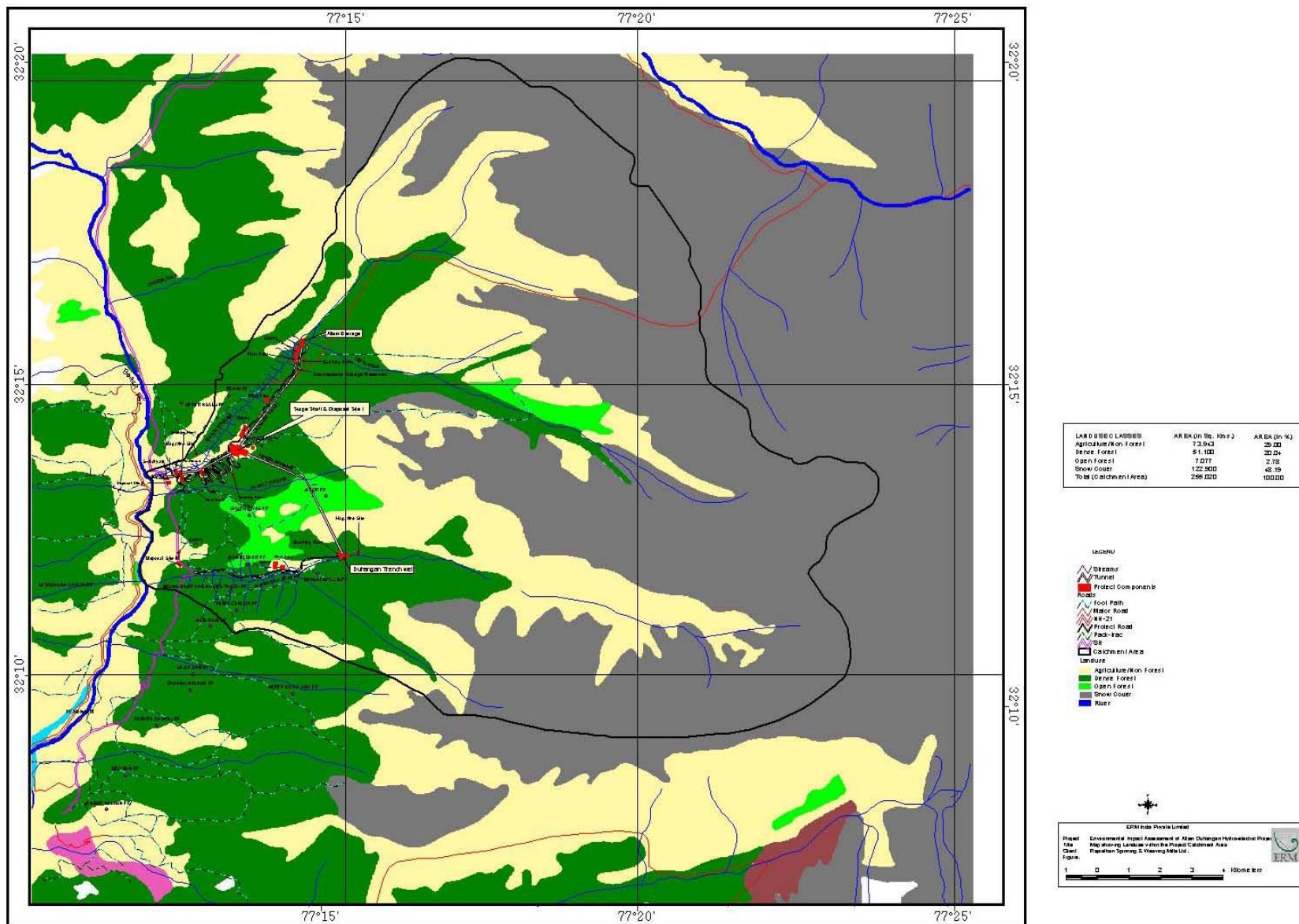




The project area lies in the hilly terrain of Rohtang Range of the Great Himalayan Zone with high steep hill slopes dissected by streams having steep bank slopes and narrow width characteristics of glacial terrain. Mainly Allain, Duhangan and Pahali streams, which are tributaries of Beas River on its eastern bank, drains the catchment area. The Allain and Duhangan streams have their source in permanent snow covered mountains at altitude of the order of 3400-5000 m. The snow cover in the project area extends down to an altitude of about 2600 m in the month of April and recedes back to an altitude above 4500 m by October – November. All these streams join the Beas River at acute angles by cutting deep into the river terrace deposits and maintain nearly E – W trend.

4.4.5 *Hydrology*

The proposed ADHEP will be set-up by utilising the perennial flows of the Allain and Duhangan, the snow-fed tributary streams of the Beas. The Allain stream originates from the glacier zone in the Pir Pinjal range at EL 4800 m while the Duhangan stream originates from Chander Tal glacier at EL 5229 m. The catchments lie in Zone-7 (Western Himalayas) of India. This zone covering Jammu & Kashmir, Punjab, Himachal Pradesh and Uttarakhand, is located between Lat: 32°07' to 32°21' N and Long: 77°07' to 77°11' E, mostly bounded by International boundaries – Indo China border in the north and north-east, Indo-Pakistan border in the west and Indo-Nepal border in the east. The geographical area is the cradle of all the major rivers of north-west India, which are fed by snow and rainfall precipitation. In Western Himalayas, the highest peak is K2 (8611 m) located in Karakoram Range. In addition there are many snow-clad peaks below 8000m.

The standard followed by HPSEB for the present project to arrive at the snow-fed catchment areas is – permanent snow line for catchments is at EL 4280m and area below EL 4280m is rainfed catchment. The catchment areas of the two streams are indicated in the *Table 4.4*.

Table. 4.4: *Catchment area of Allain and Duhangan streams*

Stream & Location	Catchment area in km ² .		
	Above permanent snow-line (EL 4280m)	Below permanent Snow-line (EL4280m)	Total
Allain Stream:			
At Barrage site	51.5	77.4	128.9
At confluence with the Beas	51.5	93.2	144.7
Duhangan Stream:			
At Weir site	36.1	60.1	66.2
At confluence with the Beas	40.2	51.6	91.8

Considering the catchment area below EL 4280m as per HPSEB standard to be rainfed for assessing design floods is an over assessment of design flood peaks. Also, considering the paucity of rain and snow precipitation data of desirable quality and quantity, liberal assessment made by RSWM's consultants has been accepted by Central Water Commission while according the technical clearance, as the increase in cost is marginal and does not effect the cost benefit appraisal of the project.

No meteorological data is available to assess the snow-line in the case of the catchment s for Allain Duhangan project. Hence the snow line is assumed on the

basis of available data for similar projects and locations. Examination of various published reports and documents infers that snow-line during severe rainfall storms could be lower than EL 4280m. The estimated snow-line of 3675m for Dul Hasti Hydroelectric Project in the adjacent Chenab basin (which also originates in Pir Pinjal ranges) needs particular mention.

Water availability

RSWML consultants on hydrology made discharge observations using floats (as per HPSEB guidelines) thrice a day at Aleo gauging station on the Allain from Jan 1973 to May 1995 and at Jagtsukh gauging station on the Duhangan from Jan 1971 to May 1995. Thus, the data availability for stream flow is for a period of 22 years and for 24 years for Allain and Duhangan streams, respectively. Consistency checks have been carried out on the flow data, adopting the standard procedure/practices in vogue and those recommended in CBI &P guidelines and codes of BIS. The 24-year 10-daily average series obtained (with some regression of flow records to cover 2 more years) are then transferred to the diversion sites on catchment area proportion basis. Based on these field data, 10-daily average flow series computed have been supplied to RSWM's consultant for analysis and power planning.

In absence of precipitation stations in the catchments of Allain and Duhangan, (particularly in the upper reaches) it was not possible for RSWML consultants on hydrology to check precipitation-runoff consistency. However, attempts were made to arrive at an estimate of glacier/snow melt contribution during monsoon season to assess the reasonability of the average annual yields of the project catchments in the region. This estimate has been made based on the mean monsoon yield of Allain-Duhangan catchments and the average observed glacier/snowmelt contribution in Zone-7 (Western Himalayas) as recorded and analysed by CWC. The rainfall-runoff factor is estimated to be around 34% for Allain-Duhangan catchments, which can be considered as reasonable.

As it is planned to utilise combined flows of the two streams, a combined flow sequence was prepared and statistical parameters of the flow sequence and the flows at different dependabilities have been worked out using Weibull distribution. The average, 50% and 90% dependable flows on 10-daily average flow basis at diversion sites worked out are presented in the following **Table 4.5**

Comparison of seasonal flows of streams in the Project Region

Stream flow data of hydro-electric projects in the region have been obtained and processed for comparing the trend followed by the average 10 daily flows for the project catchments with those of others. Corresponding values for monsoon, non-monsoon and annual average run-offs of the streams of these projects have been compared with that for Allain Duhangan streams.

Comparison reveals that all other catchments follow similar trend, except in the case of Hurla-Manihar catchment. This can be considered as an exception, since the catchment area for Hurla-Manihar is very small and the average runoff of 5578 mm considered seems to be out of tune with annual rainfall normals in the region.

Allain stream drains a catchment area of 128.9 km², out of which 51.5 km² is under permanent snow cover. Similarly Duhangan has a catchment area of 66.2 km², out of

which 36.1 km² is under snow cover. The inflow in both streams comes from snow melt and rainfall.

Table 4.5: Dependable Flow Estimates at Diversion Sites (in Cumecs)

Catchment Diversion Site	Average	50% Dependable year	90% Dependable year
Allain Stream	9.133	5.940	3.028
Duhangan Stream	4.817	2.950	4.301
Combined Flows	13.950	8.871	4.467

About 3.028 and 1.301 m³/s water is available at Allain barrage and Duhangan weir sites respectively at 90% dependability. The 90% dependable combined flow available is 4.467 m³/s. The minimum flows in a year are observed during January and February being 1.54 and 1.08 m³/s for Allain and Duhangan streams respectively. The combined minimum flow will be about 2.73 m³/s. The pattern of combined flows of Allain and Duhangan streams have been estimated as under:

Table 4.6: Pattern of Combined Flows of Allain & Duhangan Streams in Cumecs

Periods	Spell of Flows	Average Year	50% Dependable Year (76-77)	90% Dependable Year (73-74)
Jun	1 st 10 days	21.579	18.042	23.185
	2 nd 10 days	23.381	18.359	34.266
	3 rd 10 days	26.897	17.592	26.566
Jul	1 st 10 days	29.124	23.891	31.365
	2 nd 10 days	35.008	33.041	26.619
	3 rd 10 days	32.146	36.205	21.268
Aug	1 st 10 days	32.958	40.278	24.489
	2 nd 10 days	30.103	36.689	23.426
	3 rd 10 days	26.895	34.997	22.577
Sep	1 st 10 days	22.582	32.446	15.339
	2 nd 10 days	19.027	28.441	15.120
	3 rd 10 days	15.218	20.443	12.203
Oct	1 st 10 days	12.561	13.072	8.674
	2 nd 10 days	10.629	9.225	7.064
	3 rd 10 days	9.213	9.5983	6.968
Monsoon Average		23.147	24.863	19.883
Nov	1 st 10 days	8.095	10.469	5.686
	2 nd 10 days	7.265	8.851	5.481
	3 rd 10 days	6.617	8.434	5.284
Dec	1 st 10 days	5.980	8.376	4.912
	2 nd 10 days	5.508	6.204	5.033
	3 rd 10 days	5.191	5.538	4.625
Jan	1 st 10 days	5.052	5.577	4.206
	2 nd 10 days	4.935	5.229	3.283
	3 rd 10 days	4.813	4.506	3.377
Feb	1 st 10 days	4.688	4.234	3.356
	2 nd 10 days	4.587	4.158	3.172
	3 rd 8 days	4.654	4.248	4.121
Mar	1 st 10 days	4.764	3.908	3.065
	2 nd 10 days	5.093	4.224	3.506
	3 rd 10 days	5.561	4.635	4.028