tree fodder, and leguminous plant species shall be planted in the land area earmarked for this purpose. Effective fencing would also be provided for protection of saplings. Before any new area is taken up eradication of weeds and unpalatable grass species is equally important. It is recommended that some parts of the pastures should also be closed for seeding purpose only.

7.5.2 Engineering Measures

Brief engineering measure proposed under the CAT work are as follows:

7.5.2.1 Silt Retention Dam

Silt Retention Dam is a concrete structure which constitutes of spillway in one side and diversion in the other side. This kind of structure is useful for retaining the silt where discharge is more and the slope is moderate around 100 to 250. Normally a free board of 0.5 m is provided and the cost estimation.

7.5.2.2 Contour Bunding

Contour bunding in shallow and medium soil at appropriate vertical interval and horizontal distance across the slopes helps in reduction of soil erosion and conservation of moisture. It consists of constructing narrow based trapezoidal bunds on contours to improve runoff rainwater in such a manner that it percolates and recharges the root profile on either side of the bunds up to 50 to distance between two such terraces

7.5.2.3 Brush Wood Check Dams

Gullies are mainly formed on account of physiography, soil type and heavy biotic interferences in an area. The scouring of streams at their peak flows and sediment laden run-off cause gullies. Narrow gully can be treated with brush wood check dams or plots to control gully erosion. Brushwood will be available locally in abundance. The construction will be faster and the catchment can be protected from gulley erosion. Subsequently this will help in reducing sedimentation in the reservoir.

Before commencing the construction for the check dam, the sides of the gully at the selected sites are slopped to 1:1.5 and the gully bottom, for the whole length of the dam, is lowered by about 15 cm. Also, 15 cm excavations are carried up into the bank as high as required to give the necessary notch capacity for discharging the run-off. The country wood stakes, about 10 cm to 13 cm in diameter are driven 0.90 m apart in two rows to go at least 0.90 m to 1.2 metre in to the hard bed of gully. The distance between the rows will be 0.9 m. The tops of the stakes are kept at such a height as to form a distinct depression in the middle to form a notch of the required waterway to enable the maximum run-off to discharge. The first layer of straw and brushwood is laid across the gully between two rows of wood stakes. Over it long branches of specially selected species are laid lengthwise of the gully and well pressed. The process is repeated till the required height is obtained. The brush is anchored on to the stakes by means of galvanised iron wire. Intermediate stakes of shorter lengths are driven and the brush is anchored on to them to prevent lifting form bed by water.

7.5.2.4 Loose Bolder Check Dam

Like brushwood check dam, loose boulder check dams can be made of boulder piled up across the gulley if they are locally available. Such structures for damming a gulley or a stream to refine the flow velocity are called loose bolder check dams. The site where the dam is to be erected is cleared and the sides are sloped to 1:1.5. The bed of the gully is excavated to a uniform depth of 0.30 m and the dry boulders are packed over pressed straw from that level. In the centre of the dam portion sufficient waterway is allowed to discharge the maximum run-off from the catchment. The boulder filling should go up to 0.30 m to 0.60 m into the stable portion of the gully side to prevent end cutting. In the rear sufficient length (0.90 m) and width of apron has to be provided to prevent scour. The thickness of apron packing should not be less than 0.45 m and gully sides above apron have to be protected with stone pitching to a height of at least 0.30 m above the anticipated maximum water level to prevent side scouring. The boulders should be properly packed and may be supported on the downstream side by putting few post. It may be kept in mind that the stability of these structures is basically due to the weight of the materials i.e. boulders. As the boulders are easily available in the streams/rivulets, such structures can easily be constructed.

7.5.2.5 Gabion Structures

If loose boulders are considered not to be stable in a particular reach of the stream, Gabion structure or stone masonry structures can be installed. This is not very much encouraged because the terrain is stiff and the cement has to be carried by human labour. Carrying the cement will be tedious, time consuming and some times cement itself can set damaged during the carriage or while it is stocked at site for use. Therefore with proper judgement about the site conditions these structures may be installed

7.5.3 Maintenance Support for Soil Conservation Works

Mass movement of land, glacial erosion, monsoon related landslides and large cloudbursts are common in the catchment area, since it is geologically very fragile and seismologically active. It is most likely that the soil conservation structures constructed get affected due to the natural phenomenon. The structures will therefore require annual repairs as the need arises. One time planning and allocation of budget in this river valley project would render insufficient to take care of the treatment measures in long term. Hence a long term provision of funds for maintenance and up gradation of old soil conservation works would become necessary.

7.5.4 Silt Observation Points

Silt observation locations for regular monitoring of silt load coming in tributaries of sub watersheds falling under high and very high categories have been suggested. This would ensure monitoring efficacy of implementation various treatments measures suggested as in CAT plan.

Monitoring would be undertaken for a period of 10 years including 5 years for CAT plan implementation period. Cost towards this is kept as 110 lakhs

7.6 COST ESTIMATE AND PHASING OF WORKS

Cost of the CAT works has been estimated to Rs 3621.79 lakhs indicated in **Table 7.7** and year wise physical and financial targets of catchment area treatment works are given in **Table 7.8**

The catchment area treatment works have been phased over a five year duration, so as to complete them along with the project construction. The actual start time shall, however, depend upon the overall progress of the project including approvals and disbursement of funds for the CAT plan.

TABLE 7.7
COST ESTIMATE FOR CATCHMENT AREA TREATMENT WORKS

S No	ITEM	UNIT	Quantity	Rate for first year (Lakhs)	TOTAL (Lakhs)
1	Barbed wire fencing for protection	Km	50	1.09	66.48
2	Brushwood check dam	No.	400	0.01	2.83
3	Contour Bunding	No.	300	0.01	2.04
4	Gabion Structure	No.	150	0.18	32.85
5	Loose Bolder Check Dam	No.	350	0.13	56.74
6	Silt Retention Dam	No.	675	0.90	741.77
7	Development of Nursery	LS	20	14.00	280.00
8	Maintenance of Nursery	Year	100	3.50	427.36
9	Plantation in degraded forest land and Maintenance for 5th year	Ha	350	0.56	237.87
10	Fodder Plantation	Ha	250	0.25	76.31
11	Plantation of Horticulture Crops	Ha	100	0.75	91.58
12	Pasture Development	Ha	50	0.25	15.26
	Sub Total (A)				**2031.10**
	Administrative Expenditure				
13	Government Expenditure (5%) of total				101.56
14	Establishment Cost 8% of total				162.49
15	Contingency @5% of total cost				101.56
	Sub Total (B)				365.60
	Sub Total C (A+B)				**2396.70**
16	Provision for forestry research in the area@5% of CAT cost				119.84
17	Provision for eco-tourism @1%				50.33
18	Provision for monitoring & evaluation activity @5%				119.84
19	Provision for forest protection measures				400.00
20	Provision for eco-services to local communities@10%				239.67
21	Provision for training for forest staff and sensitization of local communities@2.5%				59.92
22	Maintenance Support for Soil Conservation Works				125.00
23	Silt observation sites (10 year cost including manpower)				110.50
	Sub Total (D)				**1225.09**
	Grand Total (C+D)				**3621.79**

TABLE 7.8
YEAR WISE PHYSICAL AND FINANCIAL TARGETS OF CATCHMENT AREA TREATMENT WORKS

S. No.	ITEM	1st YEAR		2nd YEAR		3rd YEAR		4th YEAR		5th year		TOTAL	
		PHYSICAL	FINANCIAL (RS. Lakh)	PHYSICAL	FINANCIAL (RS. Lakh)	PHYSICAL	FINANCIAL (RS. Lakh)	PHYSICAL	FINANCIAL (RS. Lakh)	PHYSICAL	FINANCIAL (RS. Lakh)	PHYSICAL	FINANCIAL (RS. Lakh)
A	**Engineering Measures**												
1	Fencing/Protection Work	10	10.89	10	11.98	10	13.18	10	14.49	10	15.94	50	66.48
2	Brushwood check dam	80	0.46	80	0.51	80	0.56	80	0.62	80	0.68	400	2.83
3	Contour bunding	60	0.33	60	0.37	60	0.41	60	0.45	60	0.49	300	2.04
4	Gabion Structure	30	5.38	30	5.92	30	6.51	30	7.16	30	7.88	150	32.85
5	Loose Bolder Check Dam	70	9.29	70	10.22	70	11.25	70	12.37	70	13.61	350	56.74
6	Silt Retention Dam	135	121.50	135	133.65	135	147.02	135	161.72	135	177.89	675	741.77
B	**Biological Measures**												
7	Development of Nursery	20	280.00	0	0.00	0	0	0	0.00	0	0.00	20	280.00
8	Maintenance of Nursery	20	70.00	20	77.00	20	84.70	20	93.17	20	102.49	100	427.36
9	Plantation including Maintenance on degraded forest area(ha)	70	38.96	70	42.86	70	47.14	70	51.86	70	57.04	350	237.87
10	Fodder Plantation (ha)	50	12.50	50	13.75	50	15.13	50	16.64	50	18.30	250	76.31
11	Plantation of Horticulture Crops (ha)	20	15.00	20	16.50	20	18.15	20	19.97	20	21.96	100	91.58
12	Pasture Development (ha)	10	2.50	10	2.75	10	3.03	10	3.33	10	3.66	50	15.26
	Total		**566.83**		**315.51**		**347.06**		**381.77**		**419.94**		**2031.10**

Chapter –8

Environmental Monitoring Plan

CHAPTER - 8
ENVIRONMENTAL MONITORING PLAN AND COST

The environmental monitoring programme is a vital process in the Management Plan for a water resources / river valley project. This helps in signalling the potential problems that would result from the proposed project and will allow for prompt implementation of corrective measures. The environmental monitoring will be required during construction and operational phases. The following parameters need to be monitored:

- Land Compensation and Social Welfare,
- Water Quality and Public Health,
- Catchment Area Treatment Measures; and
- Air Quality and Noise Level.

8.1 LAND COMPENSATION AND SOCIAL WELFARE

Land required for various components of the project would be acquired through the State Forest Department and private land through State Revenue Department of Uttarakhand. Compensation would be paid as decided by the revenue department in accordance with the prevailing norms of the state for such acquisitions. In addition to the compensation for land acquired, a number of social welfare measures have been proposed under the Social Response Program. These include income generation, education assistance, development of infrastructure, healthcare facility etc with a budgetary provision of Rs.113.50 Lakhs. An active participation of project-affected people, local administration and other relevant institutions has been envisaged.

A separate SRP cell under the control of the general manager of the project would be responsible for implementation of the program. Measurable for each of the schemes need be specified for monitoring purpose. A separate body comprising of representatives from project management & public representatives shall be responsible for monitoring and concerted evaluation of the SRP.

8.2 WATER QUALITY AND PUBLIC HEALTH

Since water contamination leads to various water related diseases, the project authorities shall establish a procedure for water quality surveillance and ensure safe water for the consumers. A detailed epidemiological study related to water borne diseases shall be carried out and the data shall be compiled for every year in the project area. This data would help the authority in finding out the trends for incidence of water related diseases prevalent in the area, which would help them to take suitable remedial measures for reducing or eradicating the occurrence of these diseases in future.

Water quality parameters shall be monitored for one year before and for at least three years after the completion of the project. Monitoring shall be carried out on monthly basis to cover seasonal variations for four years. Water quality shall be analysed by applying the standard technique. The parameters recommended for monitoring are as follows:
1. pH
2. Dissolved Oxygen

3. Biochemical Oxygen Demand
4. Total Dissolved Solids
5. Temperature
6. Total Hardness
7. Calcium
8. Magnesium
9. Iron
10. Manganese
11. Chlorides
12. Sulphates
13. Nitrates
14. Fluorides
15. Total Nitrogen
16. Total Phosphates
17. Total Coliform

Water quality monitoring at two distinct locations i.e., the barrage and the tailrace tunnel outlet would be ensured, through the environmental division of the project.

8.3 SEDIMENTATION AND CAT WORKS MONITORING

Soil erosion rates shall be continuously monitored to establish effectiveness of the soil conservation measures undertaken through CAT plan. The sediment load monitoring shall be carried out through the environmental officer of the project.

Monitoring of afforestation schemes shall be required to measure the change in forest cover of the catchment area. It shall allow for validation of the assessment made in the present study and will give timely signal against potential problems, which could result from the proposed project, thus allowing for prompt implementation of corrective measures. The project authorised need to monitor the vegetation cover through remote sensing techniques for this purpose. A provision of Rs. 10,00,000 is kept for monitoring the progress of CAT works (plantation) through GIS.

8.4 AIR AND NOISE QUALITY MONITORING

Though there is no significant air or noise pollution by the proposed project, however, to assess the effectiveness of air pollution control measures suggested towards maintenance of approach roads, stone crushers, muck disposal sites and quarry sites and noise control measures suggested towards operation of various construction machinery, it would be required to monitor these parameters at regular interval. The environmental division of the project would carry this out.

8.5 ESTABLISHMENT OF ENVIRONMENTAL DIVISION

UJVNL shall establish an Environment Division in the initial stage of the project itself. The division shall have an Environmental Engineer/Officer, a Technical Assistant (environment background) and two other assistants (miscellaneous works). The task of the division would be to supervise and co-ordinate studies, monitoring and implementation of environmental mitigation measures, and it shall report directly to the General Manager of the Project. An Environmental Advisor shall review progress of the division every year. The Environmental Advisor would be an experienced Ecologist or Environmentalist familiar with environmental planning of water resources projects. Cost of such a Division has been estimated as Rs.76.50 lakh as per details given in **Table 8.1** below.

TABLE 8.1
COST OF ENVIRONMENTAL DIVISION

Sl.No.	Item	Cost (Rs.)
1.	Capital cost:	
	Office building including laboratory 150sqm @ Rs.8000/Sqm	12,00,000
	Office furnishing including computer etc.	5,00,000
	Laboratory equipment	5,00,000
	Vehicle 1 no.	6,00,000
2.	Recurring cost for4.5 years	
	Manpower (1 Engineer, 1 T.A.,2 Assistants) @ 4,50,000/year	22,50,000
	Vehicle running cost @ Rs 1,20,000/year	6,00,000
	Office maintenance and consumables @ Rs 3,00,000/year	15,00,000
3.	Services of Environmental Advisor @ Rs. 1,00,000/year	5,00,000
	Total	**76,50,000**

8.6 ENVIRONMENTAL COSTS

All costs involved in Environmental Mitigating measures and Management to be put on the account Bowala Nand Pryaga Hydroelectric project works out to Rs. 5283.91 lakhs as summarised in **Table 8.2**.

TABLE 8.2
ENVIRONMENTAL COSTS

S. No.	Item	Amount (Lakh rupees)
1.	Social Response Program Works of the project (As per table 4.14)	1071.55
2.	Compensatory Afforestation	81.24
3.	Catchment Area Treatment Works: (As per table 7.7)	**3621.79**
4.	Establishment of Environmental Division	76.50
5.	Development of muck disposal sites as green patches	18.78
6.	Stabilization of quarry slopes	10.00
7.	Subsidy towards provision of alternative fuel in worker's camp	67.50
8.	Water supply and wastewater treatment facility in worker's camp	83.00
9.	Domestic solid waste management facility	54.95
10.	Health delivery system	83.60
11.	Cultural upliftment assistance	10.00
12.	Environmental training program	5.00
13.	Sedimentation and CAT works monitoring	10.00
14.	Wildlife Enhancement	10.00
15.	Setting up of a Satellite Communication for Disaster Management	80.00
	Total	**5283.91**