CATCHMENT AREA TREATMENT PLAN

RESSING SHP

M/S GEKAM POWER PRIVATE LIMITED

Prepared By-
Grej Engineers

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CHAPTER -1

INTRODUCTION

GENERAL

Ressing is a Hydro – electric plant proposed on Pare River which is a tributary of subansiri River. Subansiri which meets Brahmaputra River in lakhimpur district of assam state. The project is a run-of-the-river scheme with an installed capacity of 12 MW located in the Papumpare 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.

Papum Pare district is an administrative district in the state of Arunachal Pradesh in India. As of 2011, it is the most populous district of Arunachal Pradesh (out of 20). The district headquarters are located at Yupia. Papum Pare district occupies an area of 2,875 square kilometres (1,110 sq mi).

Project Location from:	
Naharlagun (Nearest rail head)	100 Km
Dibrugarh (Nearest Airport)	270 Km

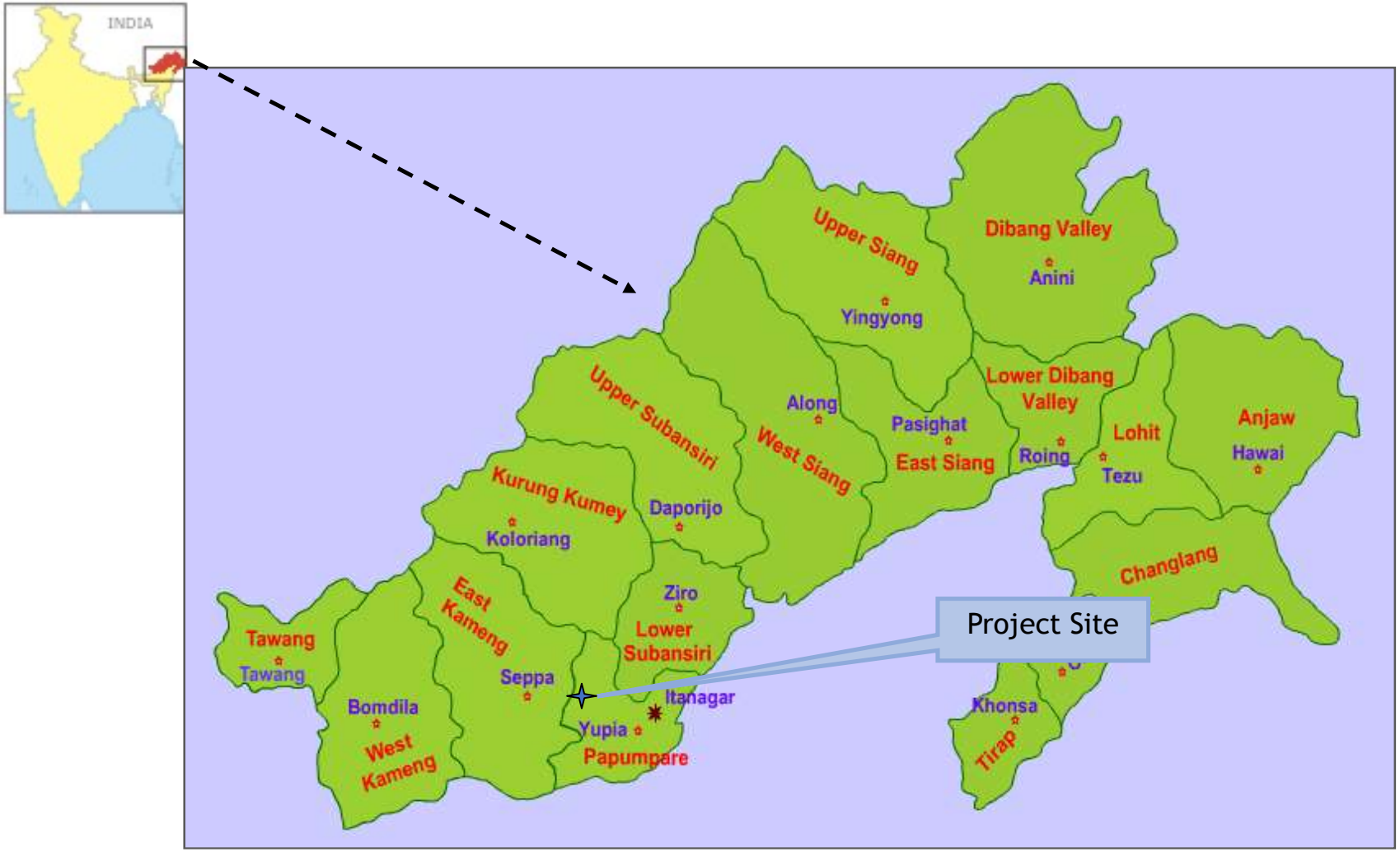


Fig 1 – Location Map of Ressing SHP

TOPOGRAPHY

The Project area is underlain by rock formations of Recent to Precambrian age. The Precambrian rocks comprise high grade gneisses and Schists of Sela Group, followed by quartzite, phyllite, conglomerate, Shales, Biotite gneiss, Calc and Graphite Schist of Bomdila Group and Miri quartzite, Shale and conglomerates belonging to Miri Formations of Lr Gondwana Group and Abor volcanics of Paleozoic epoch and Tertiary sedimentaries comprising Geku and Dalbuing formations of Sagalee Group. The Sela Group of rocks of Precambrian age consists of high-grade gneisses, lit-per-lit gneisses and schists. It occurs in the west and north-western part of the district. Bomdila Group of rocks representing low to medium grade metasediments comprising quartzites, mafic meta volcanics and carbonates, associated with ortho-gneisses, granites and mafic intrusive.

The overlying Miri formations (Gondwana) of lower Paleozoic age constitutes mainly quartzite with shale and phyllite association occur along a N-S trending patch inside the Bomdila Group of rock. The Miri formation is having tectonic contact with the underlying Bomdila Group of rocks. Paleozoic Abor volcanics representing basaltic flows with fossiliferous intertrappean shale and sandstone are rimming around the Tertiary Sagalee Group representing Shale, sandstone with welded tuff and mafic volcanics of Geku formation and Foraminiferal limestone and shale of Dalbuing formation.

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 borderup 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.

The Subansiri River is a tributary of the Brahmaputra River in the Indian states of Assam and Arunachal Pradesh, and the Tibet Autonomous Region of China. The Subansiri is 442 kilometres (275 mi) long, with a drainage basin 32,640 square kilometres (12,600 sq mi) large. The Subansiri is the largest tributary of the Brahmaputra. Its maximum observed discharge was 18,799 cubic metres per second (663,900 cu ft/s), and

its minimum 131 m3/s (4,600 cu ft/s). It contributes 7.92% of the Brahmaputra's total flow.[2]

The Subansiri River originates in the Himalayas, in China. It flows east and southeast into India, then south to the Assam Valley, where it joins the Brahmaputra River in Lakhimpur district. Pare is a tributary of Subansiri River. Main Tributaries of Pare River are Pang and Nimte Rivers.

❖ PROJECT CATCHMENT AREA

The catchment area of the proposed scheme lies between Longitude 93° 26' 35.40'' E to 93° 18' 40.51'' E and Latitude 27° 22' 25'' N to 27° 17' 5.6'' N. The coordinates of the Proposed Diversion structure i.e. Barrage is Longitude 93° 20' 19.30" E and Latitude 27° 16' 0.20" N. The catchment area up to the proposed barrage site is 118.63 sq km.

The total length of the Pare River up to diversion site is 23.605 km from its origin (i.e. within the catchment area for the project). The highest point in the catchment is at EL. 2800 m and the river bed elevation at the proposed diversion structure is about 1242.50 m.

Presently there is no existing hydroelectric project upstream of this Project on Pare River. Figure 2 below shows the map of the catchment area of the Pare River up to barrage site. The elevation difference in the catchment area of the project site is shown in Fig. 3 whereas in Fig. 4 the main course of Pare River is shown along with its major and minor tributaries.

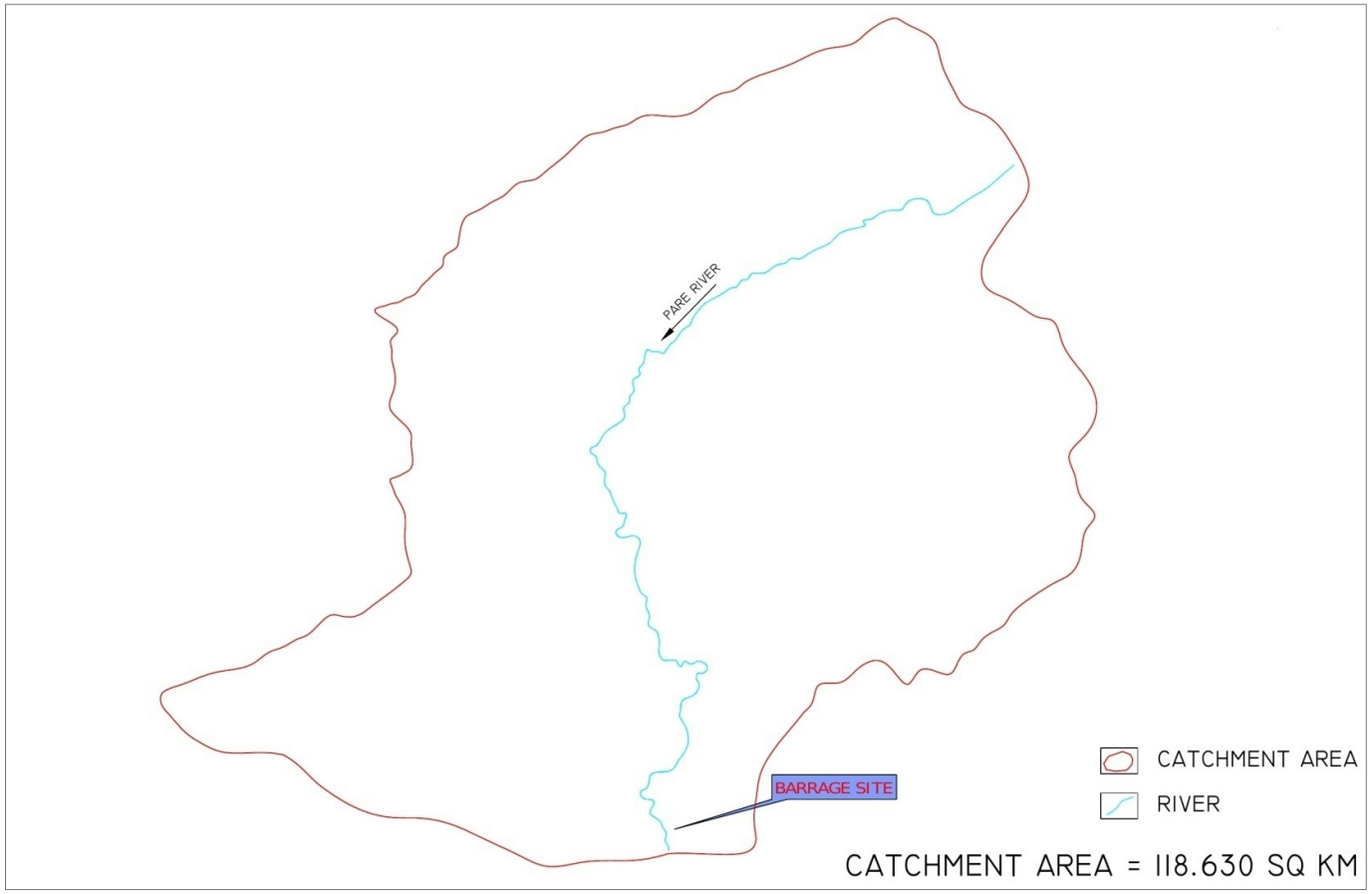


Fig 2 Catchment Area of RESSING HEP

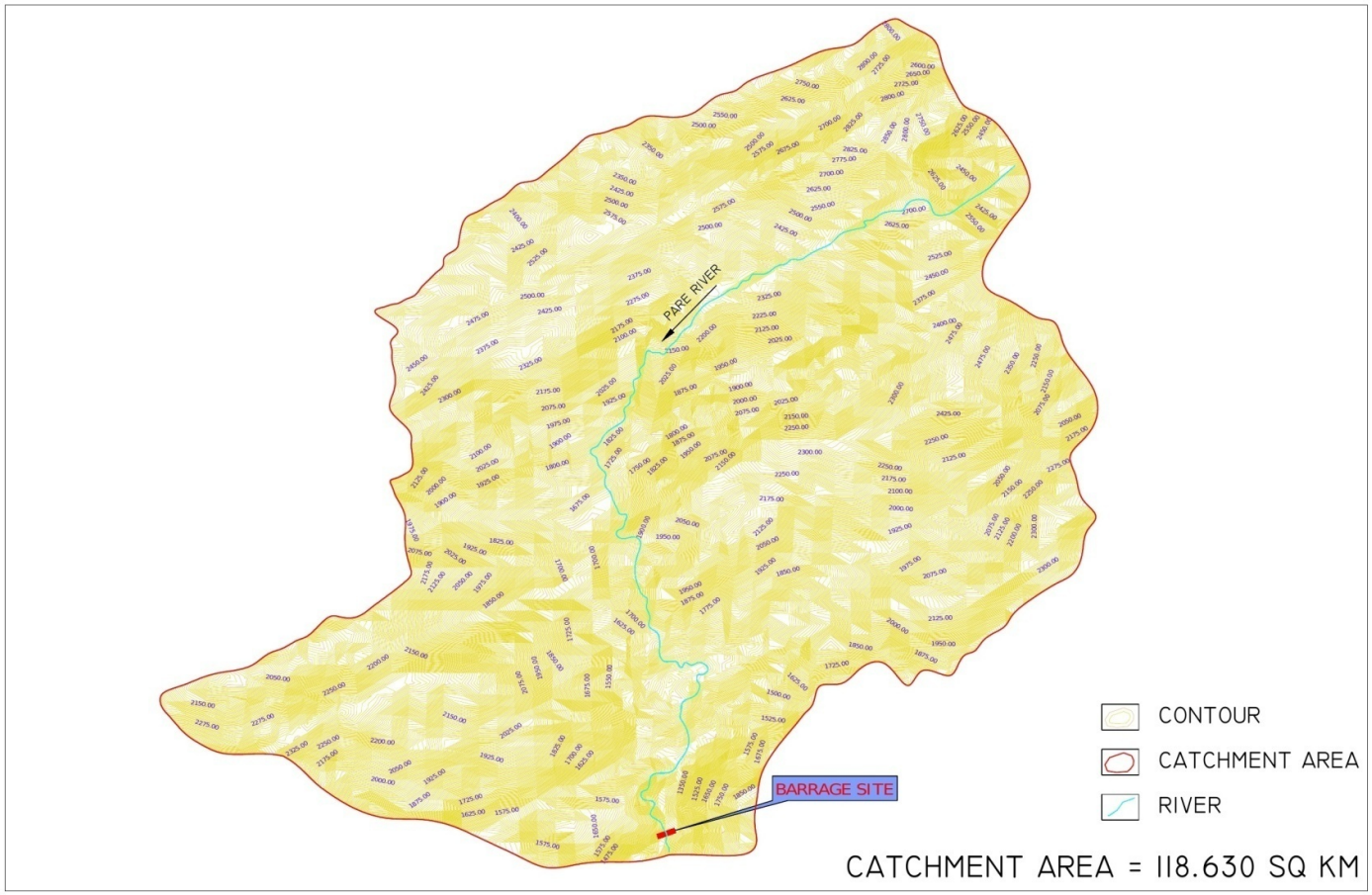


Fig 3 Catchment Plan With Contour

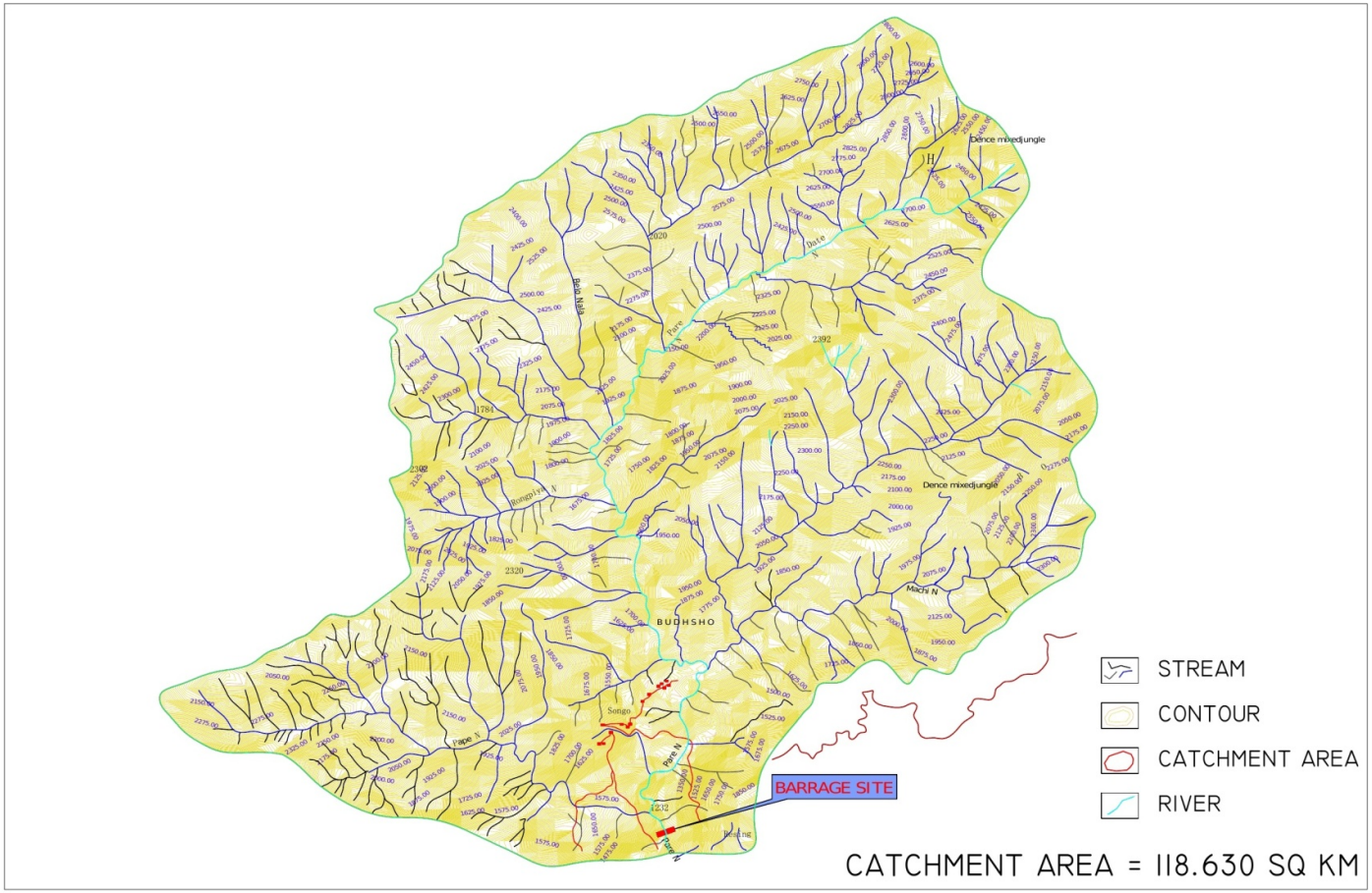


Fig 4 Showing Catchment Plan with all tributaries

❖ **WATER AVAILABILITY**

The available discharge series derived for the Ressing project is well described in chapter - 5 hydrology of DPR report. Following is the discharge series derived from the rainfall data and the actual observed discharge is provided below.

Table No - 2

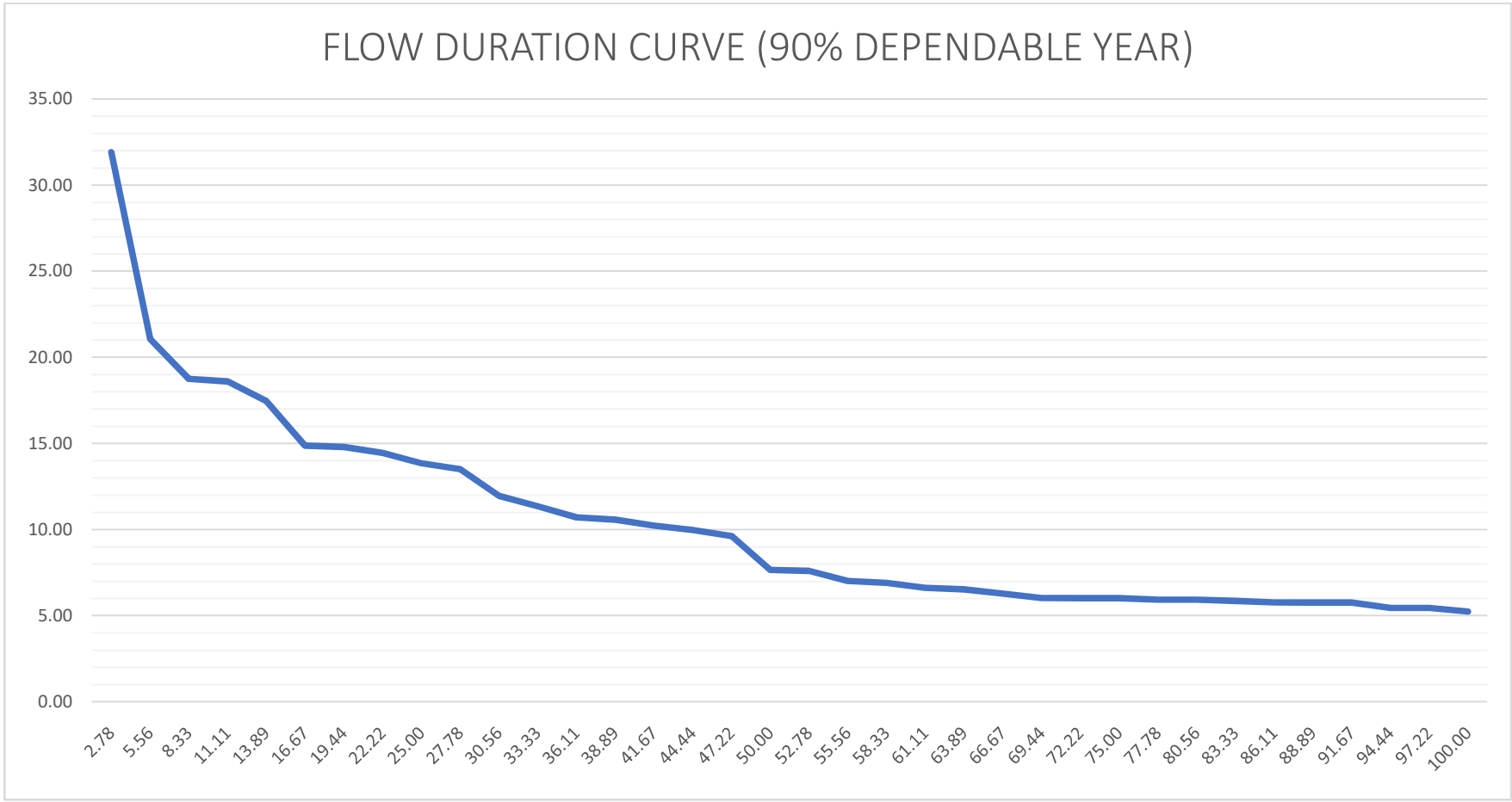
S.No.	Dependability	Annual Discharge in Descending Order (MCM)	Corresponding Year	Remark
1	10.00	481.35	2018-19	
2	20.00	429.41	2014-15	
3	30.00	423.66	2015-16	
4	40.00	405.29	2016-17	
5	50.00	379.01	2012-13	50% Dependable year
6	60.00	361.89	2017-18	
7	70.00	359.74	2010-11	
8	80.00	344.89	2013-14	75% Dependable Year
9	90.00	324.70	2011-12	90% Dependable Year

Table No – 3

90% Dependable Year Series

Rank	% of time Equalled or Exceeded	Ten Daily Discharge in Descending order
1	2.78	31.89
2	5.56	21.06
3	8.33	18.75
4	11.11	18.59
5	13.89	17.45
6	16.67	14.87
7	19.44	14.79
8	22.22	14.44
9	25.00	13.84

10	27.78	13.50
11	30.56	11.95
12	33.33	11.35
13	36.11	10.71
14	38.89	10.57
15	41.67	10.23
16	44.44	9.97
17	47.22	9.63
18	50.00	7.65
19	52.78	7.60
20	55.56	7.01
21	58.33	6.90
22	61.11	6.62
23	63.89	6.53
24	66.67	6.27
25	69.44	6.02
26	72.22	6.02
27	75.00	6.02
28	77.78	5.93
29	80.56	5.93
30	83.33	5.84
31	86.11	5.76
32	88.89	5.76
33	91.67	5.76
34	94.44	5.45
35	97.22	5.45
36	100.00	5.23


FLOW DURATION CURVE (90% DEPENDABLE YEAR)
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
2.78
5.56
8.33
11.11
13.89
16.67
19.44
22.22
25.00
27.78
30.56
33.33
36.11
38.89
41.67
44.44
47.22
50.00
52.78
55.56
58.33
61.11
63.89
66.67
69.44
72.22
75.00
77.78
80.56
83.33
86.11
88.89
91.67
94.44
97.22
100.00

CHAPTER – 3

STUDY & METHODOLOGY

❖ NEED FOR CATCHMENT AREA TREATMENT PLAN

As per the Environment Impact Assessment report of the Hydro-Electric project the Catchment Area Treatment Plan has been prepared.

The details are:-

It is well-establishment fact that reservoirs formed by Barrages/ Dams on rivers area 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 RESSING 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. RESSING 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.

The study of erosion and sediment yield from catchments is of utmost importance as the deposition of sediment in reservoir reduces its capacity, thus affecting the water availability for the designated use. The eroded sediment from catchments when deposited on streambeds and banks causes braiding of river beach. The removal of top fertile soil from catchments also adversely affects the agricultural/ plantation production.

Another important factor that adds to the sediment load, and which contributes to soil degradation is grazing pressure. There is only one village in the catchment of the project area i.e. SANGO. According to the 2011 census total population of the village is 249.

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.
    - Existing 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 are influential in determining the rate of sedimentation.

3. Based on our previous experience, it was determined that a period of four years is sufficient for implementation of treatment measures. This time is that required for project implementation, and not operations and maintenance. If thought necessary, a further period of two years may be considered for looking after plantations.

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. Each sub-catchment can be treated within eighteen months. Roughly equal distribution of areas leads to ease in management and deployment of resources.

5. *PRIORITIZATION OF CATCHMENT AREA TREATMENT*
    1. The catchment area is comprised of 6 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:

Vs = 1.067 X 10-6. 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 each sub-catchment, the full spectrum of area, and drain-line, soil conservation methods needs 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. 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 siltation rate of the sub-catchment has been considered for phasing of the program while logistical concerns are addressed for the sequencing of works within each phase.

❖ 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.

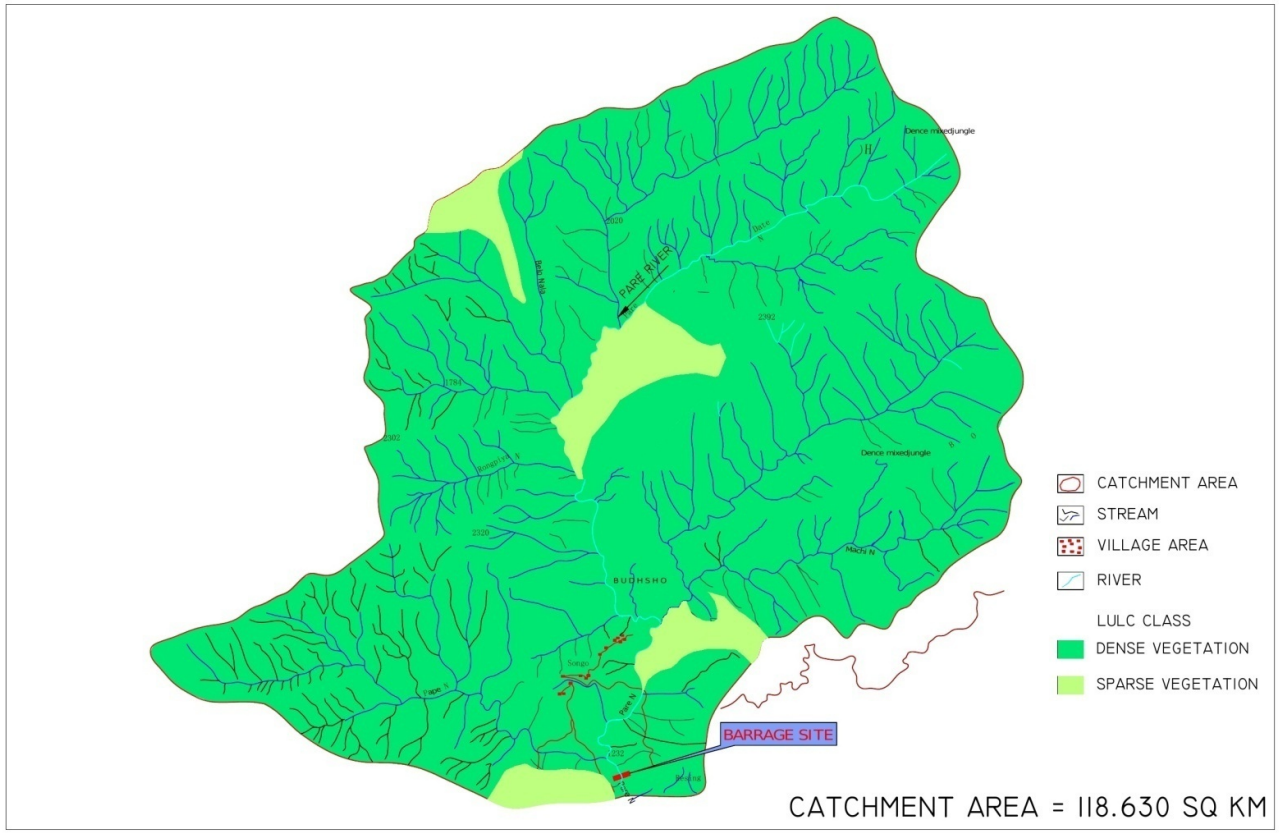
❖ LAND USE AND LAND COVER STUDIES OF DELINEATED CATCHMENT AREA

Land Use Land Cover derived from Google Image

From Google image, in total about five LULC classes were derived for 118.63 sq. km of the study area. Among the prominent classes observed was Spare and Dense Vegetation together accounting for 98.45% of the entire catchment. Other classes include Built up area covering 0.001 % while the River / Water body covering about 1.549 % of the area. The details are provided in the table as well as a processed satellite image.

Land Use and Land Cover (LULC) classes of the Catchment area			
S. No.	LULC Class	Area (Sq.mt)	%
1	Sparse Vegetation	29538870.0	24.90
2	Dense Vegetation	87252365.0	73.55
3	River / water body	1838765.0	1.549
4	Built Up Area/Village	1186.30	0.001
	Total area	118630000.00	100

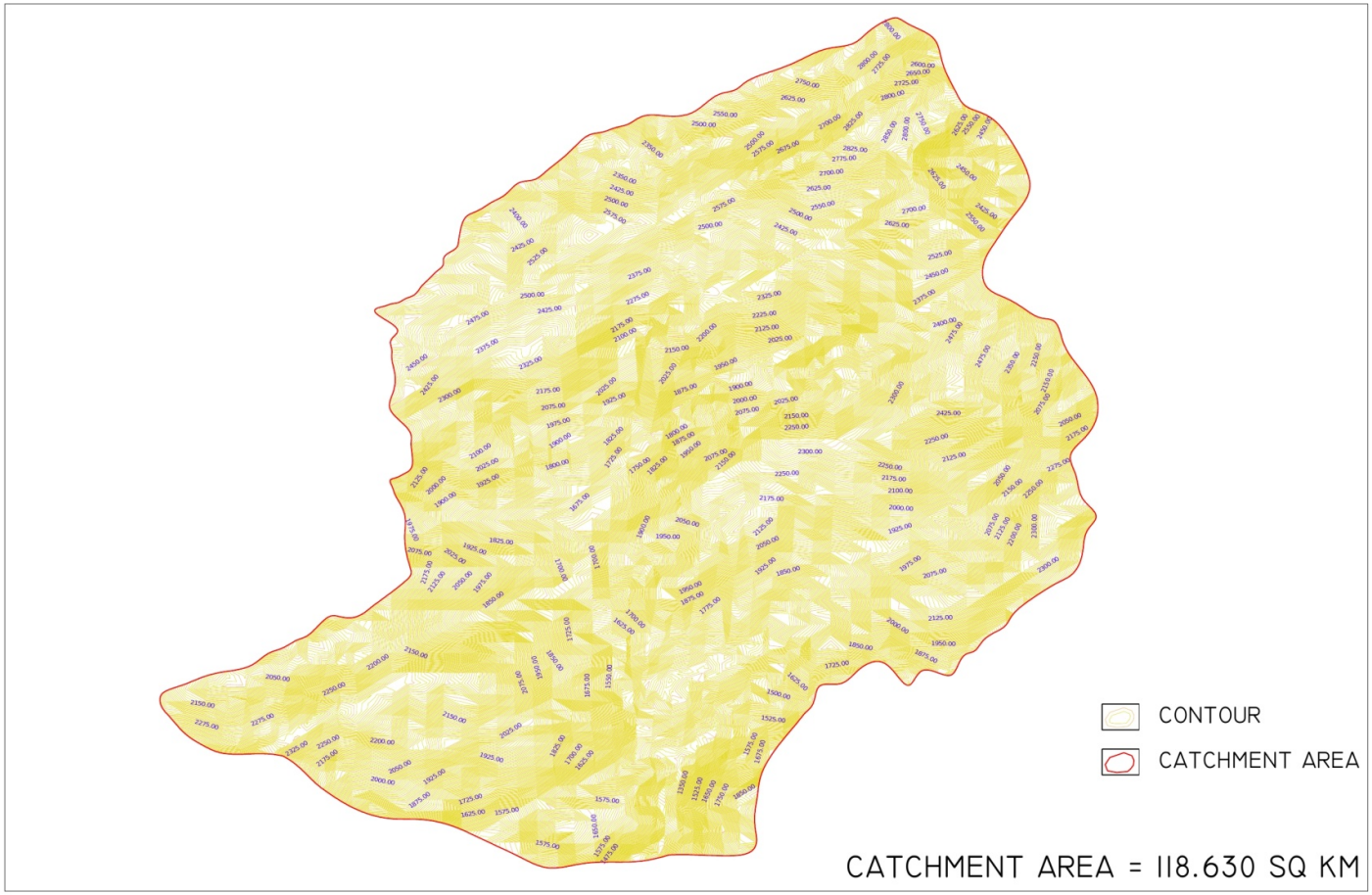
The image of catchment showing Land Use and Land cover (LULC) classification



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.

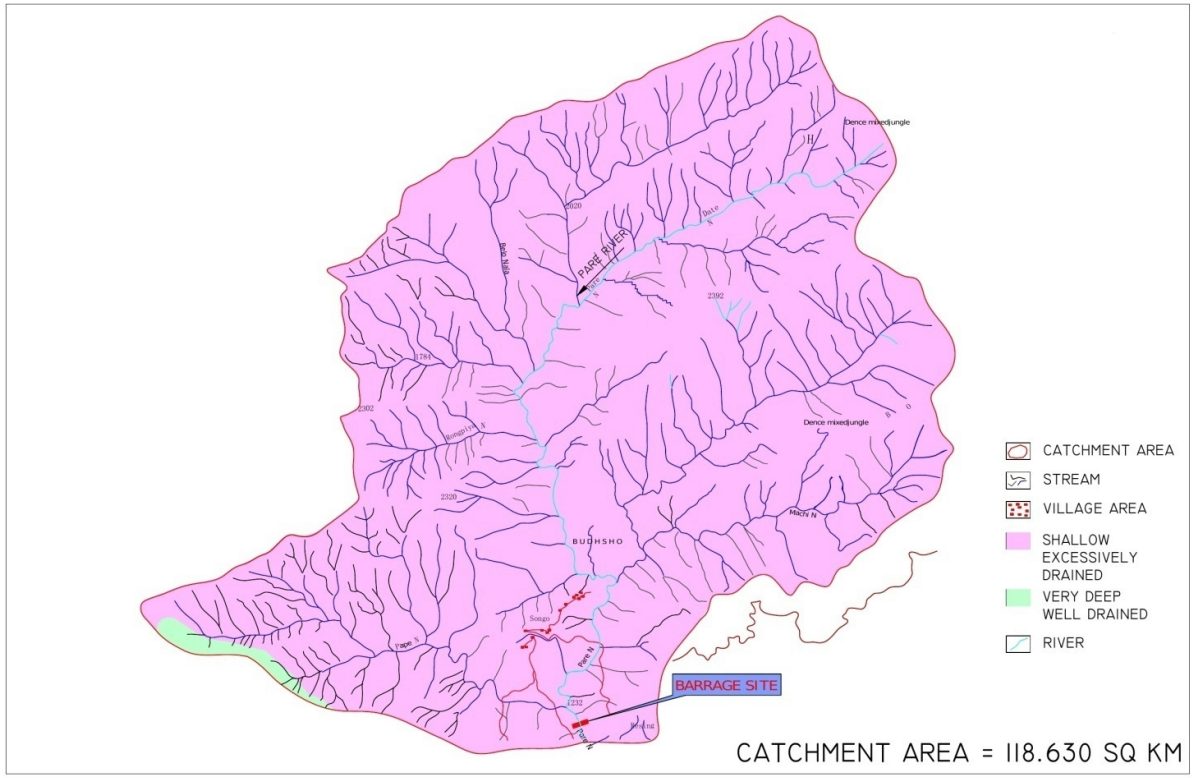

CONTOUR
CATCHMENT AREA
CATCHMENT AREA = 118.630 SQ KM

Methodology/ matrix for calculation of Composite Erosion Intensity Unit

Erosion	Slope Landcover	Landuse/ 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	

❖ **SOIL MAPS:**

Soil maps were digitized based upon Soils map of Arunachal Pradesh, prepared and published by National Bureau of Soil Survey & Land Use Planning (NBSS&LUP), Nagpur in co-operation with Department of Agriculture, Govt. of Arunachal Pradesh.



As per the data and map published by NBSS&LUP, the soil type and classification is as under:
Table Soil class, association type and percentage of the free area draining

Sr No	Soil Code	Description	Soil Taxonomy
1	3	Shallow, excessively drained, loamy-skeletal soils on steep sloping summits having loamy surface with severe erosion hazard and slight stoniness: associated with; Moderately deep, somewhat excessively drained, loamy-skeletal soils on moderately steep sloping side slopes and slight stoniness	1) Loamy-skeletal, Lithic Udorthents 2) Sandy-skeletal, Dystric Eutrochrepts
2	12	Very deep, well drained, fine soils on moderately steeply sloping side slope of hills having clayey surface with moderate erosion hazard: associated with; Deep, somewhat excessively drained, fine soils with erosion hazard	1) Fine, Typic Kandihumults 2) Fine Pachic Haplumbrepts

❖ **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.

The area of each of the mapping units is arrived at and Silt Yield Index of individual sub-water sheds will be computed using following equation:

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:

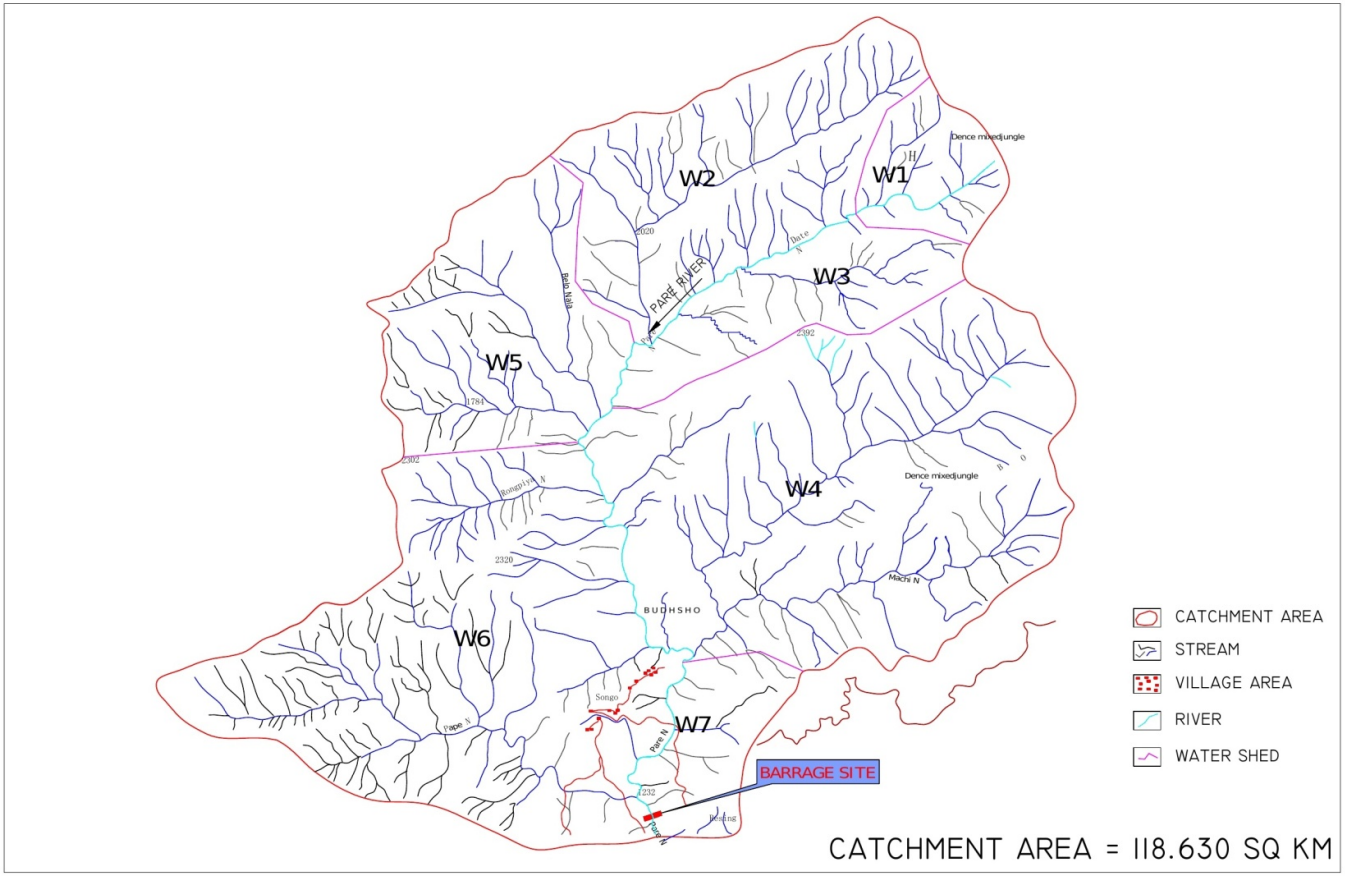
A) Drainage line treatment for soil Conservation.
B) Soil Conservation Activity for Area Treatment
C) Plantation and Afforestation – for increasing the soil cover

All works are to be completed in two phases of two years each. The physical and financial targets to be met in each of the two phases have been detailed in the estimate. It takes into account existing watershed activities in the catchment.

❖ **WATERSHEDS / DRAINAGE MAPS**

All of the rivers in Pare river watershed are rain fed. During its initial course it flows from north to west, then south west and finally towards south.

Pare river catchment for Ressing 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.


W1
W2
W3
W4
W5
W6
W7
Dence mixedjungle
PARE RIVER
BUDHSHO
Songo
BARRAGE SITE
CATCHMENT AREA
STREAM
VILLAGE AREA
RIVER
WATER SHED
CATCHMENT AREA = 118.630 SQ KM

Details of the Ressing River Watershed Area				
NAME	Area in sq km	Area in sq m	area in Ha	Percentages
W-1	4.568119999	4568119.999	456.812	3.850723
W-2	16.808021760	16808021.760	1680.802	14.168419
W-3	7.873918894	7873918.894	787.3919	6.637365
W-4	36.861341528	36861341.528	3686.134	31.072481
W-5	13.857051742	13857051.742	1385.705	11.680882
W-6	33.642960877	33642960.877	3364.296	28.359528
W-7	5.018771040	5018771.040	501.8771	4.230602
TOTAL	**118.63**		11863.0	**100**

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 - 4 has the highest land cover and W - 1 has the least.

❖ CALCULATION OF SILT YIELD INDEX

Silt yield index (SYI) has been calculated for all the 7 sub-watersheds, following the All India Soil and Land Use Survey (AISLUS) method and accordingly prioritized for treatment. It can be noted that around 98.45% of the catchment area has presence of forest / good vegetation. The focus was therefore on the remaining 1.55% area which accounts to around 183.88 ha.

Based upon the degradation and other parameters, watershed among these 7 sub watersheds were selected as a priority for treatment. The maximum estimated SYI value of 1429.95 is recorded for W – 2 sub-watersheds while minimum value of 1093.60 is calculated from W – 6 sub-watersheds. Both the sub-watersheds fall in the Pare watershed. An area of 183.88 ha will be taken for treatment in the first and second year according to the prioritization of SYI.

Table for Computation of Silt Yield Index

A	B	C	D	E	F	G	H
Sub-watershed code	Erosion intensity	Area* (ha)	Weightage	Area x weight- age	Delivery ratio	Gross silt yield	Sediment yield index
				(C*D)		(E*F)	(G/C)*100
W – 1	a	87.99	17	1495.86	0.95	1421.07	
	b	177.68	16	2842.88	0.9	2558.59	
	c	105.67	14	1479.38	0.85	1257.47	
	d	85.47	11	940.17	0.8	752.14	
Total		456.81				5989.27	**1311.10**
W – 2	a	165.96	19	3153.24	0.95	2995.58	
	b	689.50	17	11721.50	0.85	9963.28	
	c	732.30	16	11716.80	0.85	9959.28	

	d	93.04	15	1395.63	0.8	1116.51	
Total		1680.80				24034.64	**1429.95**
W – 3	a	0.00	0	0.00	0	0.00	
	b	13.65	17	232.05	0.85	197.24	
	c	672.42	15	10086.30	0.85	8573.36	
	d	101.32	12	1215.86	0.8	972.69	
Total		787.39				9743.29	**1237.41**
W – 4	a	168.87	18	3039.64	0.9	2735.67	
	b	1299.20	17	22086.40	0.85	18773.44	
	c	2151.20	14	30116.80	0.85	25599.28	
	d	66.87	12	802.38	0.8	641.91	
Total		3686.13				47750.30	**1295.40**
W – 5	a	0.00	0	0.00	0	0.00	
	b	318.69	15	4780.35	0.85	4063.30	
	c	989.88	14	13858.32	0.85	11779.57	
	d	77.14	12	925.62	0.8	740.50	
Total		1385.71				16583.37	**1196.75**
W – 6	a	212.48	17	3612.16	0.85	3070.34	
	b	696.25	15	10443.75	0.85	8877.19	
	c	2132.97	13	27728.56	0.8	22182.85	
	d	322.60	11	3548.60	0.75	2661.45	
Total		3364.30				36791.82	**1093.60**
W – 7	a	2.54	17	43.18	0.85	36.70	
	b	152.47	15	2287.05	0.85	1943.99	
	c	331.42	13	4308.42	0.8	3446.74	
	d	15.45	11	169.95	0.75	127.46	
Total		501.88				5554.90	**1106.82**

PRIORITISATION OF SUB WATERSHEDS FOR CATCHMENT AREA TREATMENT MEASURE

Sub-Watersheds	Silt Yield Index *	Priority Ranking
W – 1	**1311.10**	I
W – 2	**1429.95**	I
W – 3	**1237.41**	II
W – 4	**1295.40**	II
W – 5	**1196.75**	III
W – 6	**1093.60**	IV
W – 7	**1106.82**	III

Prioritized SYI value of erosion intensity rates

Priority Category	SYI Values
1.Very High	>1300
2.High	1200 -1299
3.Medium	1100-1199
4.Low	1000-1099
5.Very Low	<1000

YEARWISE TREATMENT OF CATCHMENT AREA

Year	Sub-watershed Number	SYI Values	Sub Watershed Area (In Ha)
Year I	W – 1	1311.10	456.812
Year I	W – 2	1429.95	1680.802
Year I	W – 3	1237.41	787.3919
Year I	W – 4	1295.40	3686.134
Year II	W – 5	1196.75	1385.705
Year II	W – 6	1093.60	3364.296
Year II	W – 7	1106.82	501.8771

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
3) Combination of DRSM and crate works. For moderate to deep gullys with stones available at the sites
4) Contour Bunding

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.

Name of Sub-Watershed	Engineering Measures			Biological Measures			Total Area
	Brushwood Check Dam	DRSM Check Dam	Contour Bunding	Afforestation	Assisted Natural Regeneration	NTFP Regeneration	
W 01	6	2	265	2.21	1.25	1.1	4.56
W 02	6	4	235	2.35	1.3	1.2	4.85
W 03	4	2	220	1.12	1.06	1	3.18
W 04	4	2	200	1.04	0.93	0.7	2.67
W 05	2	1	180	0.65	0.9	0.5	2.05
W 06	2	0	60	-	0.86	-	0.86
W 07	1	1	100	0.63	0.7	0.5	1.83
Total	25	12	1260	8	7	5	20

Coordinates of the DRSM Check Dams is given at the end of this report - sub-watershed wise.

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 coppiceable 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, 25 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. 1.36 lakhs.

A View of Bushwood Check Dam

B. DRY RUBBLE STONE MASONRY (DRSM) CHECKDAMS

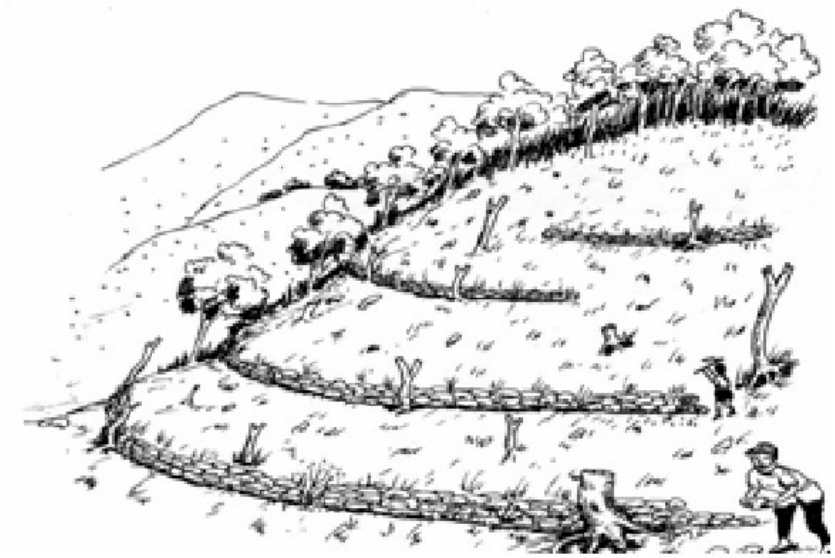
The site where DRSM check dams are to be constructed is cleared and the sides are sloped 1:1. The bed of gully is excavated for foundation to a uniform depth of 0.45 mto 0.60 m and dry stones are packed from that level. Over the foundation, DRSM super structure of check dam is constructed. The stones 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 scourbeing formed by the falling water. For gully control measures, 12 DRSM check dams would be constructed with an estimated budget of Rs. 15.25 lakhs.

A View of Dry Rubble Stone Masonry Check Dam

C. Contour Bunding

Contour bunding is the engineering practice for preventing slope/ soil erosion which is constructed following its elevation contour lines. These contour lines create a water break which reduces the formation of rills and gullies during times of heavy water run-off; which is a major cause of soil erosion. The water break also allows more time for the water to settle into the soil. In this method locally available stones and boulders are placed along the contour following the natural horizontal profile or simple earth is used. For gully control measures total 1260.0 meters of contour bunding is proposed thus covering about 18 hectare of land. The total amount under this head is 17.29 lacs.



A View of Contour Bunding

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.

An outlay of Rs. 13.21 lakhs for 8 ha has been provided to cover various areas under afforestation in different sub-watersheds with 5% for maintenance extra.

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 800 plant or patches per hectare will be planted /sown to hasten the process of regeneration in the area uniformly. An outlay of Rs. 6.15 lakh excluding its maintenance (@ 5%) has been made to cover 7 ha.

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. An outlay of Rs. 8.92 lakhs has been suggested to cover about 5 ha for establishing and its maintenance will be extra @ 5% of this facility.

❖ 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.

❖ **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 these divisions. However, temporary staff may be engaged for this purpose during the project implementation period

❖ **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 Ressing 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

❖ **MICRO-PLANNING**

An estimated cost of Rs. 3.26 lakhs (5% costs of total Engineering and biological measures) has been proposed for micro-planning.

❖ 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. 24.00 lakh is proposed for this purpose.

Budget for Development of State Forest Department Infrastructure

Amount in Lacs

Components	Establishment	Running Cost	Amount (In Lacs)
Forest Fire Fighting System	2.0		2.0
Road and Foot Path Development	5.0		5.0
Office Vehicle	10.0	2.0	12.0
Contingency	5.0		5.0
Total	22.0	2.0	24.0

❖ LOCAL AREA BENEFITS

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.

- ✓ Plantation in the degraded patches of community/civil/ forest land
- ✓ Water conservation and harvesting in the villages
- ✓ Soil conservation measures in village areas
- ✓ Improvement in agricultural and horticultural practices
- ✓ Rural technology support programmes
- ✓ Awareness programmes for conservation of wildlife and natural resources
- ✓ Promotion of income generating schemes like ecotourism

A sum of 20.0 lacs is considered for this head. Though there is only one village in the catchment area of the Ressing HEP i.e. Sango. This amount shall be used for construction of water tank and other requirement of the local as decided by the committee of the local villagers. Proper monitoring and evaluation will be done by the developers of the proposed work.

❖ 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.

For monitoring, reference points of silt load observation in the river are suggested to install silt-recording station upstream of barrage site on Pare River to evaluate the impact of the soil conservation measures. A sum of Rs. 3.26 lakhs @ 5% 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 Ressing 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 2 years for creation and 3 years for maintenance/ monitoring completing. However, CAT plan has been prepared for 5 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. Based on the silt yield index of the sub-watersheds, the conservation measures would be first taken up in sub-watershed W – 1, W – 2 and W – 3. The year-wise index map of schedule of implementation of different conservation measures under CAT plan has been given below. The table gives the year-wise physical details of various engineering and biological treatment measures to be undertaken.

Further, 3 years of period is considered owing to the delay in approval and due to other circumstances in taking up the actual work for CAT. Thus, 7.5% increase in the total plan cost is added i.e. 27.82 Lacs under this head.

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

S. No.	Items	Unit	1st Year		2nd Year (With 7.5% Annual increase from 1st Year)		Total	
			Physical	Financial	Physical	Financial	Physical	Financial
A	ENGINEERING MEASURES							
i.	Brushwood Check Dams	Nos	16	0.848	9	0.51	25	1.36
ii.	DRSM Check Dams	Nos	8	9.92	4	5.33	12	15.25
iii.	Contour Bunding							
	Using earth	Rm	670	4.69	480	3.61	1150	8.30
	Using Wire Crated Gabion Structure	Rm	50	3.925	60	5.06	110	8.99
						Sub - Total		33.90
						Add 5% for Maintenance Structures		1.70
						Total (A)		35.60
B	BIOLOGICAL MEASURES							
i.	Afforestation	Ha	5.68	9.18	2.32	4.03	8	13.21
ii.	NTFP Regeneration	Ha	3.3	5.74	1.7	3.18	5	8.92
iii.	Assisted Natural Regeneration in Existing Forest	Ha	3.61	3.06	3.39	3.09	7	6.15
						Sub - Total		28.27
						Add 5% for Maintenance Structures		1.41
						Total (B)		29.69
	Total (A+B)							65.29
C	Micro – Planning @ 5% of (A+B)			1.95		1.32		3.26
D	Administrative Setup @ 7% of (A+B)			2.72		1.85		4.57
E	Forest Infrastructure Development			18.00		6.00		24.00

F	Contingencies @ 5% of (A+B)			1.95		1.32		3.26
G	Local area Benefits			10.00		10.00		20.00
H	Monitoring and Evacuation for 5 years			1.95		1.32		3.26
						TOTAL		123.65
I	Enhancement for Processing and Execution (3 years period) @ 7.5% P.A							27.82
						GRAND TOTAL		151.47

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.

Monitoring and evacuation is considered for 5 years covering 2 years of actual work period and remaining 3 years for monitoring of the executed work and its maintenance if required.

❖ COST ESTIMATE OF CAT PLAN

The total estimated cost of catchment area treatment plan to be spent over a period of 5 years Rs. 151.47 lakhs (including 2 years of actual work period and monitoring during and after execution of the proposed CAT plan). The details of cost estimates and physical work schedule as well as phasing of expenditure are given as follows in Tables below. All the costs towards the administration during the implementation work have been included in the cost estimates of CAT including 3 years period delay in processing and execution.

Costing is being done on 2020 rates as per the PWD department Arunachal Pradesh. An annual increase @ 7.5% is considered in the worked out rates of the proposed work.

Component-wise cost Estimate for Catchment Area Treatment Plan

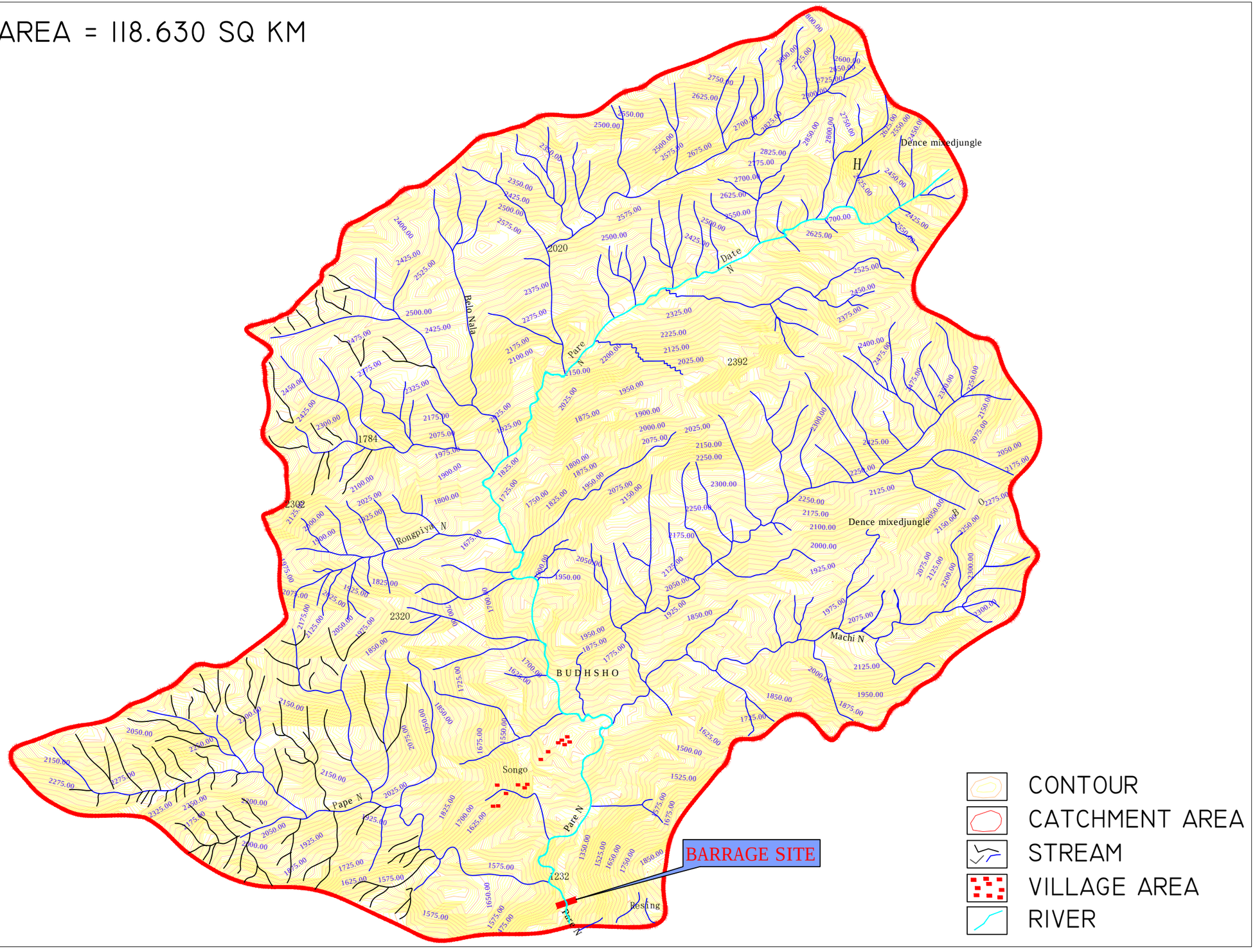
S. No.	Item of Work	Unit	Quantity	Rate (Rs.)	Amount (In Lacs)
A	ENGINEERING MEASURES				
i.	Brushwood Check Dams	Nos.	25	5,300	1.33
ii.	DRSM Check Dams	Nos.	12	1,24,000	14.88
iii.	Contour Bunding	Rm			
	Using Earth	Rm	1150	700	8.05
	Using Wire Crated Gabion	Rm	110	7,850	8.64

	Structure				
				Sub - Total	32.89
	Add 5% for Maintenance Structures + Annual increase in 2nd year work				2.71
				Total (A)	35.60
B	BIOLOGICAL MEASURES				
i.	Afforestation	Ha	8	1,61,550	12.92
ii.	NTFP Regeneration	Ha	5	1,74,000	8.7
iii.	Assisted Natural Regeneration in Existing Forest		7	84,750	5.9325
				Sub - Total	27.56
	Add 5% for Maintenance Structures + Annual increase in 2nd year work				2.13
				Total (B)	29.69
C	Micro – Planning @ 5% of (A+B)+ 7.5% annual increase for 2nd year				3.26
D	Administrative Setup @ 7% of (A+B) + 7.5% annual increase for 2nd year				4.57
E	Forest Infrastructure Development				
i.	Forest Fire Fighting System				2
ii.	Road & Foot Path Development				5
iii.	Instrument Cost, Office Furniture & Vehicle				12
iv.	Contingency				5
				Sub – Total (E)	24
F	Contingencies @ 5% of (A+B) + 7.5% annual increase for 2nd year				3.26
G	Local area Benefits				20
H	Monitoring and Evacuation for 5 years @ 5% + 7.5% annual increase for 2nd year				3.26
				GRAND TOTAL (A TO G)	123.65
I	Enhancement for Processing and Execution (3 years period) @ 7.5% P.A				27.82
				GRAND TOTAL	151.47

Coordinates of DRSM Check Dams

S. No.	Sub-Watershed	Latitude	Longitude
1	W – 1	27^0 21' 46.58"	93^0 22' 54.91"
2		27^0 21' 47.90"	93^0 23' 24.95"
3	W – 2	27^0 20' 27.85"	93^0 20' 17.05"
4		27^0 20' 53.69"	93^0 20' 55.27"
5		27^0 21' 19.06"	93^0 22' 2.29"
6		27^0 21' 4.20"	93^0 21' 15.80"
7	W – 3	27^0 20' 47.93"	93^0 22' 3.46"
8		27^0 20' 20.91"	93^0 21' 2.63"
9	W – 4	27^0 17' 45.13"	93^0 21' 2.07"
10		27^0 19' 5.75"	93^0 20' 15.46"
11	W – 5	27^0 19' 38.47"	93^0 19' 24.06"
12	W – 7	27^0 16' 47.72"	93^0 20' 55.20"

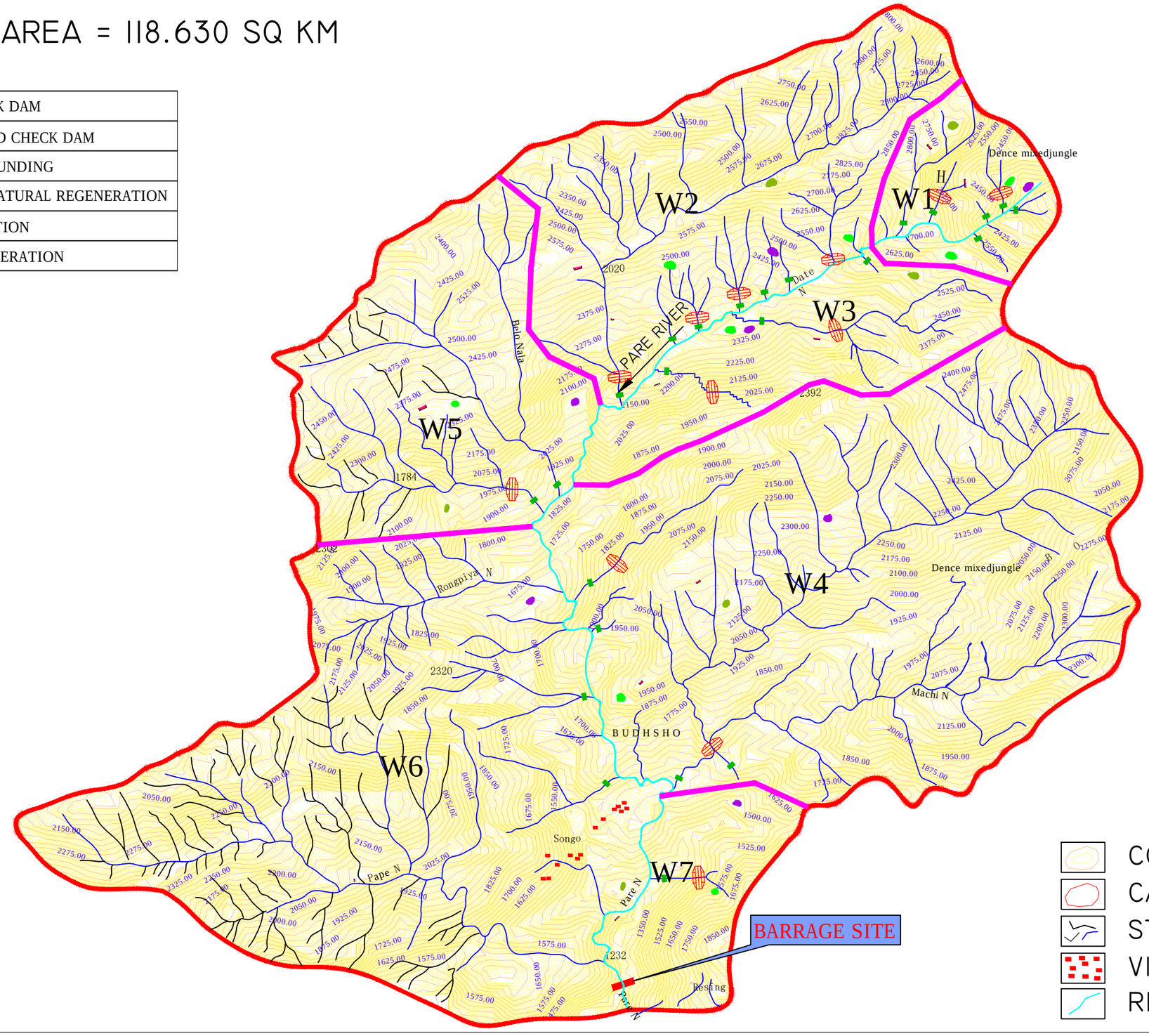
CATCHMENT AREA = 118.630 SQ KM



DEVELOPER	PROJECT TITLE	CONSULTANT	DRAWING TITLE	DRN BY: SUNDEEP	
GEKAM POWER PRIVATE LIMITED B-SECTOR, NAHARALAGUN, DSTRICT PUPUMPARE, ARUNANCHAL PRADESH - 791110, INDIA	RESSING HEP CAT PLAN	GREJ ENGINEERS	CATCHMENT AREA PLAN	DESIGNED BY: KUMAR KANISHK	
				DATE: / SHEET: 1 OF 1	SCALE: NTS / REV: 00
				DRG. No: 2020/08/CIVIL/001	

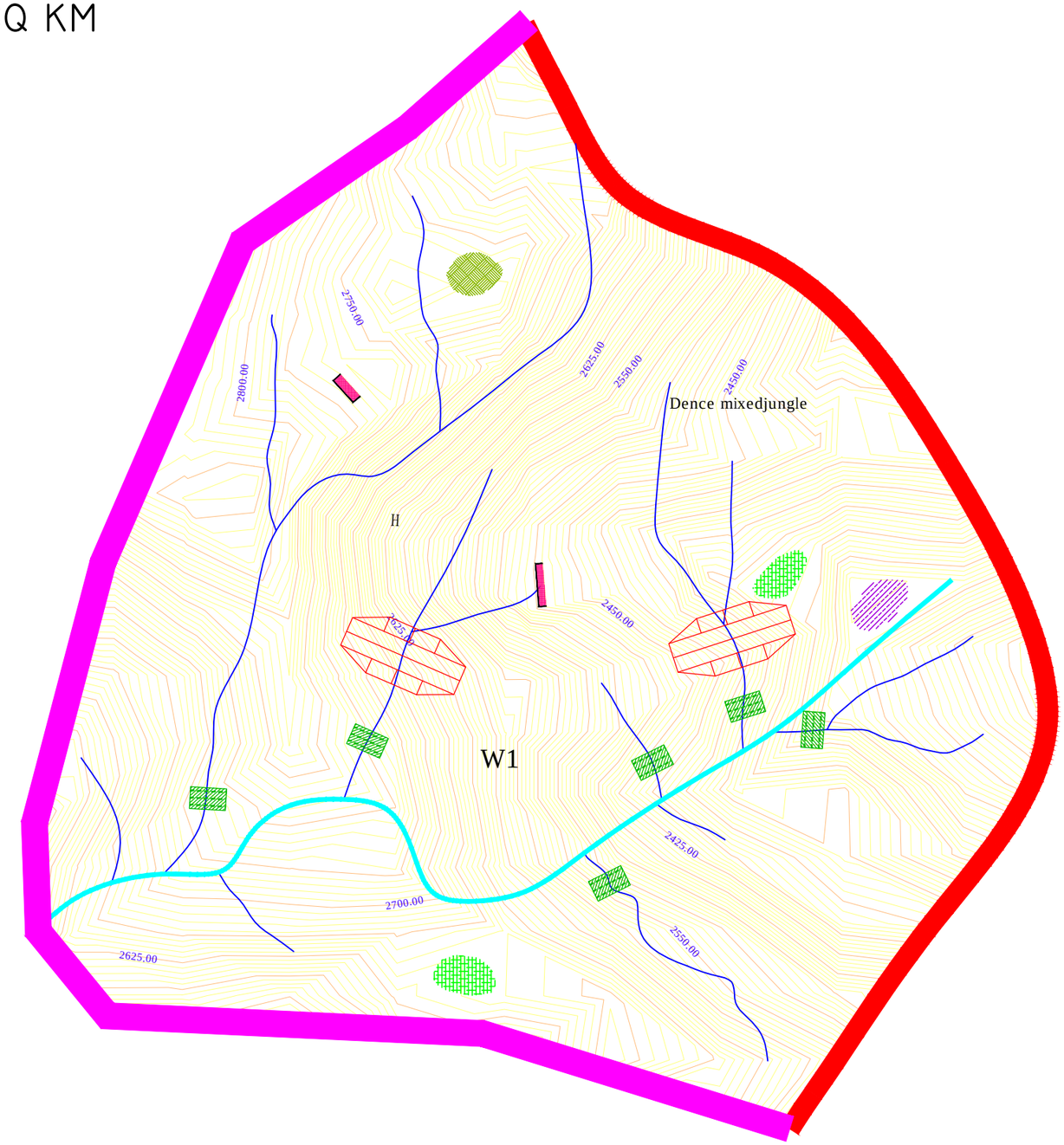
CATCHMENT AREA = 118.630 SQ KM

	DRSM CHECK DAM
	BRUSHWOOD CHECK DAM
	CONTOUR BUNDING
	ASSISTED NATURAL REGENERATION
	AFFORESTATION
	NTFP REGENERATION



DEVELOPER	PROJECT TITLE	CONSULTANT	DRAWING TITLE	DRN BY: SUNDEEP	
GEKAM POWER PRIVATE LIMITED B-SECTOR, NAHARALAGUN, DSTRICT PUPUMPARE, ARUNANCHAL PRADESH - 791110, INDIA	RESSING HEP CAT PLAN	GREJ ENGINEERS	CATCHMENT AREA PLAN WITH STRUCTURE	DESIGNED BY: KUMAR KANISHK	
				DATE: / SHEET: 1 OF 1	SCALE: NTS / REV: 00
				DRG. No: 2020/08/CIVIL/001	

WI AREA = 4.568 SQ KM

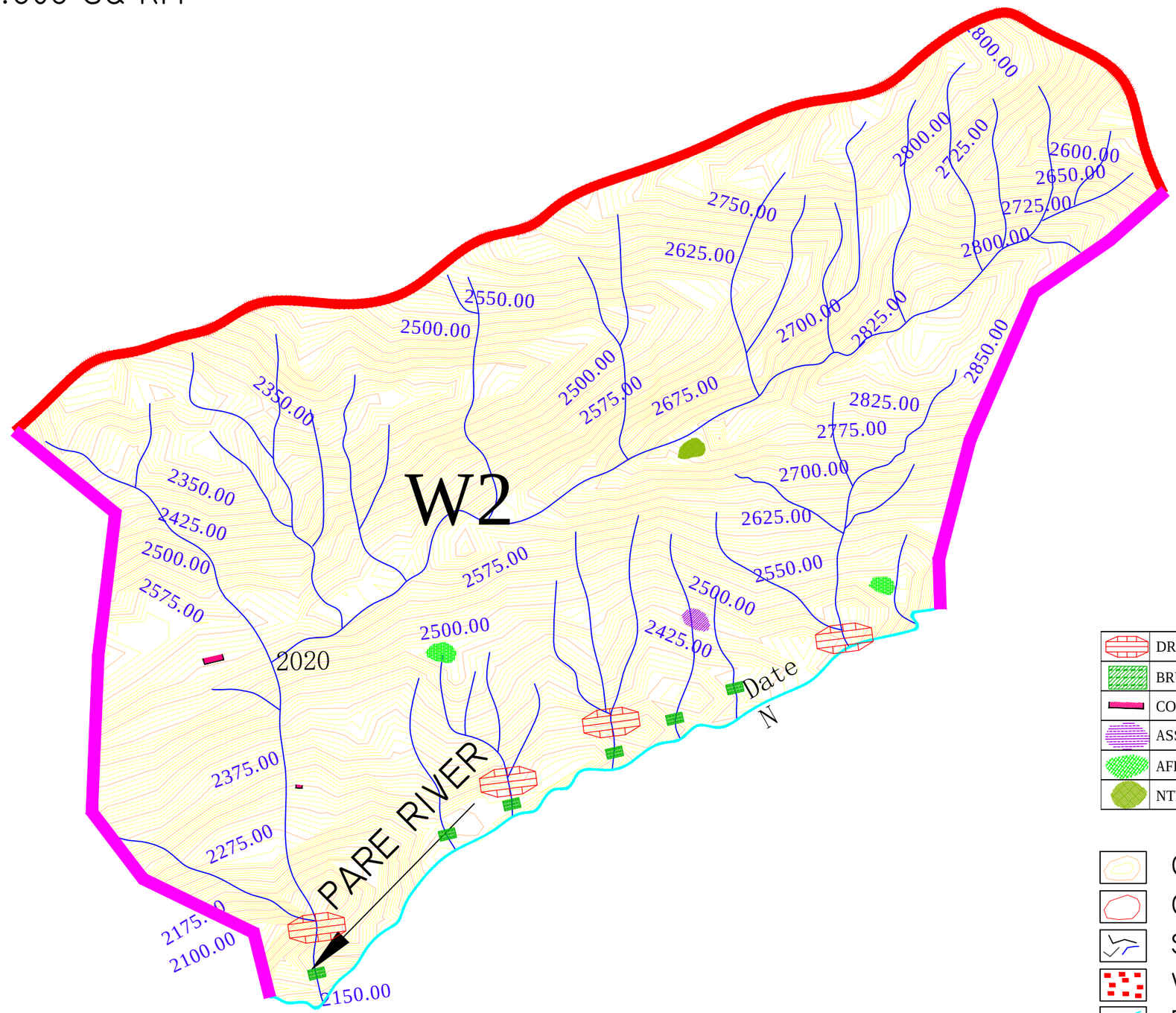


	DRSM CHECK DAM
	BRUSHWOOD CHECK DAM
	CONTOUR BUNDING
	ASSISTED NATURAL REGENERATION
	AFFORESTATION
	NTFP REGENERATION

CONTOUR
CATCHMENT AREA
STREAM
VILLAGE AREA
RIVER

DEVELOPER	PROJECT TITLE	CONSULTANT	DRAWING TITLE	DRN BY: SUNDEEP	
GEKAM POWER PRIVATE LIMITED B-SECTOR, NAHARALAGUN, DSTRICT PUPUMPARE, ARUNANCHAL PRADESH - 791110, INDIA	RESSING HEP CAT PLAN	GREJ ENGINEERS	CATCHMENT AREA TREATMENT PLAN SUB-WATER SHED W-1	DESIGNED BY: KUMAR KANISHK	
				DATE: / SHEET: 1 OF 1	SCALE: NTS / REV: 00
				DRG. No: 2020/08/CIVIL/001	

W-2 AREA = 16.808 SQ KM

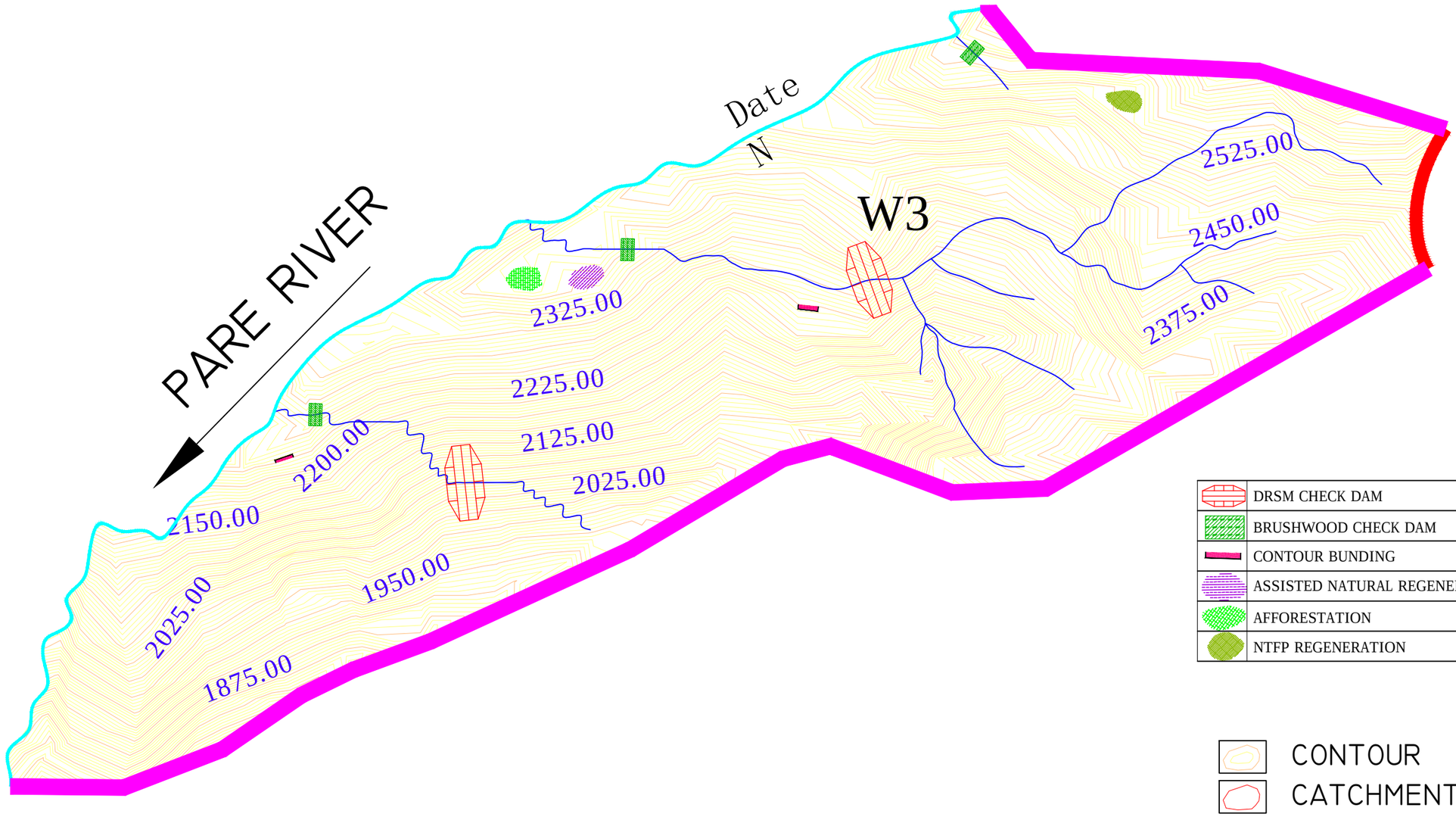


DRSM CHECK DAM	
BRUSHWOOD CHECK DAM	
CONTOUR BUNDING	
ASSISTED NATURAL REGENERATION	
AFFORESTATION	
NTFP REGENERATION	

CONTOUR
CATCHMENT AREA
STREAM
VILLAGE AREA
RIVER

DEVELOPER	PROJECT TITLE	CONSULTANT	DRAWING TITLE	DRN BY: SUNDEEP	
GEKAM POWER PRIVATE LIMITED B-SECTOR, NAHARALAGUN, DSTRICT PUPUMPARE, ARUNANCHAL PRADESH - 791110, INDIA	RESSING HEP CAT PLAN	GREJ ENGINEERS	CATCHMENT AREA TREATMENT PLAN SUB-WATER SHED W-2	DESIGNED BY: KUMAR KANISHK	
				DATE: / SHEET: 1 OF 1	SCALE: NTS / REV: 00
				DRG. No: 2020/08/CIVIL/001	

W3 AREA = 118.630 SQ KM



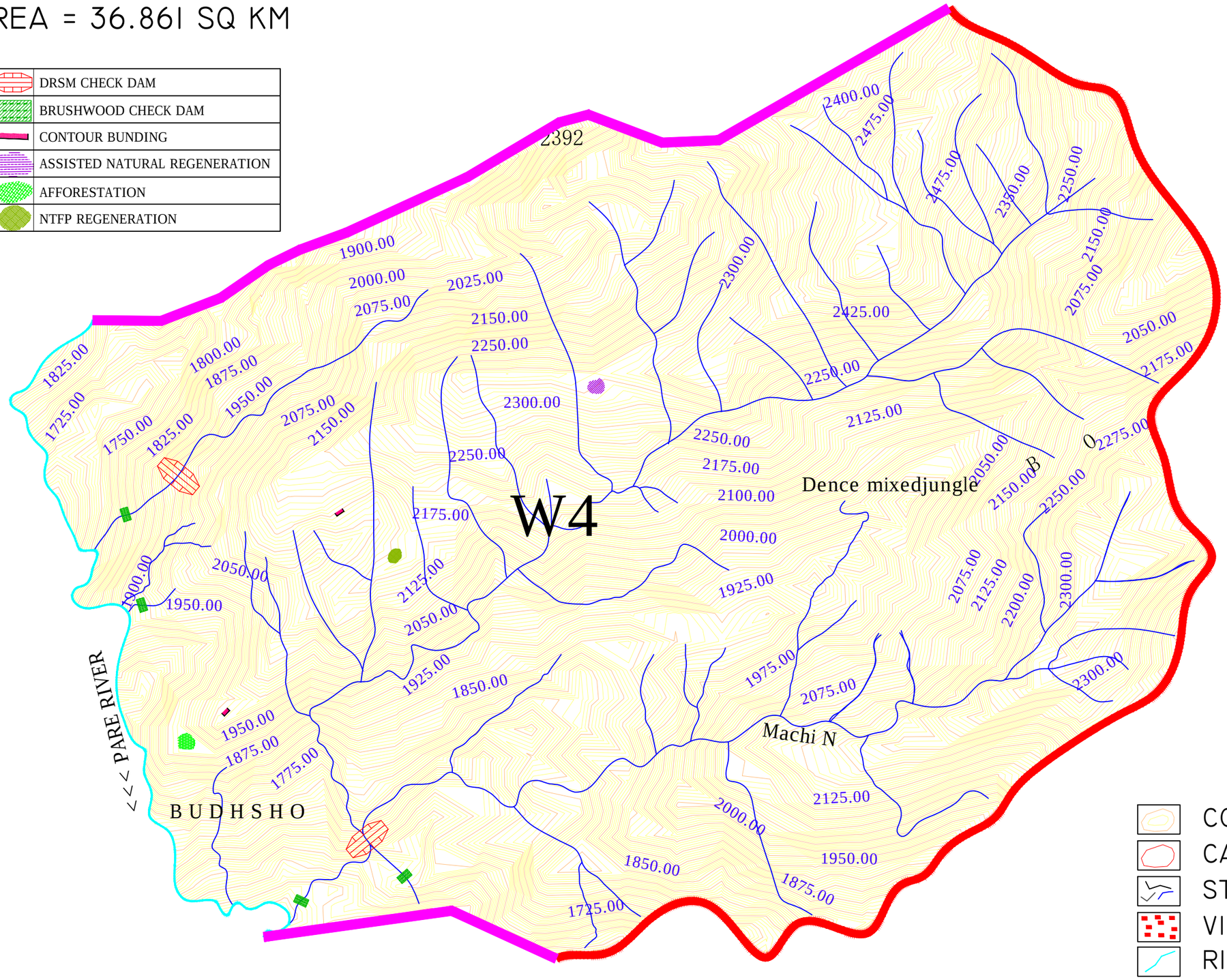
DRSM CHECK DAM	
BRUSHWOOD CHECK DAM	
CONTOUR BUNDING	
ASSISTED NATURAL REGENERATION	
AFFORESTATION	
NTFP REGENERATION	

CONTOUR
CATCHMENT AREA
STREAM
VILLAGE AREA
RIVER

DEVELOPER	PROJECT TITLE	CONSULTANT	DRAWING TITLE	DRN BY: SUNDEEP	
GEKAM POWER PRIVATE LIMITED B-SECTOR, NAHARALAGUN, DSTRICT PUPUMPARE, ARUNANCHAL PRADESH - 791110, INDIA	RESSING HEP CAT PLAN	GREJ ENGINEERS	CATCHMENT AREA TREATMENT PLAN SUB-WATER SHED W-3	DESIGNED BY: KUMAR KANISHK	
				DATE: / SHEET: 1 OF 1	SCALE: NTS / REV: 00
				DRG. No: 2020/08/CIVIL/001	

W4 AREA = 36.861 SQ KM

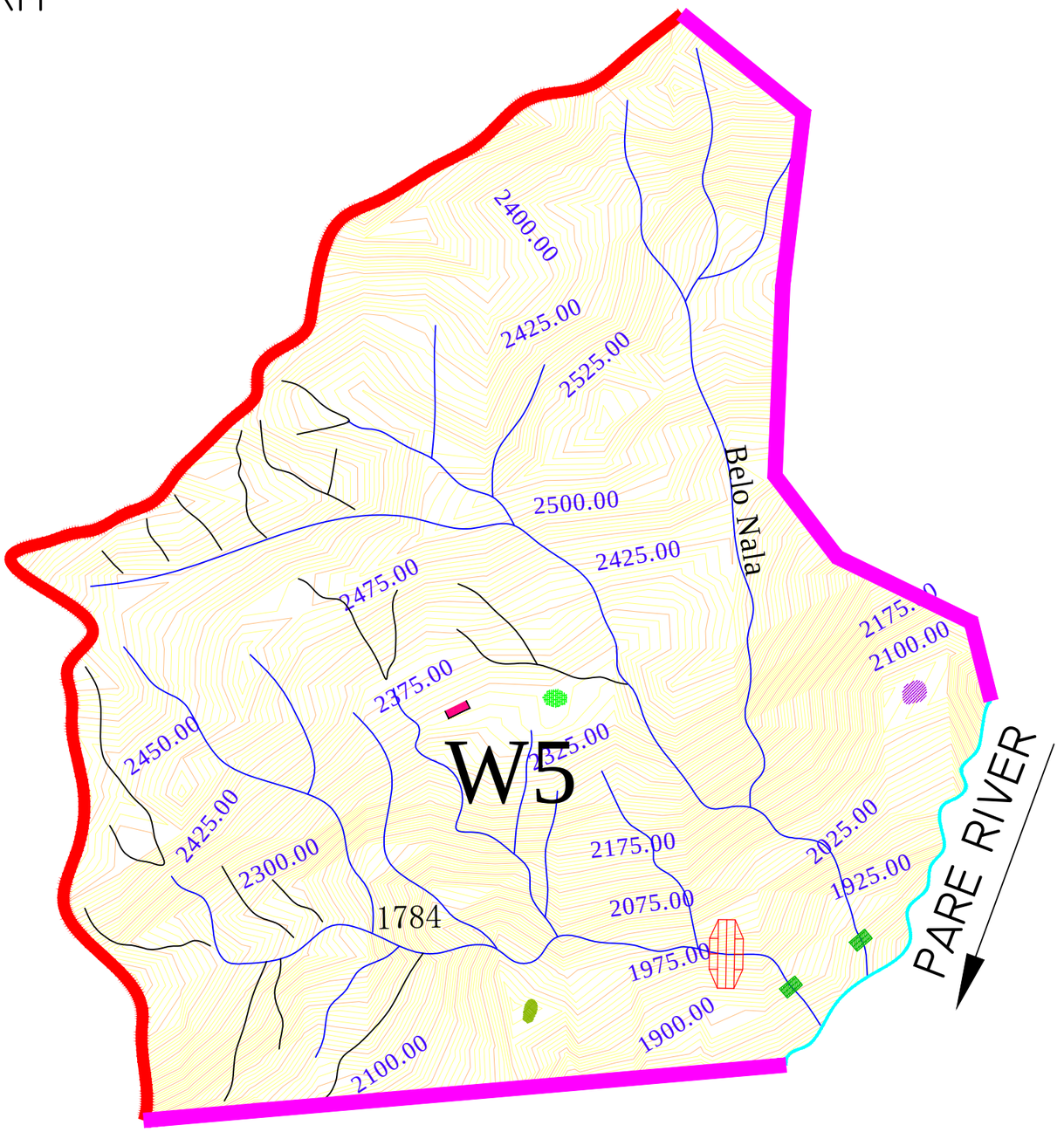
	DRSM CHECK DAM
	BRUSHWOOD CHECK DAM
	CONTOUR BUNDING
	ASSISTED NATURAL REGENERATION
	AFFORESTATION
	NTFP REGENERATION



CONTOUR
CATCHMENT AREA
STREAM
VILLAGE AREA
RIVER

DEVELOPER	PROJECT TITLE	CONSULTANT	DRAWING TITLE	DRN BY: SUNDEEP	
GEKAM POWER PRIVATE LIMITED B-SECTOR, NAHARALAGUN, DSTRICT PUPUMPARE, ARUNANCHAL PRADESH - 791110, INDIA	RESSING HEP CAT PLAN	GREJ ENGINEERS	CATCHMENT AREA TREATMENT PLAN SUB-WATER SHED W-4	DESIGNED BY: KUMAR KANISHK	
				DATE:	SHEET: 1 OF 1
				DRG. No: 2020/08/CIVIL/001	SCALE: NTS / REV: 00

W5 AREA = 13.857 SQ KM



	DRSM CHECK DAM
	BRUSHWOOD CHECK DAM
	CONTOUR BUNDING
	ASSISTED NATURAL REGENERATION
	AFFORESTATION
	NTFP REGENERATION

CONTOUR
CATCHMENT AREA
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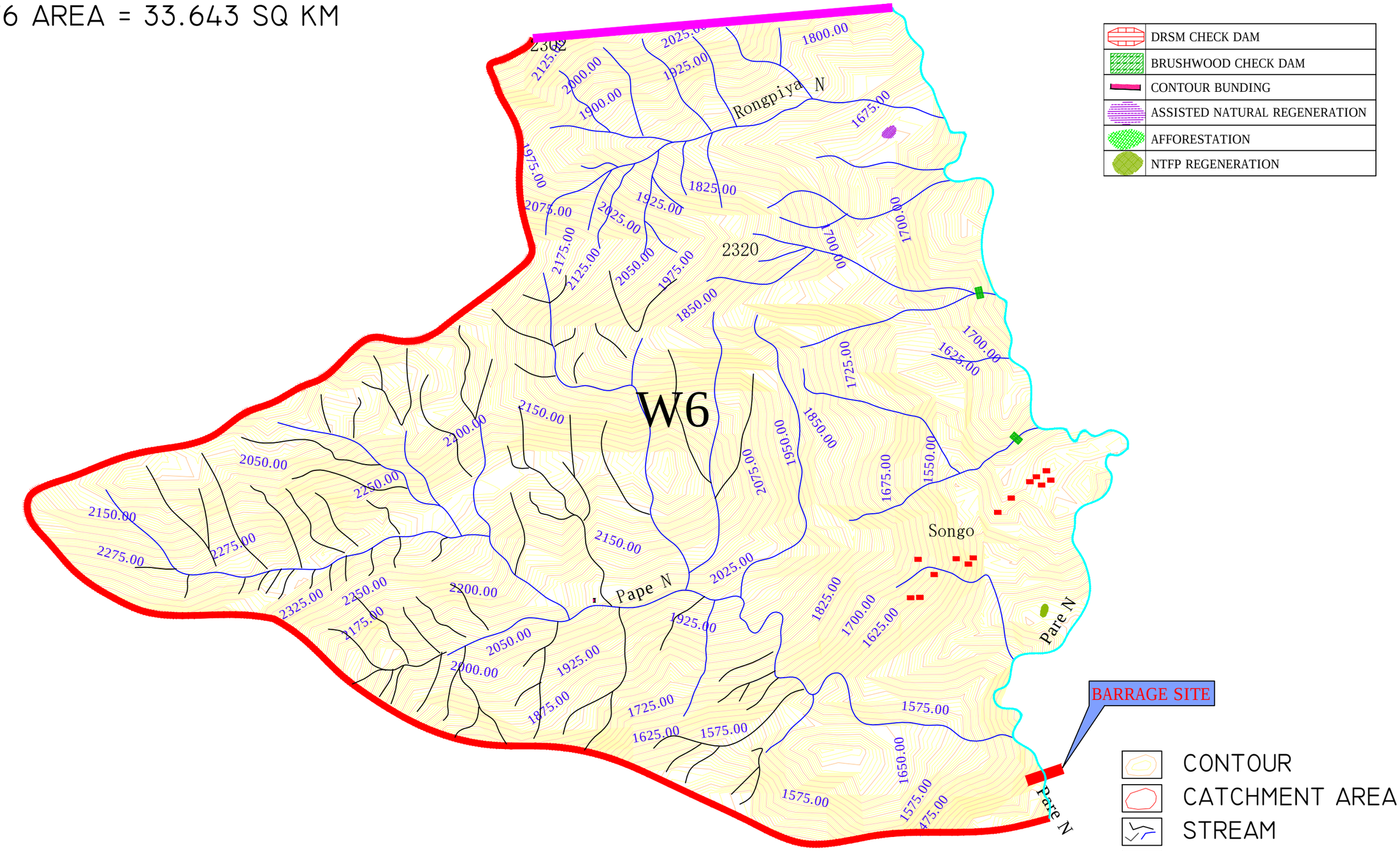
DEVELOPER	PROJECT TITLE	CONSULTANT	DRAWING TITLE	DRN BY: SUNDEEP	
GEKAM POWER PRIVATE LIMITED B-SECTOR, NAHARALAGUN, DSTRICT PUPUMPARE, ARUNANCHAL PRADESH - 791110, INDIA	RESSING HEP CAT PLAN	GREJ ENGINEERS	CATCHMENT AREA TREATMENT PLAN SUB-WATER SHED W-5	DESIGNED BY: KUMAR KANISHK	
				DATE: / SHEET: 1 OF 1	SCALE: NTS / REV: 00
				DRG. No: 2020/08/CIVIL/001	

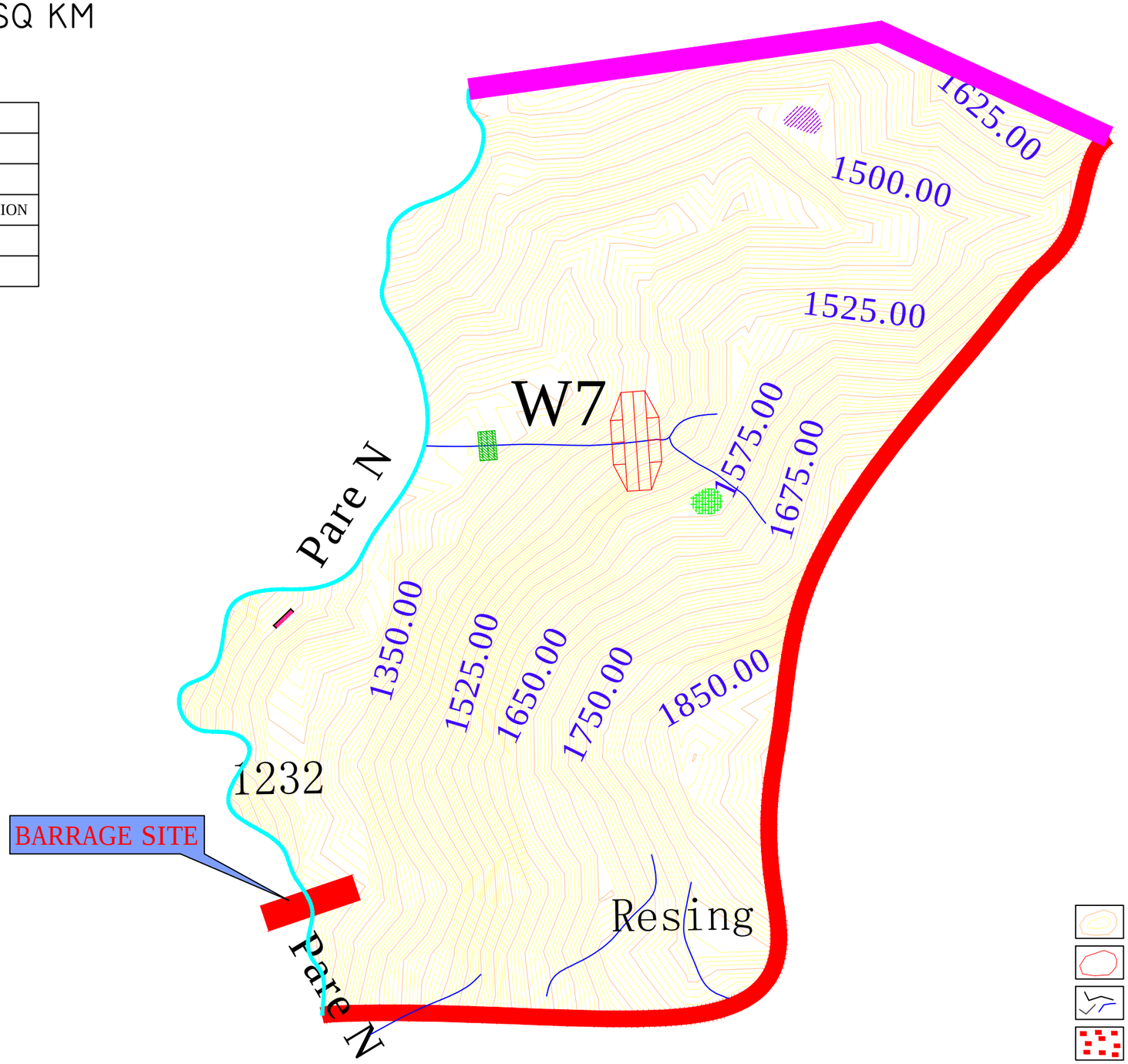
W6 AREA = 33.643 SQ KM



DEVELOPER	PROJECT TITLE	CONSULTANT	DRAWING TITLE	DRN BY: SUNDEEP	
GEKAM POWER PRIVATE LIMITED B-SECTOR, NAHARALAGUN, DSTRICT PUPUMPARE, ARUNANCHAL PRADESH - 791110, INDIA	RESSING HEP CAT PLAN	GREJ ENGINEERS	CATCHMENT AREA TREATMENT PLAN SUB-WATER SHED W-6	DESIGNED BY: KUMAR KANISHK	
				DATE: / SHEET: 1 OF 1	SCALE: NTS / REV: 00
				DRG. No: 2020/08/CIVIL/001	

W7 AREA = 5.019 SQ KM

	DRSM CHECK DAM
	BRUSHWOOD CHECK DAM
	CONTOUR BUNDING
	ASSISTED NATURAL REGENERATION
	AFFORESTATION
	NTFP REGENERATION



CONTOUR
CATCHMENT AREA
STREAM
VILLAGE AREA
RIVER

DEVELOPER	PROJECT TITLE	CONSULTANT	DRAWING TITLE	DRN BY: SUNDEEP	
GEKAM POWER PRIVATE LIMITED B-SECTOR, NAHARALAGUN, DSTRICT PUPUMPARE, ARUNANCHAL PRADESH - 791110, INDIA	RESSING HEP CAT PLAN	GREJ ENGINEERS	CATCHMENT AREA TREATMENT PLAN SUB-WATER SHED W-7	DESIGNED BY: KUMAR KANISHK	
				DATE: / SHEET: 1 OF 1	SCALE: NTS / REV: 00
				DRG. No: 2020/08/CIVIL/001	