CHAPTER-4
WATER RESOURCES

4.1 GENERAL

Dibang Multipurpose project is proposed across river Dibang, a major tributary of river Brahmaputra, near Munli village in Lower Dibang Valley District of Arunachal Pradesh. The entire project area is located in a highly mountainous and difficult terrain. The project envisages construction of a 288 m high concrete gravity dam across Dibang river. At Full Reservoir Level (EL 545 m) the reservoir storage is 3748.2 M.cum and reservoir surface area is 40.1 sq.km. The length of reservoir at FRL is 43 km.

As a part of DPR, hydrological analysis has been conducted by studying the hydro meteorological characteristics of the basin for establishing various hydro meteorological parameters required for the project design. The key findings of the hydrological analysis are presented in this chapter.

4.2 DIBANG RIVER BASIN

The Dibang Multipurpose Project is located on river Dibang, a major tributary of river Brahmaputra. The topography and the basin characteristics of these two rivers have been briefly discussed in the following paragraphs.

River Brahmaputra

In the southwest of Tibet, four major rivers originate around Mt. Tesi (Kailash). One is the Yarlung Tsangpo which travels through the Tibet. Its easterly course skirts north of the Himalayan divide before turning sharply south into the plains of Arunachal Pradesh, where it is known as the Brahmaputra. After flowing through Assam Plains in India, Brahmaputra enters Bangladesh before joining Ganges and Meghna to form the great delta of north-eastern India known as the Sunderbans.

The Yarlung Tsangpo watershed drains most of the southern part of Tibet except for the area just north of Chomolungma (Mt. Everest). It originates from western Tibet, just south-east of Mapham Tso (Lake Mansarovar). The Yarlung Tsangpo flows east through the most densely populated region of Tibet, irrigating most of the agricultural land in the historical Yarlung valley. Then it passes through Shigatse city and flowing south of Lhasa, it drains river Kyichu. East of Lhasa, it flows through the once forested and now degraded Kongpo region before turning abruptly near Mt. Namchakbarwa to the south, cutting straight through the Himalyan divide to flow into India as Brahmaputra and then to Bangladesh.

River Dibang

The river Dibang which is also called as Talon by Idus, is one of the major tributaries of Brahmaputra river system contributing about 8.5% to the annual discharge of river Brahmaputra at Pandu. The river originates from the snow covered southern flank of the Himalyas close to the Tibet border at an elevation of more than 5000 m. The river Dibang cuts through deep gorges and difficult terrains in its upper reach through the mountains of the Dibang valley district of Arunachal Pradesh. The river flows from north to south through Dibang valley district and finally meets river Lohit near Sadiya in Assam. The river emerges from hills and enters the sloping plain areas near Nizamghat in Arunachal Pradesh from where the river flows for a distance of about 50 km to meet river Lohit. Although there is no hill in between this reach, the river gradient is very steep for such a large river. In this 50 km reach, river loses a height of about 160 m. In this portion, the river is highly braided and destructive in nature. It branches out into a number of channels, somewhere as many as 15 numbers and occupies a width of about 4 to 9 km. In this reach, the river changes its course quite often destroying large tracts of jungle and cultivable land and floods occur in the low lying area of Sadiya in Tinsukia District of Assam.

The total length of river Dibang from its source to its confluence is 195 km. The major tributaries of river Dibang are Mathun, Tangon, Dri, Ithun and Emra. A number of small tributaries i.e. Ahi, Aripani, Illupani, Ashupani, Epipani, Deopani etc also join the river.

The important feature is that all the tributaries barring Epipani and Deopani join river Dibang in its hilly catchment. The three major tributaries viz Tangon, Dri and Mathun are almost equal in size because of which shape of the Dibang catchment is comparatively wide in its upper reach.

The catchment of the Dibang is more or less of fan shaped. Most of the catchment area of Dibang is rainfed and the snow line may be assumed as 4500 m. The total catchment area of Dibang up to dam axis is worked out as 11276 sq.km. The basin lies between Latitude $28^0$11'50'' N & $29^0$25'59'' N and Longitude $95^0$14'47'' E & $96^0$36'49'' E.

4.3 CLIMATE

Two distinct climatic conditions prevail over the entire Dibang Catchment. The upper reach starts from the Indo-Tibet border up to Mayudia Hill Range and the lower reach starts from Mayudia Hill range to the confluence of Lohit. In the upper catchment, rainfall is comparatively less and the region is very cool during winter and comfortable during summer. The lower part maintains tropical climate. Rainfall is very high and the climate remains very humid. On the basis of the available data, average rainfall in the basin up to the dam site has been estimated to be 4405 mm.

4.4 WATER AVAILABILITY

The water availability series available in "Feasibility Report of Dibang Multipurpose Project CWC (2003)" has been modified and updated by CWC and Brahmaputra Board and extended up to April 2003. It is given in report of "Power Potential studies of Dibang Multipurpose Project and Cost Benefit Analysis for Optimisation of Project Parameters, Brahmaputra Board (Jan-2005)". This series has been finally adopted in the DPR of Dibang Multipurpose Project and is given in **Table 4.1**. However, before adopting this discharge series the internal and external consistency checks has been carried out by NHPC. The average annual yield thus computed as 26940 Mcum. Monthly variation in river flow is shown in **Figure 4.1**. The river flows are low during the period October to

March with the lowest mean flow during the December-January. The river flows start steadily raising there from up to May and more abruptly during June which coincides with the onset of monsoons. The high flows continue up to August after which the discharge shows a decreasing trend.

TABLE 4.1
Water Availability Series (Unit - Cumec)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JLY	AUG	SEP	OCT	NOV	DEC	AVG
1985					976.4	1689.0	1597.2	1244.6	851.1	804.7	327.5	333.7	**978.0**
1986	317.4	428.2	379.9	568.5	1289.3	1818.7	1411.9	1682.1	886.6	652.7	338.7	307.7	**840.1**
1987	301.0	463.4	487.7	588.5	1253.1	2458.6	2423.8	2112.8	883.5	606.9	331.5	340.8	**1021.0**
1988	356.6	412.1	374.2	573.6	1012.6	1822.6	1533.8	1883.5	898.2	561.8	335.1	309.8	**839.5**
1989	383.3	426.3	586.5	714.3	1464.3	3199.5	2444.3	1553.5	1524.3	1520.8	490.5	347.0	**1221.2**
1990	487.9	690.9	514.7	994.9	949.2	2106.7	2158.4	1797.0	1290.4	1005.6	319.1	312.7	**1052.3**
1991	462.6	439.7	374.8	560.3	960.2	1822.6	1250.7	1662.8	987.4	795.2	336.1	314.1	**830.5**
1992	359.6	439.7	413.4	573.6	1012.7	1822.6	714.4	782.9	701.6	442.4	312.6	303.1	**656.6**
1993	351.7	408.1	338.3	355.2	840.1	1301.0	1337.2	1448.6	532.3	564.0	344.4	315.1	**678.0**
1994	365.2	439.7	389.4	466.2	780.4	1548.6	603.2	1111.5	484.1	799.6	462.7	310.4	**563.4**
1995	352.0	384.5	502.4	817.2	838.5	2442.3	940.4	1690.2	1004.2	789.9	321.6	319.2	**866.9**
1996	374.3	356.9	378.5	480.2	907.7	1110.4	2947.1	1303.2	875.8	727.8	344.4	315.1	**843.5**
1997	330.8	652.4	395.3	385.2	1629.4	1602.9	990.8	659.5	906.5	378.5	324.0	307.5	**713.6**
1998	292.3	351.6	567.3	1104.6	1057.2	1688.2	2617.7	2697.4	1130.5	766.9	417.4	349.0	**1086.7**
1999	307.2	299.2	308.2	837.2	1205.1	1403.6	1252.8	1067.7	575.4	466.6	421.5	380.8	**710.4**
2000	360.0	356.2	415.6	1356.3	1125.9	2274.2	1382.1	1539.6	935.2	662.1	369.9	331.3	**925.7**
2001	324.3	305.4	398.5	666.2	594.7	927.9	1074.1	1190.7	886.4	574.8	491.5	434.9	**655.8**
2002	549.3	484.1	510.3	918.6	767.8	922.2	2000.4	1089.4	1120.9	1535.6	406.8	321.9	**885.6**
2003	278.5	362.5	630.0	1212.6									
Average	**364.1**	**427.8**	**442.5**	**731.8**	**1036.9**	**1775.6**	**1593.4**	**1473.2**	**915.2**	**758.7**	**372.0**	**330.8**	**854.1**

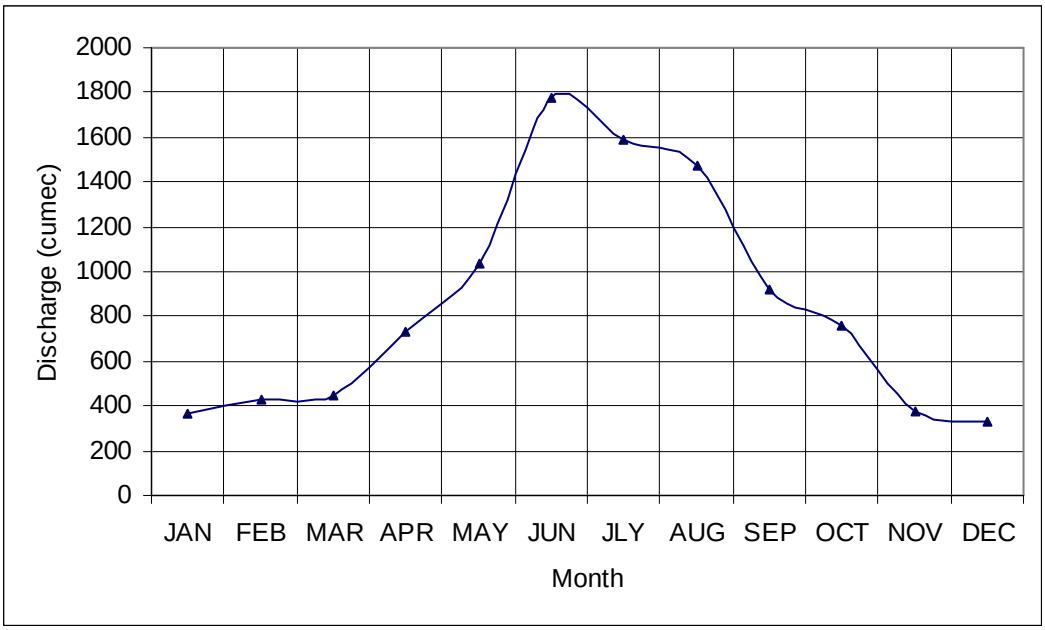

Figure 4.1 Monthly Variation in River Flows at Dam site

4.6 RATING CURVES AND RESERVOIR ELEVATION AREA CAPACITY CURVE

Data available

- G & D data at Munli, 475 m u/s of proposed dam site – Apr-2004 to May-2005
- Gauge data at Old TRT taklapahar helipad 2.162 km d/s from proposed dam site – Apr-2004 to May-2005
- Gauge data at Taklapahar 2.91 km d/s from proposed dam site – Apr-2004 to May-2005
- X-sections from dam site to 2400 m d/s and 2445 to 2945 m d/s at an interval of 100 m.

Methodology adopted

The methodology adopted in the DPR is briefly described as below:

- TRT outlet and DT Outlet are proposed at 2.0 km d/s and 2.5 km d/s from dam axis

- A G& D curve was prepared based on observed G&D data at G&D site Munli (475 m u/s of dam axis). The range of discharges available in data base varies from 300 cumec to 14000 cumec and for higher discharges curve has been extrapolated.
- Considering the same discharges as observed at Munli and by taking the gauges of Old TRT taklapahar helipad 2.162 km d/s from proposed dam site, G&D curve has been prepared. The range of discharges available in data base varies from 300 cumec to 14000 cumec and for higher discharges curve has been extrapolated.

Based on observed water surface levels at various locations it has been established that the water surface levels at various locations it has been established that the water surface slope is around 1 in 200 in the reach lying from Munli GD site to Taklapahar gauge site

At dam axis: G&D curve at Munli GD site has been transferred to proposed dam site by a slope of 1 in 200, the developed rating curve is given in **Figure 4.2**. (Refer **Table 4.2**)

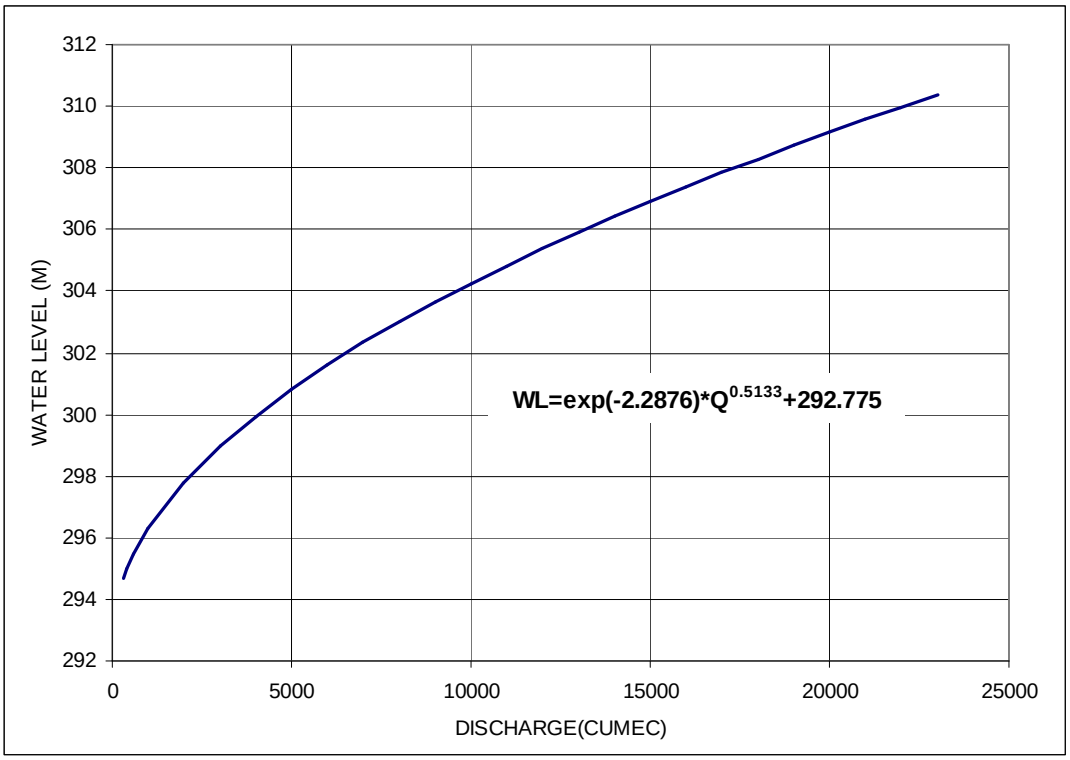

Figure 4.2 Rating Curve at Dam site

TABLE 4.2

Rating Curve at Dam site

Discharge (cumec)	Water Level (m)
300	294.67
400	294.97
600	295.48
1000	296.29
2000	297.80
3000	298.96
4000	299.94
5000	300.81
6000	301.60
7000	302.33
8000	303.01
9000	303.65
10000	304.25
11000	304.83
12000	305.38
13000	305.90
14000	306.41
15000	306.91

Discharge (cumec)	Water Level (m)
16000	307.38
17000	307.84
18000	308.29
19000	308.73
20000	309.15
21000	309.57
22000	309.98
23000	310.37

At TRT Outlet: G&D curve at old TRT taklapahar helipad 2.162 km d/s has been transferred to proposed TRT outlet by a slope of 1 in 200. The developed rating curve is given in **Figure 4.3**. (Refer **Table 4.3**)

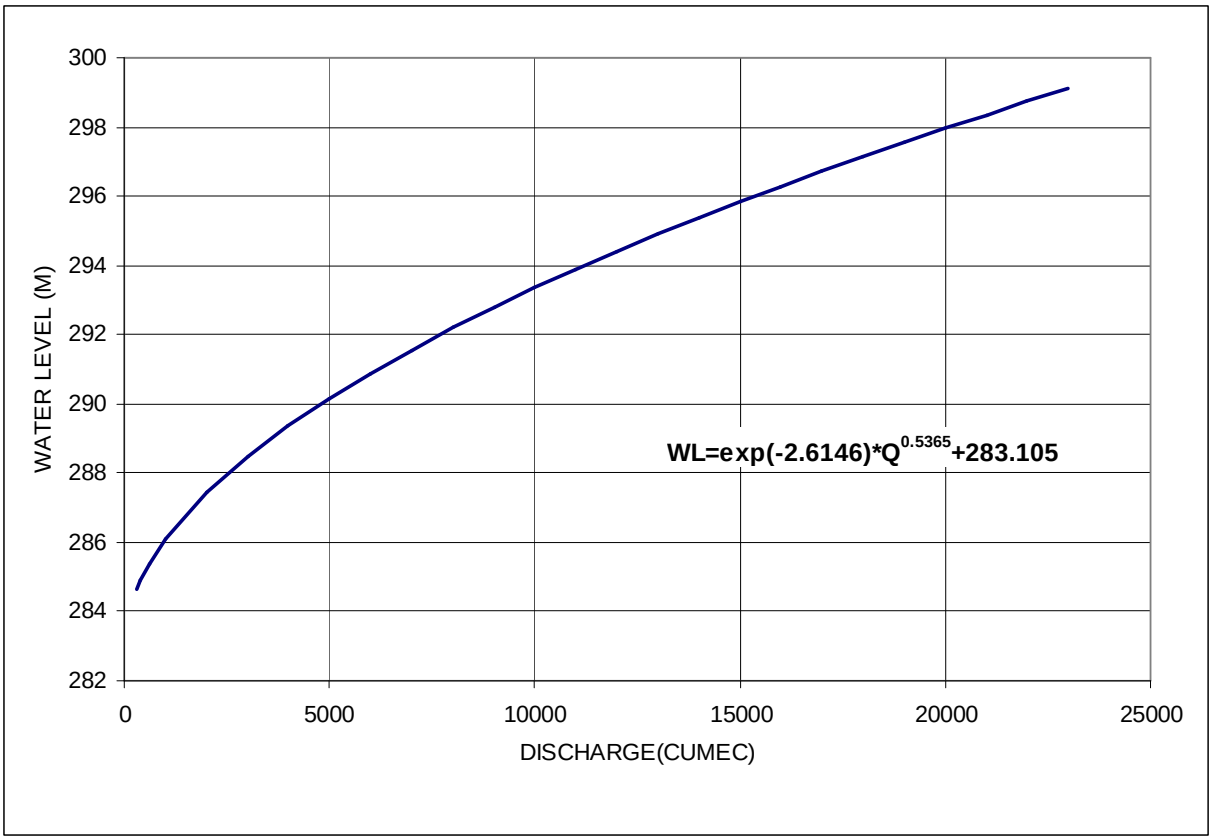

Figure 4.3 Rating Curve at 2 km downstream of dam site

TABLE 4.3

Rating Curve at 2 km downstream of dam site

Discharge (cumec)	Water Level (m)
300	284.67
400	284.93
600	285.37
1000	286.08
2000	287.43
3000	288.47
4000	289.37
5000	290.17
6000	290.89
7000	291.57
8000	292.19
9000	292.79
10000	293.35
11000	293.89
12000	294.40
13000	294.90
14000	295.38
15000	295.84
16000	296.29
17000	296.72
18000	297.15
19000	297.56
20000	297.96
21000	298.36
22000	298.74
23000	299.12

At DT Outlet: G&D curve at old TRT taklapahar helipad 2.162 km d/s has been transferred to proposed DT outlet by a slope of 1 in 200. The developed rating curve is shown in **Figure 4.4**. (Refer **Table 4.4**)

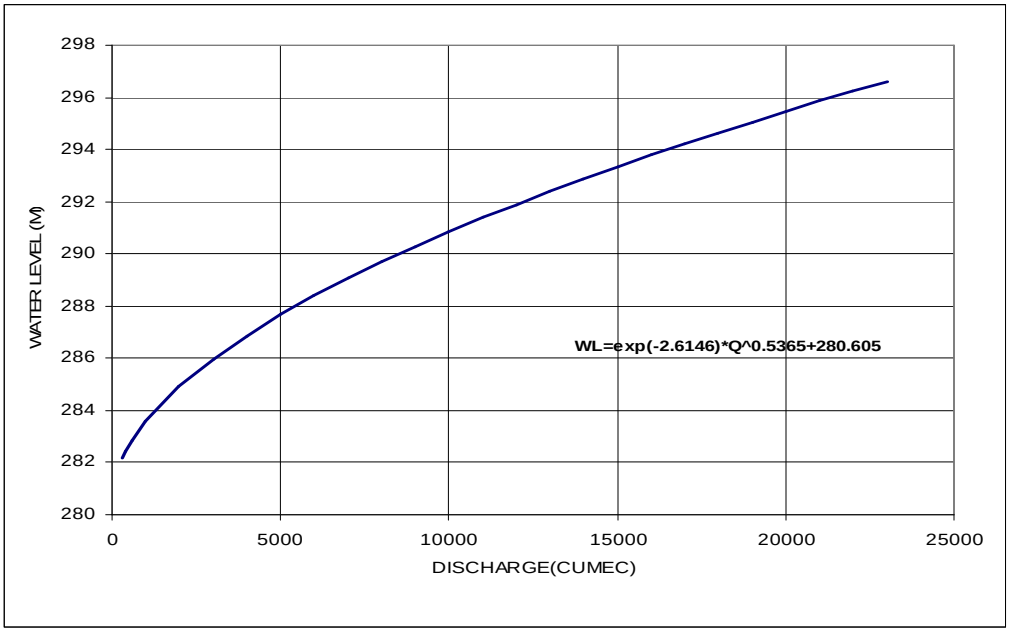

Figure 4.4 Rating Curve at 2.5 km downstream of dam site

TABLE 4.4

Rating Curve 2.5 km downstream of dam site

Discharge (cumec)	Water Level (m)
300	282.17
400	282.43
600	282.87
1000	283.58
2000	284.93
3000	285.97
4000	286.87
5000	287.67
6000	288.39
7000	289.07
8000	289.69
9000	290.29
10000	290.85
11000	291.39
12000	291.90
13000	292.40
14000	292.88
15000	293.34
16000	293.79
17000	294.22
18000	294.65
19000	295.06
20000	295.46
21000	295.86

22000	296.24
23000	296.62

4.7 RESERVOIR ELEVATION AREA CAPACITY CURVE

The Reservoir Elevation Area Capacity curve is given in **Figure 4.5.** (Refer **Table 4.5**). At FRL 545, the reservoir capacity is 3748.21 Mcum, surface area is 40.09 sq.km and reservoir length is 43 km. A rate of sedimentation of 0.1 Ham/sqkm/yr including 15% bed load has been adopted for Dibang basin. The sediment load thus worked out to be equal to 11.276 Mcum/Year at dam site.

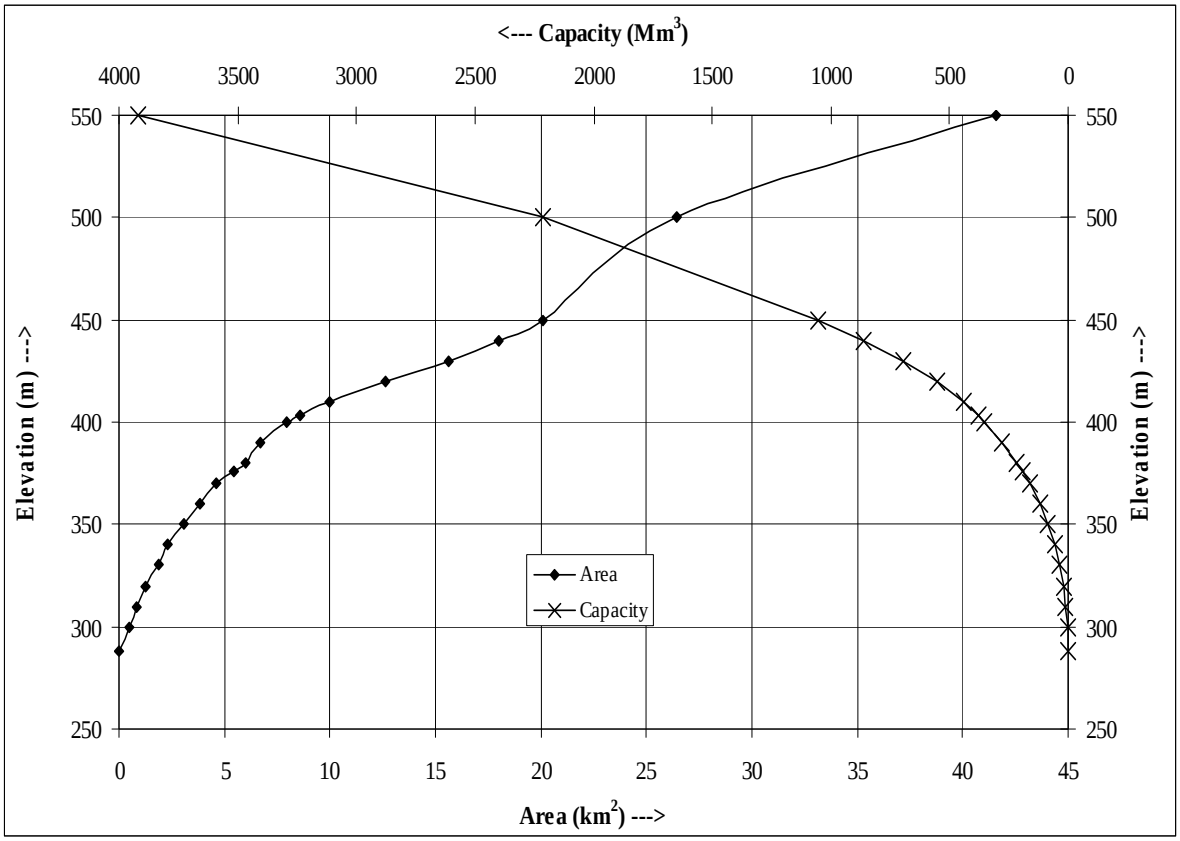

Figure 4.5 Reservoir Elevation Area Capacity Curve

TABLE 4.5

Reservoir Elevation Area Capacity Curve

Elevation (m)	Area (km^2)	Cumulative Volume (Mm^3)
288	0	0
300	0.490	2.94
310	0.860	9.69
320	1.280	20.39
330	1.910	36.34
340	2.320	57.49
350	3.040	84.29
360	3.850	118.74
370	4.620	161.09
376	5.448	191.29
380	6.000	214.19
390	6.700	277.69
400	7.930	350.84
403	8.550	375.56
410	10.000	440.49
420	12.600	553.49
430	15.600	694.49
440	18.000	862.49
450	20.080	1052.89
500	26.470	2216.64
550	41.600	3918.39

4.8 DESIGN FLOOD AND DIVERSION FLOOD

A 288 m high concrete gravity dam is proposed at Munli dam site on Dibang River with gross storage capacity of 3748.21 Mcum at FRL EL 545 m. The criteria of selection of inflow design flood for safety of dam as per IS-11223-1985 are given below in **Table 4.6.**

TABLE 4.6
Criterion for Selection of Design Flood

Classification	Gross storage	Static head at FRL	Inflow design flood for safety of dam
Small	Between 0.5 and 10 Mcum	Between 7.5m and 12 m	100 year flood
Intermediate	Between 10 and 60 Mcum	Between 12m and 30 m	Standard Project Flood
Large	Greater than 60 Mcum	Greater than 30 m	Probable Maximum Flood

The gross storage capacity is much more than 60 Mcum and the static head is more than 30 m. Therefore, the spillway of the proposed dam has been designed to negotiate probable maximum flood**.** The design flood was computed after dividing the basin in four subzones. Design storm values estimated by IMD,Delhi for individual zones have been applied on unit hydrographs derived using CWC-subzone 2(a) report for each sub-basin. 2-day PMF of 26223 cumec has been finally adopted and approved by CWC as design flood and shown in **Fig.4.6** and **Table 4.7**.

1 in 25 year return period flood of 8680 cumec has been taken as diversion flood for working period of 7.5 month (1-Nov to 15-Jun).

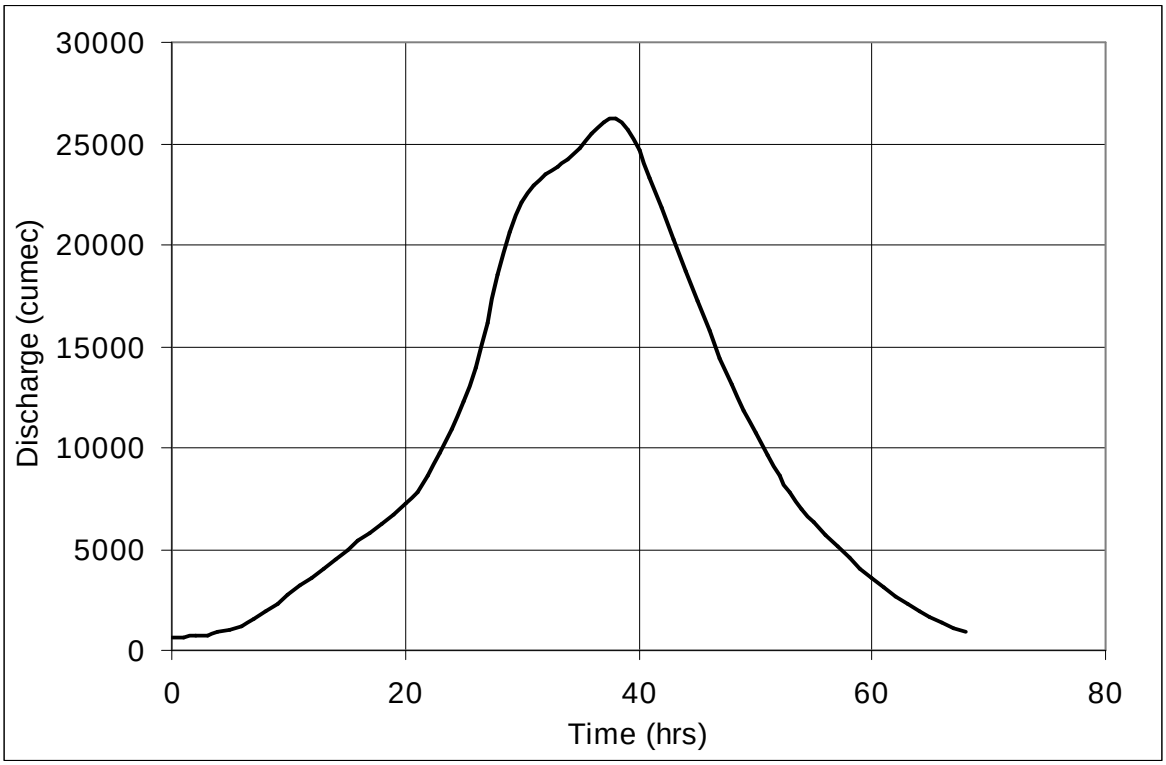

Figure 4.6 Design Flood Hydrograph at Dam site

Table 4.7 Design Flood Hydrograph at Dam site

TIME IN HOUR	PMF AT DAM SITE IN CUMEC	TIME IN HOUR	PMF AT DAM SITE IN CUMEC
0	650	36	25507
1	669	37	26030
2	712	38	26223
3	779	39	25712
4	878	40	24714
5	1026	41	23324
6	1230	42	21817
7	1527	43	20279
8	1896	44	18735
9	2302	45	17227.8
10	2732	46	15761.5
11	3176	47	14375.3
12	3617	48	13075.1
13	4050	49	11865.2
14	4488	50	10699.0
15	4934	51	9626.1
16	5381	52	8649.4
17	5811	53	7787.0
18	6252	54	6995.8
19	6709	55	6286.5
20	7203	56	5657.3
21	7844	57	5097.0
22	8661	58	4586.3
23	9690	59	4011.3
24	10884	60	3567.9
25	12333	61	3123.6
26	13988	62	2682.7
27	16133	63	2282.8
28	18527	64	1926.8
29	20676	65	1617.0
30	22148	66	1348.5
31	22945	67	1115.8
32	23483	68	911.8
33	23819		
34	24215		
35	24741		

4.10 WATER QUALITY

As per the Terms of Reference of the basin study, water quality monitoring is to be conducted at various locations in the study area for two seasons. The months in which monitoring was conducted are given as below:

- Winter season : January 2010
- Summer season : May 2010

The sampling locations covered as a part of the study are listed as below:

- 5000 m upstream of dam site
- 3000 upstream of dam site
- Dam site
- 3000 m downstream of dam site
- 5000 m downstream of dam site

The results of water quality survey conducted for the winter and summer seasons are given in **Tables 4.8 and 4.9**, respectively. The drinking water standards are given in Annexure-I.

TABLE 4.8

Results of water quality monitoring for winter season (January 2010)

Parameter	W1	W2	W3	W4	W5
pH	7.5	7.6	7.5	7.6	7.5
Electrical Conductivity, micromhos/cm	120	125	121	117	121
Total Dissolved Solids, mg/l	86	92	88	85	88
Hardness, mg/l	35	34	37	33	34
Chlorides, mg/l	10	14	12	12	14
Sulphates, mg/l	10	10	10	8	9
Phosphates, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
Nitrates, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
Sodium, mg/l	5.1	4.9	5.8	5.2	5.0
Potassium, mg/l	1.1	1.1	1.0	0.9	1.0

Parameter	W1	W2	W3	W4	W5
Calcium, mg/l	10.2	10.2	11.0	10.4	10.6
Magnesium, mg/l	2.1	2.0	2.2	1.9	1.8
Iron, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Alkalinity, mg/l	42	41	40	38	38
Copper, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Lead, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Zinc, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Chromium, mg/l	<0.05	<0.05	<0.05	<0.05	<0.05
Mercury, mg/l	<0.001	<0.001	<0.001	<0.001	<0.001
Cadmium, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
BOD, mg/l	1.1	1.1	1.1	1.4	1.1
COD, mg/l	2.0	2.1	2.0	2.5	2.0
DO, mg/l	9.5	9.5	9.6	9.4	9.5
Phenolic compounds, mg/l	BDL	BDL	BDL	BDL	BDL
Oil & Grease, mg/l	BDL	BDL	BDL	BDL	BDL
Total Coliform MPN/100 ml	Nil	Nil	Nil	Nil	Nil

TABLE 4.9

Results of water quality monitoring for summer season (May 2010)

Parameter	W1	W2	W3	W4	W5
pH	7.5	7.5	7.5	7.5	7.5
Electrical Conductivity, micromhos/cm	115	118	115	113	115
Total Dissolved Solids, mg/l	84	86	84	82	83
Hardness, mg/l	33	32	34	33	33
Chlorides, mg/l	9	11	10	10	11
Sulphates, mg/l	9	9	7	7	8
Phosphates, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
Nitrates, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
Sodium, mg/l	4.7	4.6	5.1	5.0	4.9
Potassium, mg/l	0.9	1.0	0.9	0.8	0.9
Calcium, mg/l	9.9	9.7	10.2	10.0	10.2
Magnesium, mg/l	1.9	1.8	2.0	2.0	1.9
Iron, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Alkalinity, mg/l	39	37	37	36	36
Copper, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Lead, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1

Parameter	W1	W2	W3	W4	W5
Zinc, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
Chromium, mg/l	<0.05	<0.05	<0.05	<0.05	<0.05
Mercury, mg/l	<0.001	<0.001	<0.001	<0.001	<0.001
Cadmium, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
BOD, mg/l	1.0	1.0	1.0	1.0	1.0
COD, mg/l	1.8	1.7	1.8	1.8	1.9
DO, mg/l	9.5	9.5	9.6	9.5	9.4
Phenolic compounds, mg/l	BDL	BDL	BDL	BDL	BDL
Oil & Grease, mg/l	BDL	BDL	BDL	BDL	BDL
Total Coliform MPN/100 ml	Nil	Nil	Nil	Nil	Nil

The pH level in the study area of Dibang Multipurpose Project ranged from 7.5 to 7.6 at various samples sites covered as a part of the study. The pH level indicate neutral nature of the water, and are within the permissible limit specified for meeting drinking water requirements (Refer **Annexure-I**).

The TDS level ranged from 82 to 92 mg/l which is well below the permissible limit of 500 mg/l specified for drinking water. The TDS level was found to be lower in the summer season as compared to winter season. This trend was observed for various cations and anions monitored as a part of the study. This could be attributed to higher discharges on account of snow melt in summer months.

The hardness level ranged from 32 to 37 mg/l indicating soft nature. The hardness level was well below the permissible limit of 200 mg/l specified for drinking water. Hardness is caused by divalent metallic cations. The principal hardness causing cations are calcium, magnesium, strontium and ferrous and iron. The low levels of calcium and magnesium are mainly responsible for the soft nature of water.

Alkalinity of water is a measure of its capacity to neutralize acids. The alkalinity of natural water is due primarily because of the salts of weak acids. The alkalinity was found to be higher than the total hardness in all the water sampling stations monitored

as a part of the study, which indicates that entire hardness in the water is on account of carbonate hardness and there is no bicarbonate hardness in the water.

Chlorides occur in all natural waters in widely varying concentrations, chlorides is available in natural water, mainly through solvent power of water, which dissolves chlorides from top soil and deeper formations. The chlorides level ranged from 9 to 14 mg/l, which are well below the permissible limit of 200 mg/l, specified for meeting drinking water requirements.

Sulphate ion is one of the major anions occurring in natural water. It is an important parameter because of its cathartic affect, when it is present in higher concentration. The sulphate level at various sampling stations ranged from 7 to 10 mg/l in various samples monitored as a part of the study. The sulphate was found to be well below the permissible limit of 200 mg/l specified for drinking water purposes.

The concentration of nitrates and phosphates at various sampling locations was observed to below detectable limit of 0.01 mg/l.

The concentration of various cations, e.g. sodium, potassium, calcium and magnesium was observed to be quite low which is also reflected by the low TDS level. Iron was found to be well below the permissible limit of 1 mg/l specified for drinking water purposes.

The concentration of various heavy metals was found to be well below the permissible limits. Concentration of phenolic compounds and oil & grease as expected in a region with no major sources of water pollution from domestic or industrial sources was observed to be quite low.

The BOD values are well within the permissible limits, which indicate the absence of organic pollution loading. This is mainly due to the low population density and absence of industries in the area. The low COD values also indicate the absence of chemical

pollution loading in the area. The marginal quantity of pollution load which enters river Dibang, gets diluted.

The DO level ranged from 9.4 to 9.6 mg/l at various sampling locations monitored as a part of the study. The DO levels were close to saturation limits in water, indicating the excellent quality of water in the study area.

The Total Coliform level was nil at all the sampling sites, indicating the fact that pollution loading is well within the carrying capacity of river Dibang.