CATCHMENT AREA TREATMENT PLAN

HALAIPANI HEP

M/S HALAIPANI HYDRO PROJECT PRIVATE LIMITED

Prepared By-
Grej Engineers Private Limited

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CHAPTER -1

INTRODUCTION

GENERAL

Halaipani is a Hydro – electric plant proposed on Halai River which is a tributary of Lohit River. Lohit is a tributary of Siang/ Brahmaputra River. The project is a run-of-the-river scheme with an installed capacity of 16 MW located in the Anjaw district of Arunachal Pradesh state.

Location

Arunachal Pradesh "the land of dawn-lit mountains" is one of the 28 states of India and is the north eastern - most state of the country. Arunachal Pradesh borders the states of Assam and Nagaland to the south and shares international borders with Bhutan in the west, Myanmar in the east and is separated from China in the north by the Mc Mahon Line. Itanagar is the capital of the state.

The project lies in the Anjaw District near Latul Village in the State of Arunachal Pradesh. The longitude and latitude of barrage site and power house sites in WGS - 84 co-ordinate system is as under: -

Barrage site:

Latitude	27°58'40.75" North
Longitude	96°43'10.98" East

Power house site:

Latitude	27°57'57.28" North
Longitude	96°42'45.31" East

Project Location from:	
Tinsukia (Nearest rail head)	305 Km
Dibrugarh (Nearest Airport)	350 Km

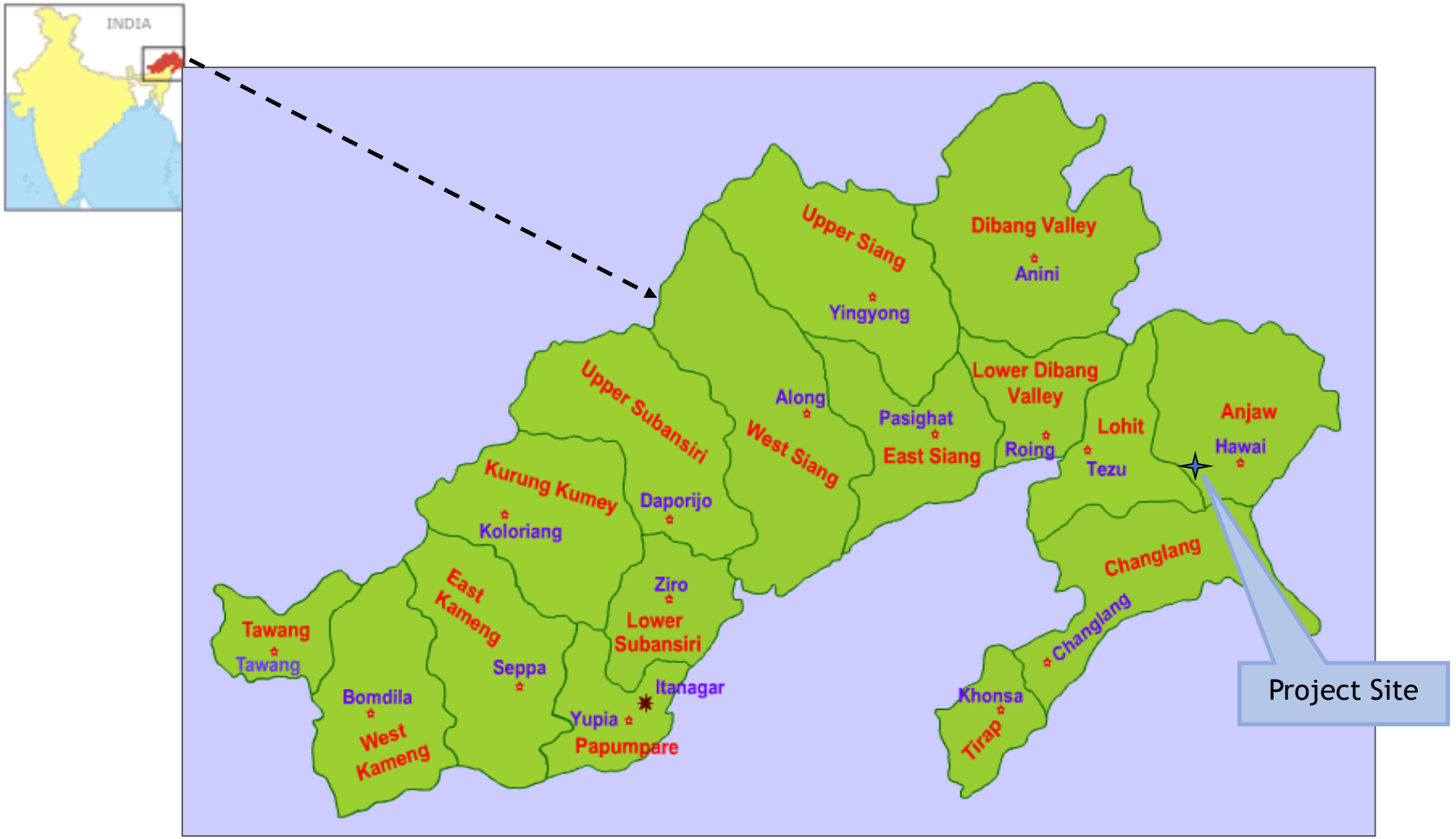


Fig 1 – Location Map of Halaipani HEP

TOPOGRAPHY

The project area is covered in the survey of India toposheet No. 91D/12, 91D/16, 90A/9 on 1: 50,000 scale. General topographic of the project area is hilly terrain with moderate to dense forestation. Project is located on Halai River which originates from an elevation of El 4500 m and joins Lohit River at El 720 m. Halai River is the right bank tributary of Lohit River which is further a tributary of main Siang/Brahmaputra River. Halai River mainly flows from North to South direction in the project area with many curves and rapids. Total catchment area of Halai River is about 280 sq. km however catchment area of Halai River at Barrage axis of Halaipani HEP is 267 sq.km.

The Barrage structure, Head Race Channel, Penstock domain and Power House Complex consist of granodiorite rock with magmatic banding as well as foliation parallel to the magmatic banding. Apart from these massive in situ granodiorites, big boulders of these massive rocks are also present. There are several slide zones along the channel.

These granodioritic rocks are cut by the set of joints, where, all three are equally prominently developed because of the massive character of the rock. Sometimes, the thinly banded variety appears to be mylonitic zone with a very narrow zone, otherwise the rocks are massive in nature. The main foliation paralleling the magmatic banding strikes N 45° - N 225° with a dip of moderate to high (average 60°) angle towards southeast. The first joint set's average strike is N 130° - N 310° with high dip (average 75°) angle towards south- westerly, whereas, the second set of joint strikes almost E-W, (average N 1000 - N 280°) with low angle dip (average 32°). The third joint set is very steep almost vertical with a strike of about N 65° - N 245°.

CHAPTER – 2

CATCHMENT AREA

❖ BASIN DETAILS

The Brahmaputra River known as the Tsangpo in Tibet, and the Jamuna in Bangladesh is one of the biggest rivers in the world. The 2,900 km long Brahmaputra traverses about 2057 km in Tibet, 843 km from India-Tibet border up to Bay of Bengal.

It originates from an altitude of 5300 m about 63 km south east of the Man Sarovar Lake in southwest Tibet where the mighty river is known as Tsangpo. The source of Brahmaputra River lies in the Kanglung Kang glacier 82° 10' E and 30° 30' N near Konggyu lake (4877 m) in the Kailash range of Himalayas. After traversing about 2057 km in Tibet, it emerges from foothills of eastern Himalayas in Indian Territory of Arunachal Pradesh. Before entering India, the river flows in a series of big cascades as it rounds the Namcha Barwa massif.

Tsangpo is known as Siang after crossing the Indo-Tibetan border. The part of Siang basin in India is bounded on the north by eastern Himalayas, on west by Subansiri basin and on east by Dibang Basin. The river in its reach upto Kobo has an average gradient of 1 in 515. The average width of the valley is about 80 km of which the river occupies 6 to 19 km. It flows through Arunachal Pradesh in a more or less southerly direction for a distance of 226 km through steep mountainous gorges before reaching Passighat. Up to Rottung, which is upstream of Passighat, the river flows in an almost straight channel. Between Rottung and Passighat, the river meanders. Near Passighat, the river flows in a braided pattern with as many as four channels. River terraces are also noticeable along the river stretches between Yinkiong and Pasighat. From Passighat, the Siang flows another 52 km before it is joined by two major rivers from east and north-east namely the Lohit and the Dibang, a short distance upstream of Kobo to form the Brahmaputra.

Lohit River, a Major left bank tributary of Bhramputra River, originates at an elevation of 6190 m from the snow-clad peaks of Nimbout Chcumbouri Nechai Gongra Tirap Phasi ranges (approximate elevation of 6000 m) in the eastern Tibet, constituting part of Kangrigarpo range, and flows down as Kangrigarpo Qu (also called Zayal Nga Chu and Rongtu Chu), forming the eastern-most river basin of India. The river flows into India near its eastern most inhabited tip Kibithoo and surges through Arunachal Pradesh for two hundred kilometres before emptying itself in the plains of Assam. Its flow is uncontrolled and turbulent, and the

river is therefore is known as the river of the blood in the local language. The river flows through Mishmi hills to meet the Siang at the head of the Brahmaputra valley.

❖ PROJECT CATCHMENT AREA

The catchment of Halai River (a tributary of Lohit River) lies in the state of Arunachal Pradesh, the largest mountain state in India. The state is situated in the north – eastern part of the Himalayan region and can be divided in to four distinct zones; the snow-capped mountains above 4500 m, the lower Himalayan ranges between 3500 m and 2000 m; the sub – Himalayan Siwalik hills at around 700 m and the eastern Assam plain. The Halai river basin is fan shaped and the catchment elevation varies from 4500 m to 720 m. In its initial reaches, the river flows in the southern direction and then takes south western direction, till it joins river Lohit near Chamukh village in the Anjaw district. The slope of the river is about 10.1 m/km. The catchment area up to the proposed diversion site is 267 sq km. The river network is trellis type, and its tributaries are sub- parallel in nature which shows presence of structural control and flows the geomorphological trends of the hills and mountains. In the hilly terrain, the river has deep gorge along their courses. The total length of the river up to the Barrage site is 36.7 km. The bed level of Halai River at proposed Barrage site of Halaipani Hydroelectric Project is 873 m.

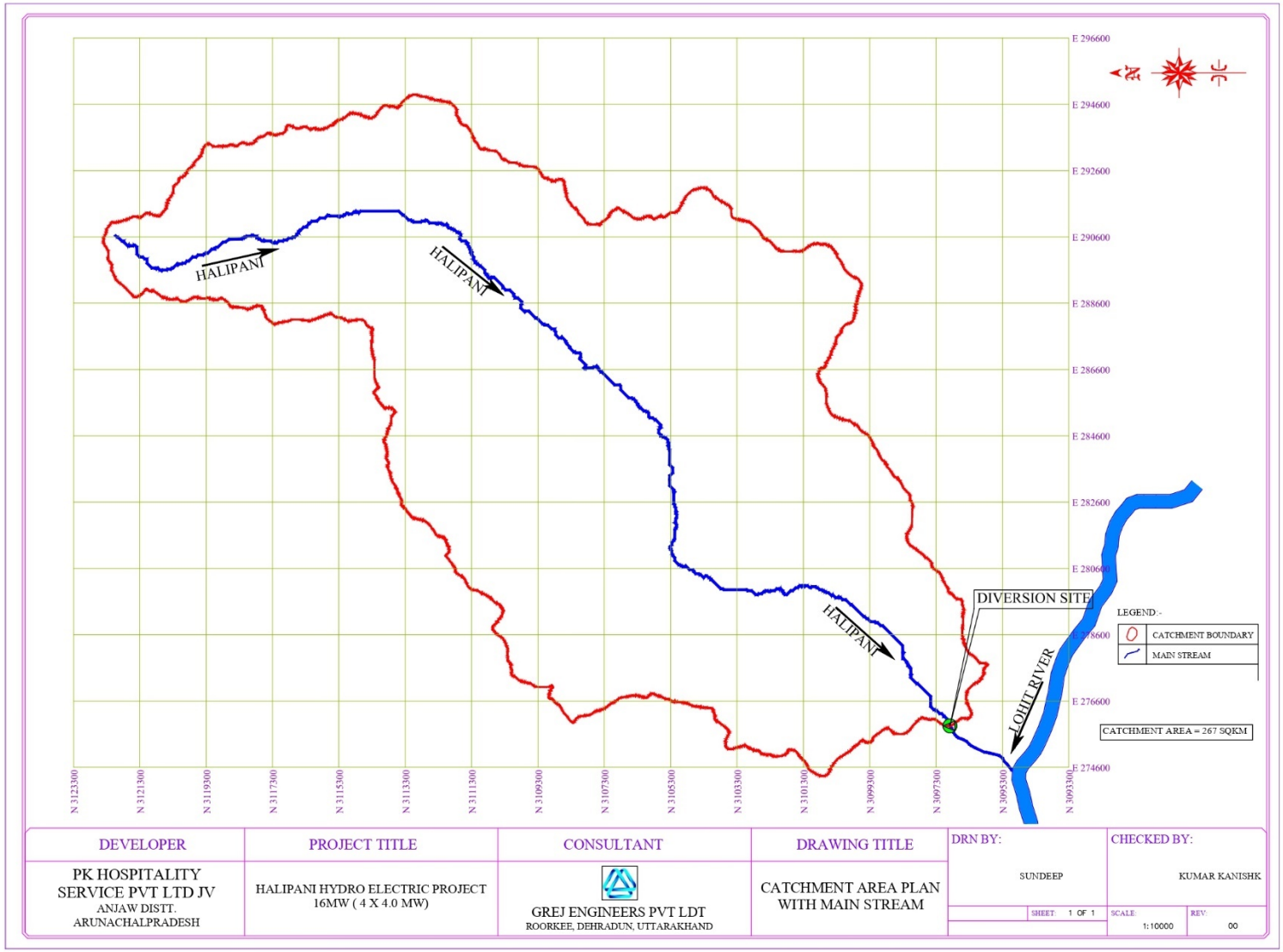


Fig 2 Catchment Area of HALAIPANI HEP

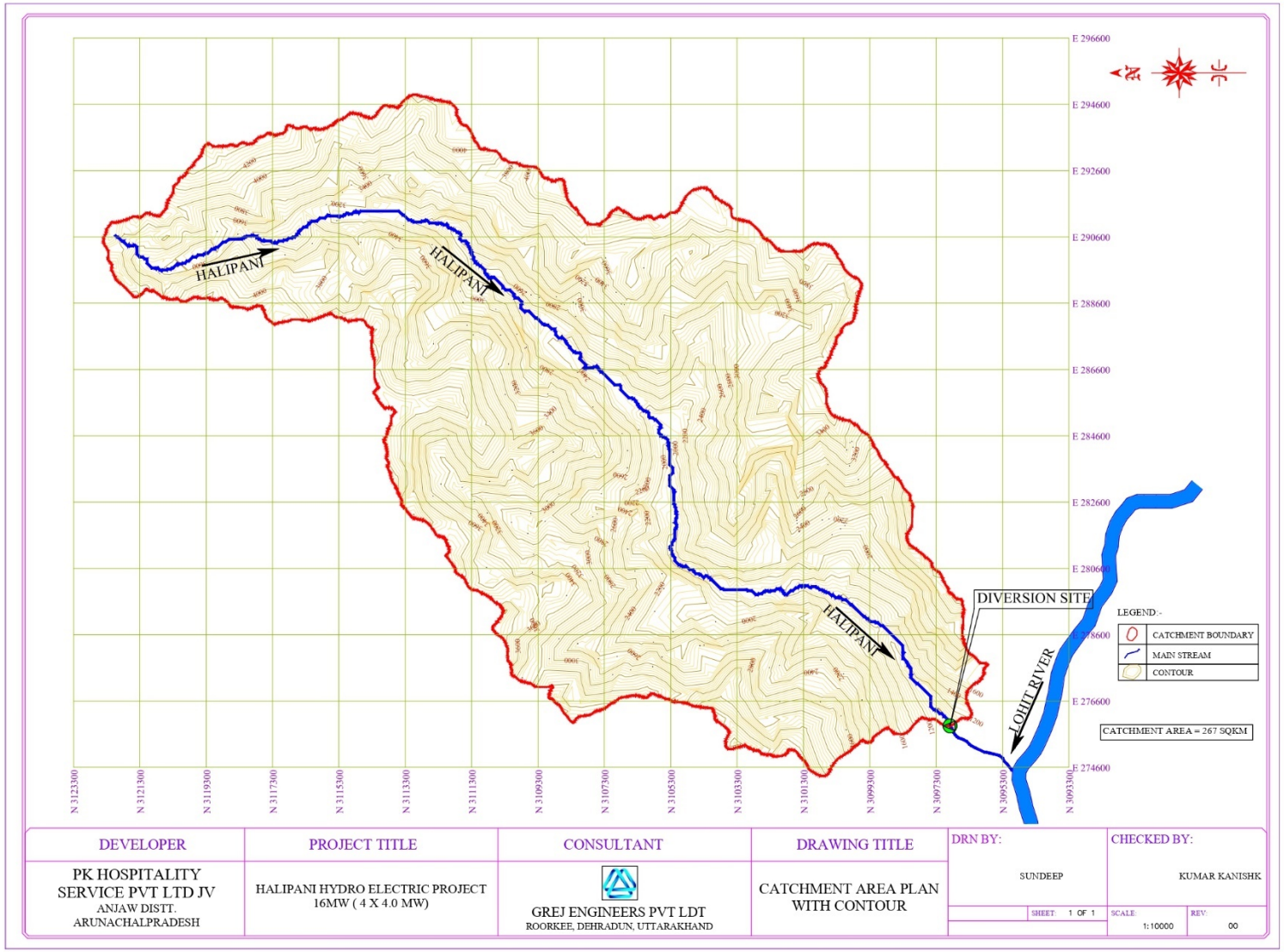


Fig 3 Catchment Plan With Contour

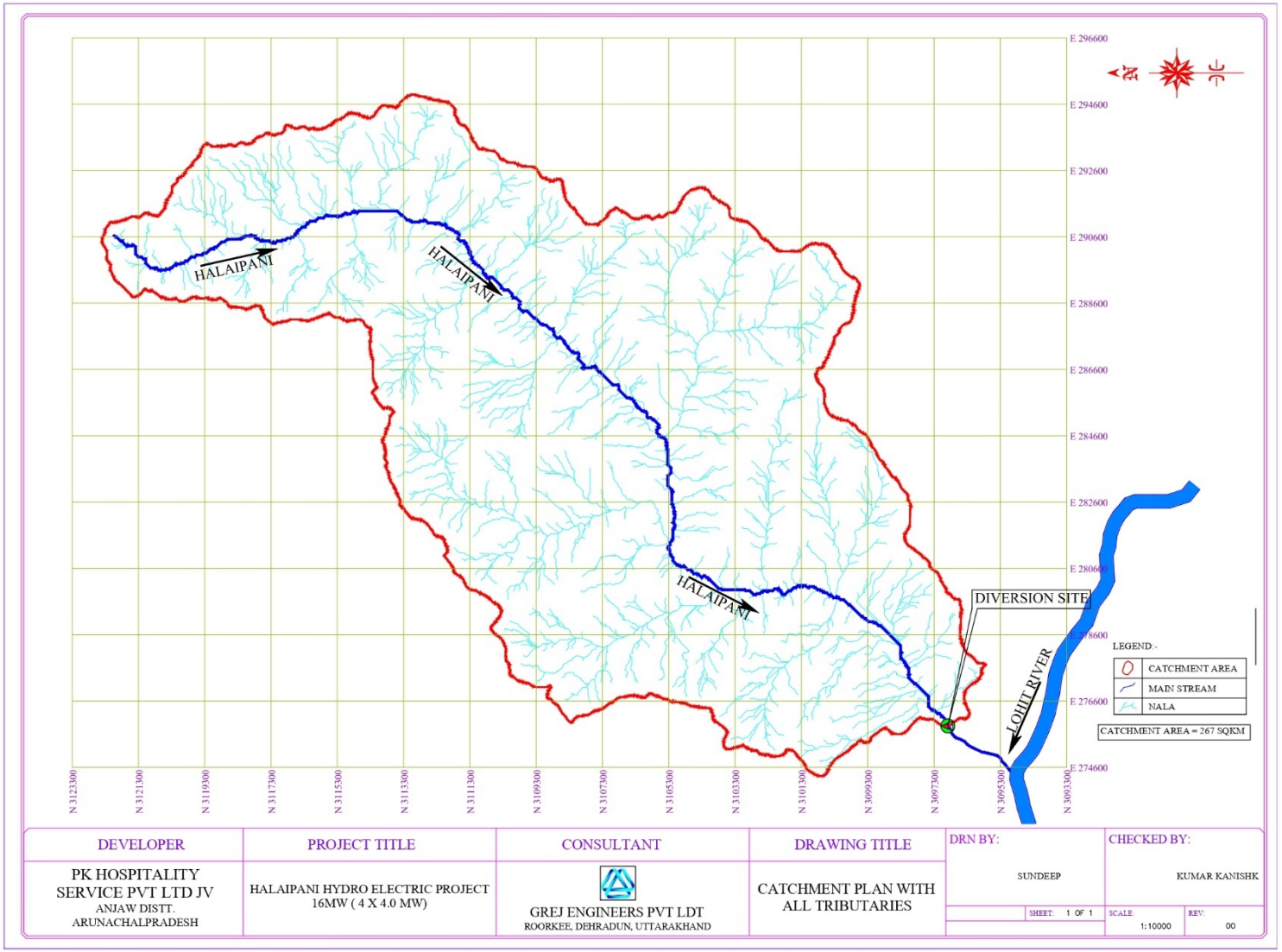


Fig 4 Showing Catchment Plan with all tributaries

❖ WATER AVAILABILITY

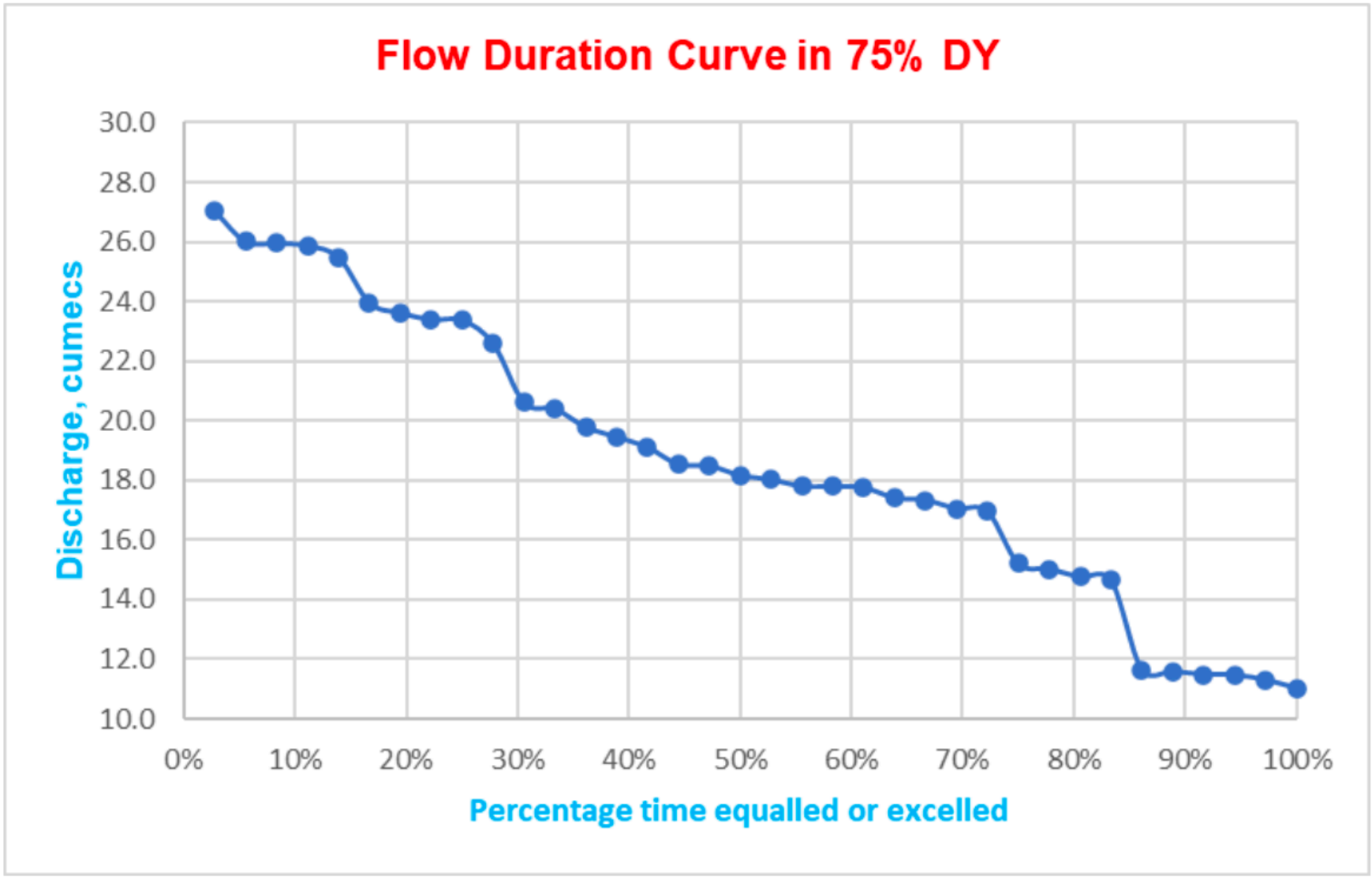
Daily discharge data of Halaipani Nallah has been measured since December 1991 to February 1992 and from January 1995 to February 2000 by H.C.D, Department of Hydro Power Development, Arunachal Pradesh.

The annual runoff at the project site in MCM (Million Cubic Meter) is provided in table 2. Further, the probability/ dependability is calculated for the discharge year after arranging them in descending order. Year 1998 is observed as 75% dependable year.

Table No - 2

Observed Series		Rank	Descending Order		Probability of Exceedance
Year	Annual Runoff at Project Site, MCM		Year	Annual Runoff at Project Site, MCM	
1995	722.17	1	1997	730.90	16.67%
1996	706.00	2	1995	722.17	33.33%
1997	730.90	3	1996	706.00	50.00%
1998	588.94	4	1999	693.85	66.67%
1999	693.85	5	**1998**	**588.94**	**83.33%**

The water availability studies were approved by HRED (formerly as AHEC), IIT Roorkee in 2010. The design discharge for power generation has been fixed at 21.75 cumecs which is available for 50% of the time in an average year and 30% in 75% Dependable Year - 1998.


Flow Duration Curve in 75% DY
Discharge, cumecs
30.0
28.0
26.0
24.0
22.0
20.0
18.0
16.0
14.0
12.0
10.0
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percentage time equalled or excelled

CHAPTER – 3
STUDY & METHODOLOGY

❖ NEED FOR CATCHMENT AREA TREATMENT PLAN

The Catchment Area Treatment Plan has been prepared.

The details are: -

It is well-establishment fact that reservoirs formed by Barrages on rivers area will be subjected to sedimentation. The process of sedimentation embodies the sequential processes of erosion, entrainment, deposition and compaction of sediment. The study of erosion and sediment yield from catchments is of utmost importance as the deposition of sediment in reservoir reduces its capacity, and thus affected the water availability for the designated use. The eroded sediment from catchment when deposited on streambeds and banks causes braiding of river reach. The removal of top fertile soil form catchment adversely affects the agricultural production.

Thus, a well-designed Catchment Area Treatment (CAT) Plan is essential to ameliorate the above-mentioned adverse process of soil erosion.

Soil erosion may be defined as the removal and transportation of soil. Water is the major agent responsible for this erosion. In many locations, winds, glaciers, etc. also cause soil erosion. In a hilly catchment area as in the present case erosion due to water is a common phenomenon and the same has been studied as a part of the Catchment Area Treatment (CAT) Plan.

The Catchment Area Treatment (CAT) Plan highlights the management techniques to control erosion in the catchment area of HALAIPANI Hydro - Electric project. The life span of a reservoir is greatly reduced due to erosion in the catchment area. Adequate preventive measures are thus needed for the treatment of catchment for its stabilization against future erosion. The directly draining catchment area has been considered for treatment under the present project i.e., HALAIPANI hydro project.

Area draining into Barrage through different local nalas situated within the Impact area mainly responsible for soil erosion. It disturbs the eco-logical balance by destroying the vegetated cover, dislocating wild life and river data, removing precious topsoil, modification of stream morphology. Consequently, natural vegetation is removed on either side of river bank.

Soil gets disturbed and is easily removed during periods of heavy down pour, leading to accelerated erosion of soil cover. This causes silt/sediment flow into streams below. Siltation of stream beds reduces the capacity of stream channel and reservoir.

Major part of the catchment is not approachable and the human settlement is only in the lower portion of the catchment. The upper area of the catchment is stable and the satellite images do not show any degraded area or erosive action due to surface runoff. The lower portion of the catchment clearly shows the degraded land along the hills and erosion along the river bank

Another important factor that adds to the sediment load, and which contributes to soil degradation is grazing pressure. There are five villages in the catchment of the project area i.e., Hamatong, Pitong, Khetong, Siet and Mangung.

Due to this pressure, the productivity of these pastures is also declining further. The lack of proper vegetal cover is a factor to cause degradation and thereby results in severe run off/soil erosion, and subsequently premature siltation of the reservoir. Thus, a well-designed **Eco-Restoration Plan of Impact Area i.e., Catchment Area Treatment Plan** is essential to ameliorate the above-mentioned adverse causes and process of soil erosion. The CAT Plan involves understanding of the erosion characteristics of the terrain and suggesting remedial measures to reduce the erosion rate. For this reason, the catchments of the directly draining rivers, streams, tributaries, etc. are treated and the treatment plan has been included in the project.

❖ AIM & OBJECTIVE

The main aims of the catchment area treatment plan are

a. Short term*: Containment*

Control of erosion and checking degradation of land

b. Mid-term: *Restoration*

Sustained restoration of the land and its resources

c. Long-term: *Improvement in bio-diversity*

To put in place a diversity of plants this would lead to natural restoration and regeneration of the eco system.

The objectives of the catchment area treatment plan may be listed as follows

- Conservation of the important natural resources like soil and water.

- Prevention of siltation in the reservoir and thus maintaining the design capacity, depth and live storage capacity of the reservoir.
- Economic up gradation of people in surrounding areas, as well as environmental conservation through afforestation and reforestation activities.
- Improvement in the density and the biodiversity of flora and fauna thus making the ecosystem more stable and mature.
- Supplementation of production of fodder and fuel to promote livestock development.
- Increase in the soil moisture content and the groundwater table level, which will result into the betterment of soil fertility and productivity.
- Reduction in the risk associated with the crop production, by softening the severity of the dry season by water conservation structures.
- Land treatment for increased vegetation and forest tree density in the area, are also envisaged.

❖ METHODOLOGY

Rationale for phasing of the Catchment Area Treatment Plan:

The following procedure has been applied for phasing of the Catchment Area Treatment Plan.

1. The subject watershed has been divided as per forest and non-forest land. The treatments vary as per the land classification as some treatments such as repairs to farm bunds can only be carried out on private lands. In addition, the soil on forest lands is generally less disturbed and prone to soil erosion than private lands.
2. These areas have then been studied and their various physical characteristics examined. The following factors have been considered for evaluation:
    - Geology: the nature of the underlying rocks and soil determines the rate at which they are eroded, and hence influences the sediment yield.
    - Silt Traps: A tank or check dam within the catchment area influences the siltation yield by acting as a silt trap / stilling basin. This drastically reduces the sediment yield as the sediment from the catchment area of the structure is almost wholly absorbed by the structure.
    - Nature of land use: is a key factor in determining erodibility of the catchment. Cultivated land is most susceptible to erosion followed by fallow and barren land. Land with dense forest cover is least susceptible to erosion.
    - Topography: The nature of the land including slope, drainage density is influential in determining the rate of sedimentation.

3. Based on our previous experience, it was determined that a period of ten years is sufficient for implementation and maintenance & monitoring of treatment measures. It is very essential that the maintenance and monitoring of the implanted work is done after the implementation for proper and effective results. Thus, a period of 10 years is considered for the whole cycle.

The plantations shall be comprised of indigenous hardy species that do not need much of attention. Maintenance shall be restricted to replacing any lost plants. The plants are expected to be established after this maintenance period, and suitable species may be selected.

4. The implementation is proposed specifically in the lower sub-catchment area, the sub-catchments which are covered by virgin forest need not be disturbed and must be kept in the natural state as they are. Therefore, the proposal is for the area which shows the degradation and where the human interventions are noticed.

5. *PRIORITIZATION OF CATCHMENT AREA TREATMENT*
    1. The catchment area is comprised of 7 sub-watersheds. The catchment area treatments been planned considering these sub-watersheds individually. However, in order to complete the work within the stipulated period, work on each sub – watershed may be carried out simultaneously. The sub-watersheds have been ranked in decreasing order of their expected sediment yields; i.e., greater the siltation rate, higher the priority.
    2. The sediment yield for each sub-watershed has been calculated using an empirical model (Kumar, 1985, Rao & Mahabaleswara, 1990) using input parameters in terms of spatial information of land use, vegetation cover, soils, slope, and drainage density, besides runoff and rainfall intensity.
    3. The model is as follows:

$$\mathbf{Vs = 1.067 \; X \; 10\text{-}6. \; p1.384 \; .A1.292 \; .Dd0.392.S0.129.Fc2.51}$$

Where,

Vs =	Sediment Yield		
P =	Annual precipitation, cm		
A =	Watershed Area, sq.km	Dd = Drainage density, km/sq.km	
Fc =	Vegetative Cover Factor	S = Watershed Average Slope	

$$Fc = \frac{0.21F1 + 0.2F2 + 0.6F3 + 0.8F4 + F5}{5}$$

Where,

F1 =	Protected Forest Area	F4 =	Grass and Pasture Land
F2 =	Unclassified Forest Area	F5 =	Wasteland
F3 =	Cultivated Area		

6. SEQUENCING OF TREATMENT ACTIVITIES WITHIN EACH PHASE

1. Within two sub-catchments i.e., W_1 & W_2, the full spectrum of area, and drain-line, soil conservation methods need to be applied. Here, the monsoon is a deciding factor when it comes to the sequencing of works.
2. Area-based soil conservation activities, i.e., plantation, grassland development, etc need to be done during the monsoons to allow the plants to become established. A nursery for plants will have to be set up before this, provision for setting up of nursery is considered in preparation of the financial layout. If the nursery is set up in January-February, the plants will be well grown by the monsoons. Transplanting the plants to their permanent sites can be carried out in the monsoon, when there shall be no requirement of irrigation.
3. Thus, the treatments involve excavation of soil. This may take the form of digging, uncovering the soil beneath boulders, etc. This excavated soil is loose and especially vulnerable to erosion by wind and water.
4. If excavation works are carried out in the pre-monsoon months, this loose soil will be exposed to the full force of the monsoon showers before the soil has a chance to settle. Large-scale erosion will then take place, which will prove detrimental to the project. Hence, these activities should be carried out in the post-monsoon period, i.e., October to March.
5. As works in each area are to be completed within the phase period, they are to be implemented almost simultaneously. In addition, sequencing of works within this period, i.e., before the onset of the monsoons will not affect the project.
6. Thus, it may be noted that the treatment activities proposed for W_1 & W_2 sub-catchment has been considered for phasing depending on the logistical concerns and the extend of the degradation seen in these areas.

❖ DELINEATION OF SUB WATERSHEDS

For giving practical shape to the systematic, scientific and rational approach of watersheds as units of planning and development, a framework of watersheds is a pre-requisite. It is thus essential to have not only a hierarchical system of delineating bigger hydrological units into watersheds but a codification system also needs to be developed so that each watershed could be identified as an individual entity without losing linkage with the bigger units i.e., catchment, sub-catchment, etc., to which it belongs.

Soil and Land Use Survey of India (SLUSI) has Watershed Atlas of India under digital environment using GIS and produced a Digital Watershed Atlas (DWA) where the delineation and codification of watersheds in the country has been undertaken in GIS environment. The delineation for DWS has been done in seven stages starting with Water Resource Regions and their subsequent division and subdivisions into Basins, Catchments, Sub-catchments, Watershed, Sub watershed and Micro-watersheds in decreasing size of the delineated hydrologic unit.

In the present project the main catchment is sub divided in 7 watersheds. But, as discussed earlier also that the major part of the catchment is inaccessible and comprises of virgin forest, therefore the proposal is limited to the lower to sub-catchments where the 5 villages are there.

❖ LAND USE AND LAND COVER STUDIES OF DELINEATED CATCHMENT AREA

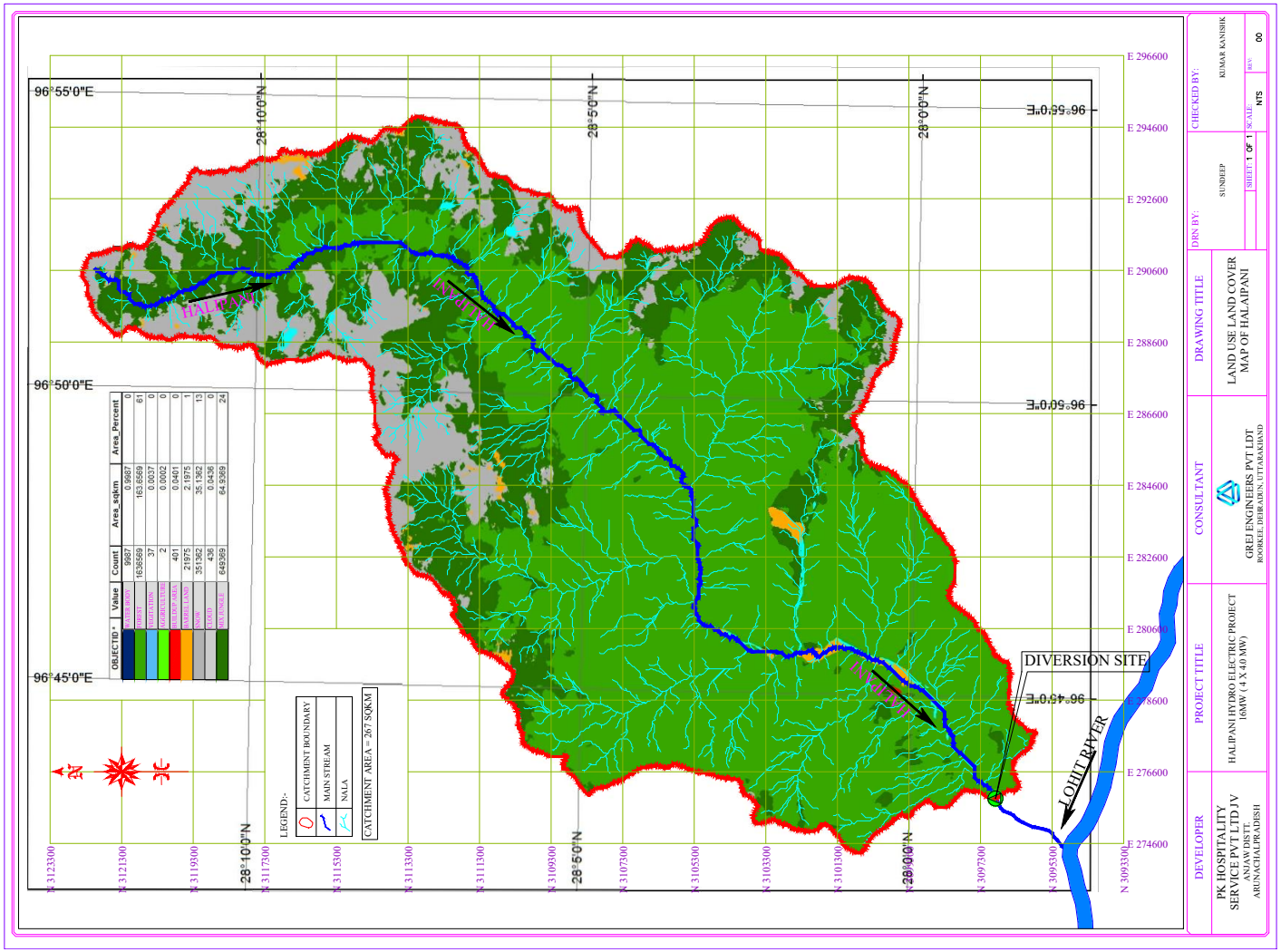
Land Use Land Cover map derived from Esri Land Cover Sentinel-2 10-Meter.

Existing artificial intelligence (AI) land classification models were enhanced by bringing together a massive training dataset of billions of human-labelled image pixels. These models were applied to the entire Sentinel-2 scene collection for each year from 2017 to 2021 – that's over 2,000,000 Earth observations from 6 spectral bands to produce the maps.

The output provides a 9-class map of the surface, including vegetation types, bare surface, water, cropland and built areas.

Among the prominent classes observed was Snow Cover, Dense Forest and Mix – Jungle together accounting for 98.77% of the entire catchment. Other classes include Built up area covering 0.02 % while the River / Water body covering about 0.37 % of the area. The details are provided in the table as well as a processed satellite image through Arc GIS software.

The image of catchment showing Land Use and Land cover (LULC) classification



Land Use and Land Cover (LULC) classes of the Catchment area			
S. No.	**LULC Class**	**Area (Sq.km)**	**%**
1	Snow Cover	35.1362	13.16%
2	Sparse Vegetation/ Vegetation	0.0037	0.00%
3	Dense Vegetation/ Forest	163.6569	61.29%
4	Agriculture/ Open Vegetation	0.0002	0.00%
5	Mix-Jungle	64.9369	24.32%
6	Barren Land	2.1975	0.82%
7	Cloud	0.0436	0.02%
8	River / water body	0.9987	0.37%
9	Built Up Area/Village	0.0401	0.02%
	Total area	**267.00**	**100.0%**

From the above map and table is can be easily seen that the catchment area of the Halaipani HEP is well covered by the forest cover. The top reaches within the catchment area are all covered with snow. The catchment is a snow fed and thus do not require treatment work in the higher and in the virgin forest area. Therefore, the treatment measures are proposed in the lower and required area of the catchment.

Note:

In high hills, variability of site parameters such as topography, soils, land use, climate and rainfall matters. Not all areas contribute equally to the erosion problem. Therefore, to address this issue, latest and accurate data will be taken for the analysis i.e., the satellite data. This along with the ground information was been taken into account for obtaining terrain characteristics. Geographic Information System (GIS) will be used as a tool to obtain characteristics on catchment areas in terms of location of barrage, areas of the submergence, and detailed land use categories.

A Digital Terrain Model (DTM) of the area will be prepared, and will be used to derive a slope map. The slope will be further divided in various slope percentages.

Methodology/ matrix for calculation of Composite Erosion Intensity Unit

Erosion	Slope Landcover	Land use/ depth	Soil DR Unit	Weightage/	Intensity
Very Severe	Very very steep >50%	Open forest, scrub forest	Shallow	20/0.95	
Severe	Steep to very steep 25 -50%	Open forest, scrub, cultivation	Moderately shallow	18/0.90	
Moderate to slight	Strongly sloping to moderately steep 10-25%	Dense forest, open forest, cultivation	Moderately deep	13-15/0.90	
Slight to Negligible	Gently sloping to moderately sloping 5-10%	Dense forest, open forest	Deep	11/0.85	

❖ SLOPE MAPS

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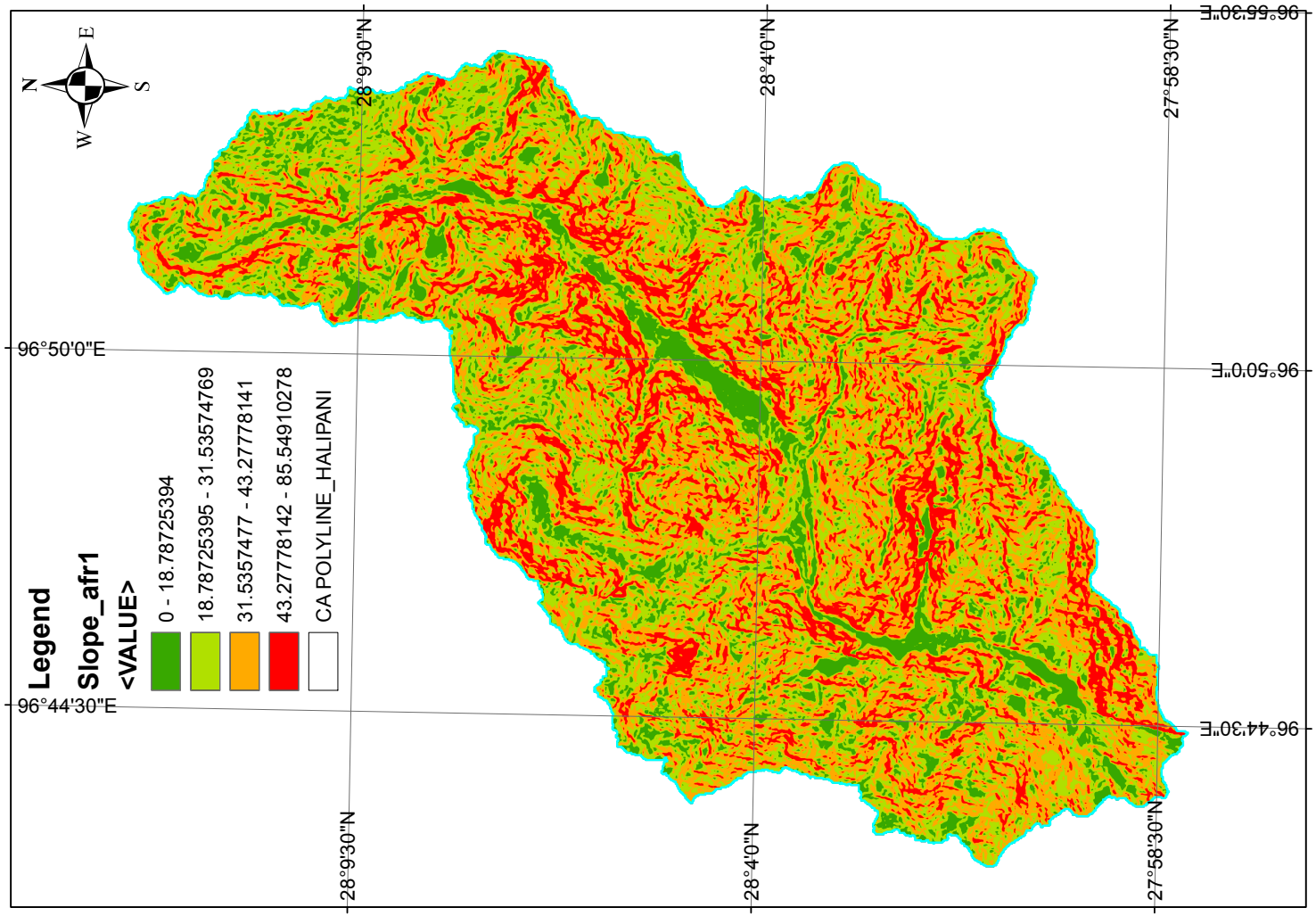
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W
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27°58'30"N
96°55'30"E
96°50'0"E
96°44'30"E
Legend
Slope_afr1
<VALUE>
0 - 18.78725394
18.78725395 - 31.53574769
31.5357477 - 43.27778141
43.27778142 - 85.54910278
CA POLYLINE_HALIPANI

Slope map is prepared using the DEM raster downloaded from ISRO Bhuwan site, raster Catosat-3R 30-Meter. The map describes the slope in percentage for the whole catchment. 0 – 18.787 degree slope is mainly in the river while the hill are sloped from mild to steep slope as shown in the map. It could be concluded that the catchment of the Halai river is a high sloped catchment with varying value.

❖ ESTIMATION OF SOIL LOSS

Soil loss can be estimated using Silt Yield Index (SYI) method. The application of SYI method for prioritisation of sub water sheds in catchment area involves the evaluation of:

1. Geomorphic factors comprising slope and drainage characteristics; landforms and physiography.
2. Surface covers factors governing the flow hydraulics.
3. Climatic factors comprising total precipitation, its frequency and intensity
4. Management factors.

a. Silt Yield Index:

$$SYI = \frac{(Ai \times Wi) \times 100}{Aw}$$

For catchment area development, three types of interventions are proposed in the project area. These are as follows:

A) Drainage line treatment for soil Conservation.
B) Soil Conservation Activity for Area Treatment
C) Plantation and Afforestation – for increasing the soil cover

All works are to be completed in three phases for biological works and in two phases for engineering works covering total 10 years of the catchment plan. The physical and financial targets to be met in each of the two phases have been detailed in the estimate year wise. It takes into account existing watershed activities in the catchment.

❖ WATERSHEDS / DRAINAGE MAPS

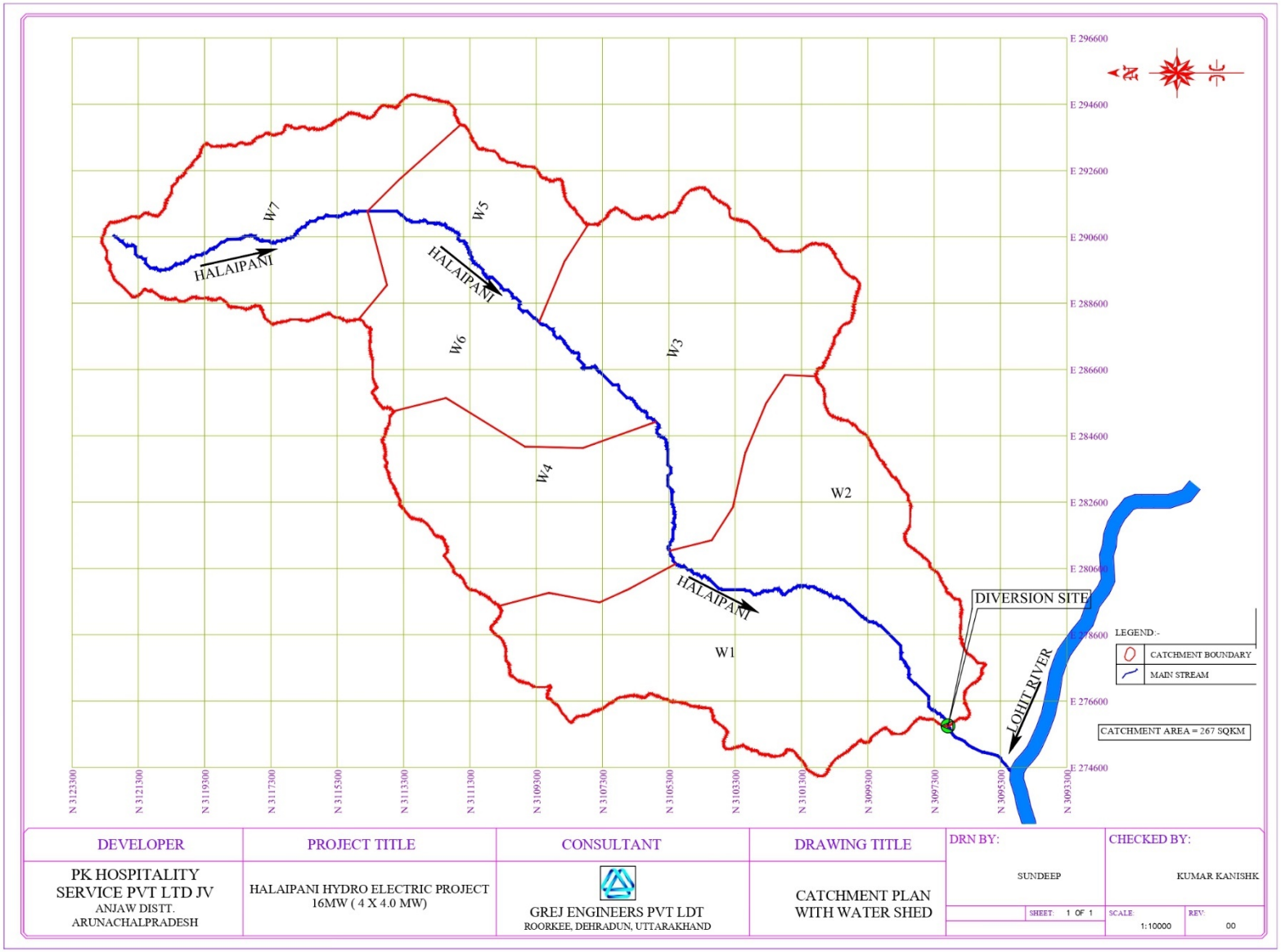
All of the rivulets of Halai River watershed are mostly snow fed. During its initial course it flows from north to south, then western direction before joining the Lohit River. The erosivity of the streams are very less in the initial reaches as the streams are fed through melting of ice. Further, through the satellite images of the catchment area only the lower area is prone to the erosion and degradation, which are considered for the treatment work. The virgin forest and the inaccessible area are not considered for the treatment measures considering the logistics and also, not disturbing the natural and unaffected areas.

Halai river catchment for Halaipani HEP has been divided into 7 major watersheds. The image showing 7 watersheds viz. W1, W2, W3, W4, W5, W6 & W7 are delineated on the map.
The details can be visualized from the digitized satellite map of drainages.
The sub-catchments W1 & W2 are taken for the treatment works. The presence of the people is seen within this part of the catchment area only. There are 5 villages namely

S. No.	Name of Village	Population	Households
i.	Hamatong	55	12
ii.	Pitong	37	8
iii.	Khetong	23	4
iv.	Siet	21	5
v.	Mangung	92	14

Total Population of all the villages = 228

* Source – District Census Handbook Anjaw (Census of India 2011)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N 3103300
N 3101300
N 3099300
N 3097300
N 3095300
N 3093300
W7
W5
W6
W3
W4
W2
W1
HALAIPANI
HALAIPANI
HALAIPANI
DIVERSION SITE
LOHIT RIVER
LEGEND:-
CATCHMENT BOUNDARY
MAIN STREAM
CATCHMENT AREA = 267 SQKM
DEVELOPER
PK HOSPITALITY SERVICE PVT LTD JV
ANJAW DISTT.
ARUNACHALPRADESH
PROJECT TITLE
HALAIPANI HYDRO ELECTRIC PROJECT
16MW (4 X 4.0 MW)
CONSULTANT
GREJ ENGINEERS PVT LDT
ROORKEE, DEHRADUN, UTTARAKHAND
DRAWING TITLE
CATCHMENT PLAN WITH WATER SHED
DRN BY:
SUNDEEP
CHECKED BY:
KUMAR KANISHK
SHEET: 1 OF 1
SCALE: 1:10000
REV: 00

Details of the Halaipani River Watershed Area				
NAME	Area in sq km	Area in sq m	area in Ha	Percentages
W-1	48.08	48080000	4808	18.01
W-2	38.00	38000000	3800	14.23
W-3	51.99	51990000	5199	19.47
W-4	38.18	38180000	3818	14.30
W-5	17.04	17040000	1704	6.38
W-6	32.15	32150000	3215	12.04
W-7	41.53	41530000	4153	15.56
TOTAL	**266.97**		**26697**	**100.00**

As the detailed provided above of the 7 sub-water sheds identified with the details of the land and its percentage in comparison to total area of the catchment. Sub-shed W - 3 has the highest land cover and W - 5 has the least.

Large degraded patches of land are seen along the villages with in the catchment area of the Halaipani HEP. The slope in these locations is steep to mild at some places. The local people cut the jungles and do jhum farming in these areas. Therefore, it is proposed to cover these degraded patches for afforestation with the consultation of the local people. The bamboo plantation is proposed in an area of 4 hectare for villagers as the bamboo is very useful for the local people in day-to-day life and will reduce the dependency of the local on the forest products.

TREATMENT OF CATCHMENT AREA

Only Sub-Catchment W – 1 & W – 2 requires treatment work. While the other sub-delineated catchments do not show any degraded land and are under good forest cover. Further, reaching out to the higher elevation is not possible. Therefore, the treatment work is being limited to the sub-catchment 1 & 2. The 5 villages in the catchment of the Halaipani HEP are in these sub-catchments only.

Around 98.77% of the total catchment area is under Snow (13.16%), Forest (61.29%) and Mix – Jungle (24.32%), thus only limited part of the catchment requires treatment work

❖ SITE PHOTOGRPHS

Regarding the total catchment area of the Halaipani HEP, it was noticed that 80% of the catchment area is inaccessible. Also, there are five village Hamatong, Pitong, Khetong, Siet and Mangung in the catchment area of the project, therefore only limited area of the catchment is being used by the local peoples. Further about 95 to 97% of the catchment area of the project is covered by dense forest and snow.

Following are the photographs showing the vegetative cover in the catchment area of the project.

Figure 5 – Showing the Vegetative Cover in the Catchment area

Figure 6 – Another photograph Showing Forest

Figure 7 – View of Hill Slope along Power Channel

Figure 8 – Another view of Forest in Catchment Area

The above photographs and the satellite images show that the area of the catchment is under good forest cover and therefore, it is recommended that the restoration work to be done at the area near to the village and at the specific sites where the treatment work is required to check the soil erosion.

CHAPTER – 4

CATCHMENT AREA TREATMENT PLAN

❖ ACTIVITIES TO BE UNDERTAKEN (TREATMENT MEASURES)

Details of treatment measures viz. engineering measures as well as biological measures to be undertaken are described in the following paragraphs. Watershed-wise details of various activities to be undertaken are provided in Table below

ENGINEERING MEASURES

Gully Control: The gully would be treated with the help of engineering/mechanical as well as vegetative methods. Check dams would be constructed in some of the areas to promote growth of vegetation that will consequently lead to the stabilisation of the slopes/area and prevention of further deepening of gully and erosion. For controlling the gully, the erosive velocities are reduced by flattening out the steep gradient of the gully. This is achieved by constructing a series of check dams which transform the longitudinal gradient into a series of steps with low risers and long flat treads. Different types of check dams would be required for different conditions comprising different materials depending upon the site conditions and the easy availability of material at local level.

The following types are recommended for this area:

1) Brushwood check dam
2) DRSM (Dry Rubble Stone Masonry) - Check dams with stones available at the site

In addition to the vegetative measures used for stabilisation of gullys, temporary or permanent mechanical measures will be used as supplementary measures to prevent the washing away of young plantations by large volume of runoff. The gullys get stabilised over a period of time with the establishment and growth of vegetation cover. With the passage of time mechanical structures weaken and vegetative measures get strengthened.

For engineering measures following types of check dams are suggested.

A. BRUSHWOOD CHECKDAMS

The main advantage of brushwood check dams is that they are quick and easy to construct and are inexpensive as they are constructed by using readily available materials at the site. In brushwood check dams, small branches preferably of coppice able species are fixed in two parallel rows across the gully or nala and packed with brushwood between the rows of these vertical stakes. The vertical stakes are tied down with wires or fastened with sticks across the top. The important consideration in erecting brushwood check dams is to pack the brushwood as tightly as possible and to secure it firmly. This type of check dam is generally constructed over small gullys or at the starting stretch of gullys. In all, 7 brushwood check dams/ vegetative spurs would be constructed to check gully erosion, stream bank protection and slope stabilisation works with an estimated budget of Rs. 0.525 lakhs.

A View of Bushwood Check Dam

B. DRY RUBBLE STONE MASONRY (DRSM) CHECKDAMS

The site where DRSM check dams are to be constructed is cleared and the sides are sloped 1:1. The bed of gully is excavated for foundation to a uniform depth of 0.45 m to 0.60 m and dry stones are packed from that level. Over the foundation, DRSM super structure of check dam is constructed. The stones are dressed and properly set in with wedges and chips. The width of

check dam at the base should be approximately equal to maximum height and successive courses are narrower so the section is roughly a trapezium. It is common to find upstream face of check dams vertical with all slopes on the downstream face but while there is sound engineering reason for this in case of large check dams but it is not of any consequence in small gully control dams. In the centre of the dam portion sufficient waterway is allowed to discharge the maximum run off. The dry stone work should go up to 0.30 m to 0.60 m in the stable portion of the gully side to prevent end-cutting. Sufficient apron is provided to prevent scouring of the structure. The thickness of the apron packing would be about 0.45 m and gully sides above the apron have to be protected with packing to a height of at least 0.30 m above the anticipated maximum water level to prevent side scour being formed by the falling water. The maximum length of the check dam across the stream is estimated as 10 m. For gully control measures, 12 DRSM check dams would be constructed with an estimated budget of Rs. 19.80 lakhs.

A View of Dry Rubble Stone Masonry Check Dam

BIOLOGICAL MEASURES/PREVENTIVE MEASURES

The Biological Measures/Preventive Measures suggested are:

A. Afforestation

B. Assisted Natural Regeneration (ANR)

C. Non-Timber Forest Produce (NTFP) Regeneration

t is always better to undertake preventive measures than to mitigate the factors that ultimately lead to soil erosion. Such preventive measures will indirectly help to conserve soil in the long run, keeping in view the importance of integrating Eco restoration strategy with socio-economic needs of the local community wherein both ecology and economics are developed. The preventive measures that are suggested for the project area have been discussed below.

A. Afforestation

In the upland region like this project area, the trees and vegetation cover play an important role in the conservation of soil and ecology. Afforestation programme would be taken up in such forest areas that contain large patches of barren grassy slopes and are generally devoid of trees and are honey-combed by cultivation. In critically degraded areas, plantation of locally useful, diverse and indigenous plant species such as Alnusnepalensis, Albizia Oodaratissima, Castanea Sativa, Cinnamomumpauciflorum, Quercus glauca, SchimawallichI, etc. would be undertaken. Afforestation measures would be taken up under catchment area treatment plan.

The tree species that would be planted under this programme are: Alangium chinense, Castaneasativ, Erythrina arborescus, Phykkanthusemblica, Pinus roxburghI, etc. The important shrubs are B*ambusa pallida, Coriarianepalensis and Zanthoxylumacanthopodium. The root species Agaresisalana, Chrysopogongryllus, Cybopogonflexuosus, Pennisetum, purpureum, Themedaarundinuca,* etc.

B. Assisted Natural Regeneration in Existing Forest

In some of the forest areas, conditions are conducive to natural regeneration provided some sort of assistance is provided. Such areas shall be taken up under this component. The areas shall be closed to exclude biotic interference. Forest floor will be cleared of slash; debris and felling refuse to afford a clean seedbed to the falling seed. At certain places some soil raking may also have to be done to facilitate germination of seeds. Where natural regeneration is found deficient, it will be supplemented by artificial planting. Patch sowing in suitable areas may also be done. Bush cutting & cleaning operations are done depending on necessity. Up to 300 plant or patches per hectare will be planted /sown to hasten the process of regeneration in the area uniformly.

C. Non-Timber Forest Produce (NTFP) Regeneration

Arunachal Pradesh Forest Division is rich in a variety of non-timber forest produce. However, because of over-exploitation of NTFP in the past there has been depletion of this valuable resource. Therefore, in order to augment natural stock of NTFP in the forests, it is proposed to take up planting of NTFP and establishing nursery. It is proposed to establish bamboo in 4 hectare of land which will benefit the villagers lifelong.

A total outlay of Rs. 37.212 lakhs have been suggested to cover about 30 ha for establishing including its maintenance.

It includes 18 hectares of land for afforestation, 8 hectares for ANS and 4 hectares for NTFP.

❖ COST OF OTHER COMPONENTS OF CAT PLAN

Apart from the Forestry works and the drainage line treatment in the catchment area there are other aspects of the CAT plan to be addressed and their cost to be included in the overall plan. The eco-restoration works, livelihood support works, social mobilization, documentation and publication, monitoring and evaluation are some of the integral ingredients which have to be considered and included while formulating the CAT plans as per suggestions made from time to time by the MOEF.

❖ SOCIAL MEASURES

There is urgent need to reduce the dependency of local population on the forest and other natural resources which are under severe pressure. The eco-restoration works and other activities related to income generation are suggested and should be carried out through Community Welfare Committees of local villages. These should include the following measures, which would help in rejuvenating the ecosystems and in reducing the soil erosion in the region.

- ✓ Distribution of solar cooker/ installation of solar lights
- ✓ Water conservation and harvesting in the villages
- ✓ Fencing of agricultural fields to kept cattle away
- ✓ Improvement in agricultural and horticultural practices
- ✓ Rural technology support programmes
- ✓ Awareness programmes for conservation of wildlife and natural resources “VAN MAHOTSAV”

- ✓ Promotion of income generating schemes like ecotourism

A sum of 18.02 lacs is considered for this head. There are only three villages in the catchment area of the Halaipani HEP. This amount shall be used for construction of water tank, distribution of solar cookers, fencing of the agricultural field to kept the cattle away from grazing and other requirement of the local as decided by the committee of the local villagers. Proper monitoring and evaluation will be done by the developer/ forest department of the proposed work.

❖ ESTABLISHMENT WORKS RELATED TO AREA DEVELOPMENT

There is urgent need to reduce the dependency of local population on the forest and other natural resources which are under severe pressure. The establishment works related to area development is suggested and should be carried out through Community Welfare Committees (CWC) of local villages in catchment area of Halaipani HEP. This should include the following measures, which would help in rejuvenating the ecosystems and in reducing the soil erosion in the region.

1. Establishment of a committee for plantation
2. Avenue plantation using fuel wood trees with suitable fencing in the villages
3. Technical and financial support for using alternate energy sources such as non-conventional energy (solar heating) to reduce pressure on the forest (tree cutting) for fuel wood
4. Maintenance of hygiene in the villages
5. Establishment of Training, Awareness programmes, etc. for water conservation and harvesting in the villages, Soil conservation measures in village areas, Improvement in agricultural and horticultural practices, etc.
6. Establishing a rural technology support programme
7. Awareness programmes for conservation of wildlife and natural resources

❖ ADMINISTRATIVE SET UP

The catchment area treatment (CAT) project involves intensive and highly technical operations, which require the expertise of technical personnel. It is, therefore, recommended that the existing forest staff of Arunachal Pradesh Forest Division in the area will look after all the works to be carried out under the CAT plan including plantation and maintenance as all the areas to be covered under CAT plan fall under forest divisions.

❖ FOREST INFRASTRUCTURE DEVELOPMENT

The works of the catchment area treatment plan will be executed by the Forest Department, Government of Arunachal Pradesh. These works will be an added responsibility for the Forest Department that may not have adequate facilities and infrastructure to execute the work as suggested in the plan. Provision has, therefore, been made in the CAT plan to develop the infrastructure of Forest Department in the region and accordingly a budget of Rs. 15 lakh is proposed for this purpose.

Budget for Development of State Forest Department Infrastructure

Amount in Lacs

Components	Establishment	Amount (In Lacs)
Nursery Area and Quarter near project site	15.00	15.00
Total		15.00

❖ MICRO-PLANNING

An estimated cost of Rs. 2.12 lakhs have been proposed for micro-planning. This will be done in accordance with the forest department.

❖ MONITORING AND EVALUATION

Monitoring and evaluation will be developed as in-built part of the project management. Thus, a process of self-evaluation at specified intervals of time will ensure the field worthiness and efficacy of the CAT plan.

Annual work plan for each sub-watershed would be prepared well in advance specifying physical and financial targets, sites, locations and beneficiaries of each component of the project activity. Month-wise work scheme of various items of each component for the financial year would also be prepared in advance and its timely implementation would be ensured. Monthly progress report on all activities would be submitted by the Range Officers to Divisional Forest Officer for its subsequent submission to the project authorities and Ministry of Environment & Forests, Government of India. The monitoring committee appointed for this purpose would also monitor on a regular basis the quality and quantity of works carried out in the area.

A sum of Rs. 6.55 lakhs have been provided for monitoring and evaluation for 5-year period.

❖ INSTITUTIONAL MECHANISM

1) Role of Project Proponent

The forest department would implement the Catchment Area Treatment plan. A joint inspection group would be formalized which would include officers from State Forest Department and Official from the Environment Cell of the project proponent. The management will have liaison with the forest officials as far as the financial disbursement would evolve employment opportunities. Thus, people's participation should be encouraged and would involve mobilization of manpower for such activities. Experts and professionals competent enough in operating the plan need to be consulted from time to time.

2) CAT Implementation

Environmental Officer or Manager (Environment) of project proponent would coordinate with the forest department for the implementation of the proposed Plan. The Environment Officer would evaluate/monitor financial aspects at Site Office. The modalities of financial disbursement every quarter in a year need to be taken care of. The implementing agency shall submit completion certificate in the light of guidelines fixed by CAMPA. The implementation of CAT Plan should have enough flexibility and should be subject to changes as per requirements and periodic gains. A monitoring committee as per the MOEF guidelines should be instituted for the project for administrative guidance and smooth realization of targets.

3) Period and schedule of implementation

The execution of CAT plan for Halaipani H.E. Project area would require extensive efforts on the part of executing agencies. Keeping in view the local topography and climate, it is being estimated that the entire treatable area would require at least 10 years for creation and for maintenance/ monitoring completing. However, CAT plan has been prepared for 10 years. All these works would have to start with the preconstruction activities especially the studies in respect of micro-planning for each sub-watershed, which would require further detailed investigations. The table gives the year-wise physical details of various engineering and biological treatment measures to be undertaken.

Physical and Financial Layout plan of Catchment Area Treatment For HALAIPANI HEP

Annual Work Programme For implementation of Catchment Area Treatment Plan for construction of 16 MW Halaipani HEP

Name of the Project: 16 MW Halaipani

Location: -Halaipani Under Anjaw District

Financial Rs. In lakh

S. No.	Component	Physical Unit	I Year		II Year		III Year		IV Year		V Year		VI Year		VII Year		VIII Year		IX Year		X Year		Total	
			Phy	Fin	Phy	Fin	Phy	Fin	Phy	Fin	Phy	Fin	Phy	Fin	Phy	Fin	Phy	Fin	Phy	Fin	Phy	Fin	Phy	Fin
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
A	**Biological Measure**																							
1	Afforestation																							
1.1	Advance Works	Ha	18	4.03																			18	4.027
1.2	Creation				18	8.17																	18	8.174
1.3	Maintenance						18	3.47	18	3.47	18	2.380	18	2.380	18	2.380	18	0.860	18	0.860	18	0.860	18	16.67
	Sub Total			**4.03**		**8.17**		**3.47**		**3.47**		**2.380**		**2.380**		**2.380**		**0.860**		**0.860**		**0.860**		**28.87**
2	Aided Natural Regeneration	Ha																						
2.1	Advance Works	Ha	8	0.574																			8	0.5736
2.2	Creation Works				8	0.941																	8	0.9408
2.3	Maintenance works = 4 weeding						8	0.715	8	0.715	8	0.516	8	0.516	8	0.206	8	0.206					8	2.87408
	Sub Total			0.574		0.941		0.715		0.715		0.516		0.516		0.206		0.206						**4.388**
3	Plantation of NTFP Species a) Bamboo plantation	Ha	4																					
3.1	Advance works		4	0.059																			4	0.0588
3.2	Creation Works				4	1.808																	4	1.808
3.3	Maintenance						4	0.662	4	0.662	4	0.382	4	0.382									4	2.087

	Sub Total			0.059		1.808		0.662		0.662		0.382		0.382									**3.954**
	TOTAL OF - A																						**37.212**
B	**Engineering Measure**																						
i	Brush wood check dams	7 Nos.	7 Nos.	0.525																			0.525
ii	DRSM	12 Nos.	12 Nos.	19.80																			19.8
iii	Contour Bunding	1200Rm	1200	9.00																			9
iv	Maintenance Works @ 5% for 2 years					1.466		1.466															2.933
	Sub total			29.325		1.466		1.466															32.258
	Sub Total of B																						**32.2575**
C	Social Measure																						
i	Public Benefits		1Time	15																		1Time	15
ii	Entry Point Activity		1	2.01																		1	2.01
iii	Awareness Programme		1Year	1.01	2 yrs	1.01																2Years	2.02
	Sub Total			18.02		1.01																	**19.03**
	Total of -C																						**19.03**
D	Administrative Setup																						
i	a) Cost of Woki Toki set	1 set	1st year	2.5																			2.5
	Total of -D																						**2.5**
E	Forest Infra Structure Development																						
i	Nursery Area & Quarter for Department	1 no.	1st Year	15																			15
	Total of -E																						**15**
F	Monitoring -	5	years																				
i	Site inspection		1st yr	2.01	2nd yr	1.51	3rd yr	1.01	4th yr	1.01	5th yr	1.01										5 Years	6.55

	Total of-F																						**6.55**
G	Contingency @ 5%	per year	1st yr	0.530	2nd yr	0.530	3rd yr	0.530	4th yr	0.530	5th yr	0.530	6th yr	0.530	7th yr	0.530	8th yr	0.530	9th yr	0.530	10th yr	0.530	10 Years	5.300
i	Micro planing-2%	1	1st yr	2.120																				2.120
	Total of -G																							**7.420**
	Grand Total																							**119.970**

Total Cost = One Crore Nineteen Lacs and Ninety Seven Thousand Only.

4) Project Monitoring and Reporting Procedures

Meetings would be held every Fourth months to resolve logistic problems in plan implementation. A Joint committee would be formed with the Environment Cell of project proponent and State Forest Department team members to ensure the implementation and monitoring of the CAT works and review the progress from time to time. Quarterly progress reports and completion certificates would be submitted to project proponent, for evaluation and disbursement of finance. In addition, the work done should be published through public awareness campaigns. Visual and print media need to be used to embark on maximum benefit by direct and indirect beneficiaries. Such efforts would resolve conflicts which otherwise are potential sources for project gestation. Implementation of CAT plan is considered/ designed for 10 years covering the implementation and monitoring of all the activities proposed for the treatment of the Catchment area of the Halaipani HEP.

❖ COST ESTIMATE OF CAT PLAN

The total estimated cost of catchment area treatment plan to be spent over a period of 10 years Rs. 116.44 lakhs (including actual work period and monitoring after execution of the proposed CAT plan).

Coordinates (UTM) of DRSM/ BUSH Check Dams

S. No.	Latitude	Longitude
BUSH Check Dam List		
1	27º 59' 28.61" N	96º 43' 46.91" E
2	27º 59' 28.95" N	96º 43' 48.32" E
3	27º 59' 28.29" N	96º 43' 55.06" E
4	27º 59' 52.23" N	96º 44' 45.84" E
5	28º 00' 21.50" N	96º 45' 10.66" E
6	28º 00' 06.47" N	96º 45' 41.09" E
7	28º 00' 03.57" N	96º 45' 47.89" E
DRSM Check Dam List		
1	27º 59' 12.26" N	96º 43' 39.23" E
2	27º 59' 13.82" N	96º 43' 52.88" E
3	27º 59' 47.35" N	96º 44' 42.36" E
4	28^0 00’ 12.83” N	96º 44' 35.09" E
5	28^0 00’ 19.24” N	96º 45' 19.90" E
6	28^0 00’ 37.77” N	96º 45' 14.58" E
7	27º 59' 45.54" N	96º 45' 18.62" E
8	28º 00' 11.45" N	96º 45' 35.32" E
9	28º 00' 31.85" N	96º 45' 45.81" E
10	28º 00' 27.96" N	96º 45' 58.48" E
11	28º 01' 41.32" N	96º 45' 48.80" E
12	28º 01' 45.66" N	96º 46' 28.40" E