International Seminar on Hydrology of Extremes

1-3 December, 1988
Roorkee (India)

ANALYSIS OF STREAMFLOW DROUGHT IN KRISHNA BASIN—A CASE STUDY

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SYNOPSIS

The study of extreme hydrologic events is of great importance because of their socio-economic impacts. A great deal of time and efforts have been spent in predicting the occurrence and quantifying the effects of hydrologic extremes. However, these efforts have been mostly directed to flood studies and relatively less attention has been paid in studying drought. However, the increasing demands on available water resources and continued failure of monsoon over past 2-3 years have made the quantification and prediction of drought essential to water resources planning.

Drought is basically a phenomenon of low hydrologic extreme, which is synonymous with water deficit or water scarcity over a significant period of time and space. The water deficit refers to the choice of analysing either precipitation, soil moisture or streamflow. The hydrologists, and water resources planners are primarily concerned about impacts due to drought (soil moisture or streamflow) than the basic cause of drought (precipitation). For that reason, the Institute launched a massive programme of undertaking hydrologic studies in drought affected states of the country. For analysing the impacts of drought on streamflow, studies were done using data of selected streamflow sites in Krishna basin and brief results of studies are presented in the present paper.

INTRODUCTION

The study of extreme hydrologic event is of great importance due to their socio-economic impacts. The extreme events of hydrologic cycle are floods and drought. Drought produces more disastrous effects than floods and usually lasts longer in more areal extent and is of creeping type. A number of definitions of drought have been given and a summary of such definitions have been given by WMO (1975). Inspite of the lack of a unified definition of drought among the community of hydrologists, meteorologists and agriculturists, all tend to agree that it is basically a situation of water deficit for given use caused due to occurrence of below normal natural water availability. The impact of drought is felt in the water supply for domestic and industrial uses, agricultural and fodder production and streamwater quantity resulting in reduction of reservoir levels, depletion of soil moisture and ground water.

Streamflow is one of the important hydrological parameters as it represents the runoff from a basin or catchment and determines the quantity of water available in various surface water resources. The precipitation deficiency is ultimately reflected in the resulted streamflow. Now only this, even the catchment characteristics, land use, vegetation etc. are also responsible for generated runoff. The drought phenomenon may be more readily studied from the hydrology of river basins for which local singularities are eliminated. The low streamflow are indicative of drought situations. When the flows are not sufficient enough to meet the required demand of water, it is considered that the drought has set in. Such low flow studies may be more useful for long duration widespread large droughts occurring in more aerial extent.

In the recent past unprecedented drought conditions have been witnessed in the country during years 1985-86, 1986-87 and 1987-88 in different parts of the country. Some parts have witnessed persistent drought for 3 years in succession. As per CWC's estimates nearly 1/3 of the country's area spread over 99 districts in 13 states is prone to drought conditions (CWC, 1982). Keeping in view the serious drought conditions, the Institute initiated studies to focus attention on hydrological aspects of drought which somehow did't receive required attention in past. Analysis of low flows for selected sites of Krishna basin has been presented in the present paper.

STUDY AREA AND DATA

Krishna basin lies between $13^{\circ}30'$ to $18^{\circ}44'$N latitude to $73^{\circ}12''$ to $81^{\circ}36'10''$E longitude, covering parts of Maharashtra, Karnataka and Andhra Pradesh States. The climate of the basin is characterised by a hot summer and general dryness during the major part of the year except during southwest monsoon. The average annual precipitation in Krishna Basin is 690 mm, of which 72 and 16 percent is received during the southwest monsoon and North east monsoon, respectively. The rest 12 percent is received during December to May.

The streamflow analysis has been based on daily streamflow data for 20 years (1966-86) for four sites of Krishna basin. These sites are Narsingpur Yadgir, Wadakwal and T.Ramapuram. The basin map is shown in figure 1. The analysis of data is presented as given below.

STREAMFLOW ANALYSIS

Streamflow is one of the important hydrological parameters as it represents the runoff from a basin or catchment and determines the quantity of water available

in various surface water resources. The drought severity, frequency and duration can be studied by analysing the gross availability of streamflows, the flow duration characteristics of river flows and the extent to which the water is available in storages. Following types of analysis were done to evaluate the drought impacts on streamflow:

i) **Hydrograph Analysis:** The flow hydrograph which represents graphical relationship between discharge and time gives an immediate feel of the river flows. The monthly flow hydrographs at the sites chosen for analysis were plotted for years 1984-85 and 1985-86. These hydrographs were compared with the discontinuous values of mean flow and minimum flow recorded during last 20 years (1966-86) (Figure 2).As can be seen from Figure 2, the hydrographs show a marked difference between the response of river flows in 1984-85 and 1985-86 and mean flows. This indicates that all the chosen sub-basins were affected by relatively severe drought situation during 1984-85 and 1985-86.

ii) **Runoff Index :** A simple index which can possibly characterise drought conditions is to compare the runoff depth or volume for a given duration with long term mean or standard period normal value for the given duration. For this purpose long term average of annual flows at the sites was worked out which was compared with the annual flows during the years of study. The results are given in Table 1. It is evident from Table 1 that the annual flows for the year 1984-85 and 1985-86 were deficient more than 25% of the normal flow values except for Narsingpur site for 1984-85 indicating year 1984-85 and 1985-86 as severe drought years for all selected sub-basins.

iii) **Low Flow Index :** The low flow regime of a river often in diagrammatic form, can be described in many forms. An event to be categorised under low flow event may be based on some threshold discharge value, an accumulated volume, a length of time spent below a threshold or a rate of recession. Similarly low flow frequency can be thought of as a proportion of time (e.g. flow duration curve) or a proportion of years that a given low flow occurs (e.g. flow frequency curve). Also, low flow may also be considered for different durations or averaging periods (e.g. 10 days or 6 months) rather than taking instant values. Out of the various measures describing low flow conditions, a common one is to construct flow duration curve. This curve which basically expresses frequency of low flow shows the relationship between any given discharge and the percentage of time that discharge is exceeded. The curve can be drawn for daily or monthly flow data or for any consecutive N days or month period. The flow duration curves for various durations (viz. 7,10,30, 60,120,360) for the site Narsing-pur is given in Fig.3. Similar graphs were also developed for the other sites.

From the various low flow measures as discussed above, some indices can be derived to characterise the low flow regime. An example of such an index is the low flow index (LFI) which is the 95 percentile 10 day flow drawn from the flow duration curve. In other words the LFI is the 10 day average flow which is exceeded 95% of time of the duration of series or,

$$LFI = (Q_{10})_{95}$$

From the flow duration curves developed for various sites, values of low flow inde: were derived and are given in Table 2.

Table -2: **Low Flow Index for chosen sites of Krishna basin**

S.No.	Site	L.F.I.($10^4 m^3/km^2$)
1.	Narsinghpur	1.264
2.	Yadgir	0.314
3.	Wadakwal	0.289
4.	T. Ramapuram	0.629

An important application of flow duration curves is in those design works which require knowledge of some minimum flows for certain proportion of time such as design and licensing of direct river abstractions. The low flow index values can be correlated with catchment characteristics which may include catchment area, climate, slope, stream frequency (no.of stream junctions per square kilometer), land use and geology of basin. Based on such correlations prediction formulae for ungauged catchments can be developed.

iv) **Low Flow Spell Analysis :** The flow duration curve gives the duration below any flow. For example in a 10 year period the 95% flow on a flow duration curve is exceeded on all but 183 days (5% x 365 x 10). However, nothing can be inferred from this fact about how these 183 days occur. These 183 days may be divided into many short spells or alternatively into fewer long spells. The analysis of such low flow spells can be carried out taking some threshold values of discharge. Based on threshold value of discharge, deficit duration (length of the period that the river spends continuously below a threshold) and deficit volume (volume which would be required to maintain flow at the threshold) can be worked out for analysis. The analysis of length of spells for which flow remains below a given threshold and also the deficit flow volume below this threshold is important for hydrological drought studies. The periods when hydrograph dips below some threshold values of interest, the associated discharge variable can be used to assess the drought severity.

Analysis for annual maximum deficiency volume of low spells and annual maximum durations of low flow spells corresponding to demand level as 10%, 30%, 50%, 70% and 90% of the average daily flow (ADF) for chosen sites in Krishna basin were performed, and the results for the selected sites are given in Tables (3,4 and 5 respectively). It is evident from these tables that the maximum deficit duration and maximum deficit volume at all demands level are higher during 1985-86 than the previous years indicating severe low flow conditions during the year 1985-86.

In order to see the effects of monsoon, similar analysis has been performed at different demand levels using daily flow data of monsoon period (1st June to 31st October) for all the sites. It was observed that during the year 1985-86 the maximum deficit volume and duration of low flow spells are higher than the previous years at different demand levels indicating, 1985-86 monsoon more affected by drought conditions.

Based on computations of maximum deficient volume and corresponding deficit duration, an index for defining drought intensity can be computed as ratio of these two computed variables. Such computations were performed for all sites and values of drought intensities have been given in Tables (6 & 7). The values of drought intensity for year 1985 clearly indicates a rather intense drought situation in 1985 as compared to previous years.

CONCLUSIONS

Reliable estimation of the low flows in a stream is desired for overall planning of water resources. Accurate prediction of the rate and duration of low flows is important to design water supply and waste water disposal works, hydraulic structures and for the determination of dilution requirements of water quality control in natural water courses.

On the basis of analysis presented above, the following conclusions can be drawn :

i) The hydrographic analysis of stream flows is the simplest technique to represent magnitude of flow, as it gives an immediate feel of magnitude of flow, by which quantitatively and qualitatively drought situation can be assessed.

ii) The runoff index provides information of runoff departure from long term mean runoff through which impact of drought on stream flow can be assessed.

iii) With the help of flow duration curves developed for the sites, the probability of occurrence of a minimum flow at the site can be established. The low flow index values can be correlated with catchment characteristics to develop prediction formulae for ungauged catchments. Also there is need to study the monthly, seasonal and annual variations of flow duration curves particularly for assessing the impact of drought on stream flow regime.

iv) The analysis of length of spells for which stream flow remains below a given threshold and also the deficit flow volume below this threshold is important in hydrological drought studies. The deficit duration and deficit volume analysis at different demand level has indicated that the maximum duration and maximum deficit volume in different low flow spells were highest for 1985-86 as compared with previous years. The similar analysis carried out for only monsoon period confirmed the same results. Also, drought intensities during year 1985 are more as compared to previous years. However, at some demand levels erratic nature of drought intensity may be due to non-coincedence of maximum deficit duration corresponding to maximum deficit volume.

v) The methodology and indices defined here will be suitable for application in various hydrological situations. Such studies should be carried out using the flow data of various sub-basin located in the drought prone areas in order to study the stream flow drought alongwith the studying the rainfall pattern, impact on ground water regime etc.

ACKNOWLEDGEMENT

The authors wish to thank Dr. Satish Chandra, Director, National Institute of Hydrology, Roorkee, for his constant encouragement in carrying out this study. Thanks are also due to the authorities of C.W.C. who have provided required data for the study.

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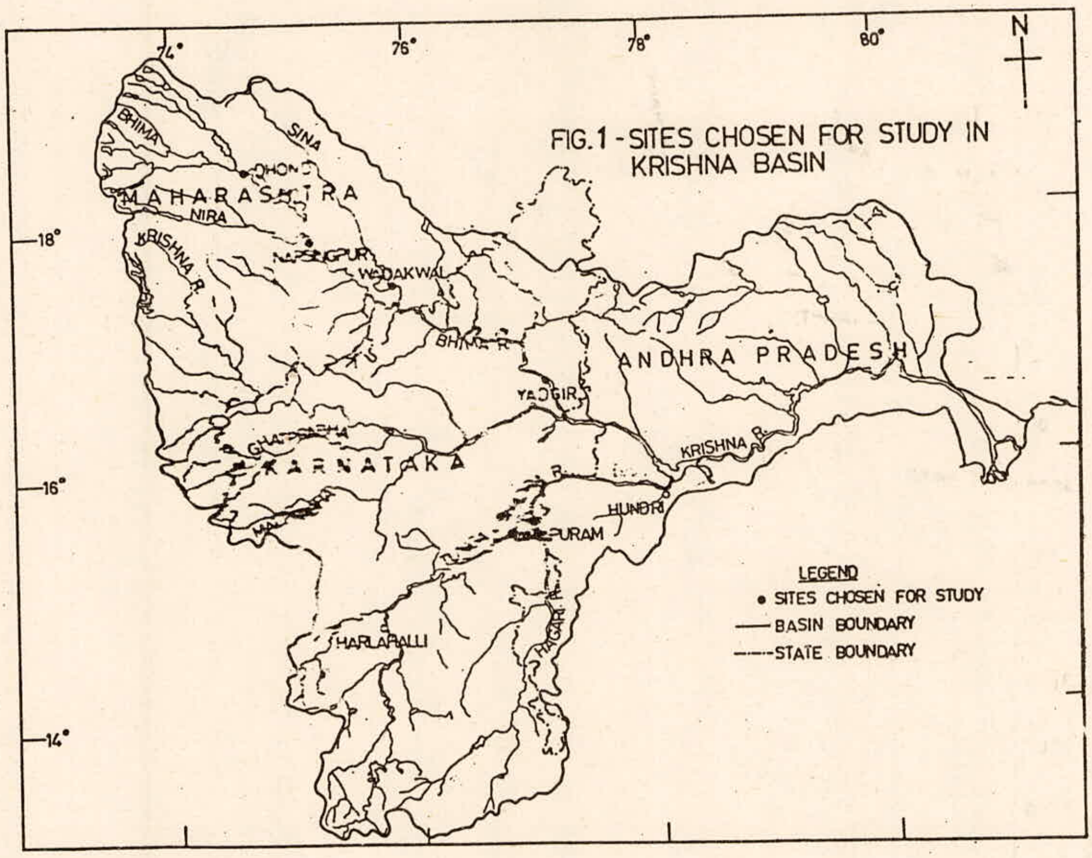

FIG.1 - SITES CHOSEN FOR STUDY IN KRISHNA BASIN

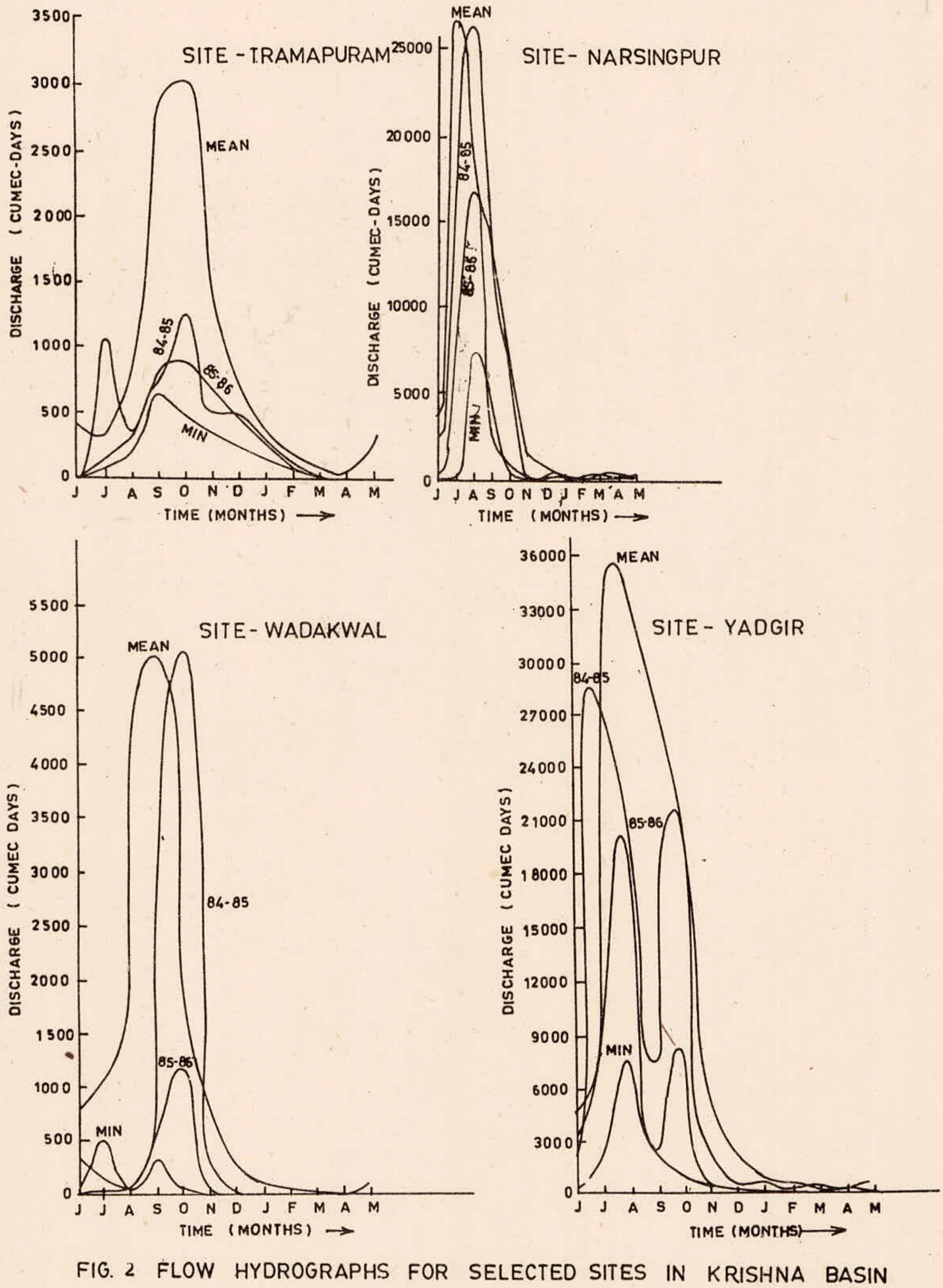

FIG. 2 FLOW HYDROGRAPHS FOR SELECTED SITES IN KRISHNA BASIN

TABLE 1: DEVIATION OF ANNUAL FLOWS FROM LONG TERM AVERAGE FLOWS

Sl. No.	Year	Narsingpur % Departure	Yadgir % Departure	Wadakbal % Departure	T. Ramapuram % Departure
1.	1965-66		- 7.52	- 17.57	
2.	66-67		- 27.34	- 22.72	- 2.50
3.	67-68	+ [illegible].66	+ 5[illegible].19	+ [illegible]1.60	- 49.80
4.	68-69	- 20.88	- 2[illegible].34	- 38.02	+ 20.46
5.	69-70	+ 60.73	+ 40.25	+1[illegible]3.82	- 14.74
6.	70-71	- 0.92	+ 2.87	+ 73.13	+ 15.59
7.	71-72	+ 13.47	+ 0.98	+ 24.47	+ 17.51
8.	72-73	- 52.32	- 69.90	- 89.78	- 33.40
9.	73-74	+ 27.27	+ 31.73	+ 37.80	+ 17.10
10.	74-75	- 8.82	+ 7.45	+ 19.55	+ 19.60
11.	75-76	+ 22.97	+101.19	+101.72	+169.25
12.	76-77	- 64.70	+ 18.59	- 76.35	- 55.25
13.	77-78	- 6.44	- 20.29	- 40.38	+ 1.63
14.	78-79	- 6.18	- 19.31	- 15.66	+ 20.94
15.	79-80	+ 8.90	+ 18.15	+ 20.25	- 14.62
16.	80-81	+ 13.52	- 22.06	- 17.02	- 40.15
17.	81-82	+ 20.52	+ 21.23	- 46.77	+ 67.38
18.	82-83	- 59.36	- 60.53	- 87.04	- 5.16
19.	83-84	+ 2.51	+ 38.05	+145.48	- 16.02
20.	84-85	- 21.76	- 29.91	- 46.58	- 53.39
21.	85-86	- 60.50	- 64.08	- 80.96	- 64.34

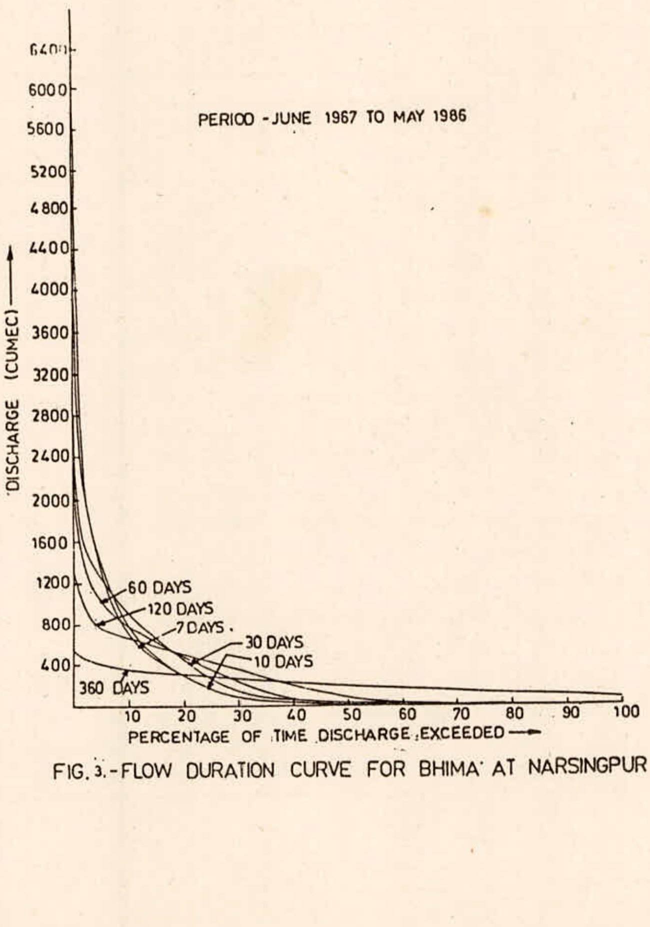

FIG. 3.- FLOW DURATION CURVE FOR BHIMA AT NARSINGPUR

TABLE 3: ANNUAL MAXIMUM DEFICIENCY VOLUME OF LOW FLOW SPELLS

Threshold % average daily flow	Volume in cumec days									
	10%		30%		50%		70%		90%	
Period	N	W	N	W	N	W	N	W	N	W
1967-68	1729.69	108.14	8080.92	793.76	14652.69	1388.93	21402.85	1990.51	28134.93	2592.60
1968-69	2536.95	434.98	11118.50	1735.29	20049.60	3110.43	29161.22	4490.53	38288.11	5884.87
1969-70	1969.06	203.36	9895.93	1155.26	19880.79	2560.62	30208.30	3925.15	40234.58	5299.55
1970-71	2234.60	286.47	10867.47	1424.81	19651.06	2763.45	28466.86	4179.31	37502.16	5634.31
1971-72	2359.48	371.87	10642.61	1617.46	19268.76	2994.93	27955.70	4424.33	36665.23	5881.64
1972-73	3331.38	701.26	11560.08	2131.98	19857.41	3571.45	28192.34	5010.91	43518.93	7727.23
1973-74	1782.18	307.47	9105.98	1438.17	17424.74	2714.64	25795.65	4050.82	34255.97	5467.88
1974-75	463.07	268.50	7125.83	1309.05	14834.83	2580.64	22887.29	3922.49	31075.93	5295.66
1975-76	1696.23	140.27	8267.25	700.33	15900.55	2020.73	24110.75	3304.63	32436.75	4633.10
1976-77	1834.63	615.37	8623.35	2289.68	19230.29	3924.40	28714.62	5696.69	38718.16	7412.97
1977-78	157.29	255.01	2843.60	1184.73	11062.23	2288.80	17942.41	3361.24	24982.86	4501.76
1978-79	2107.92	392.43	9092.29	1604.84	19654.32	2919.74	25039.69	4267.06	33174.25	5631.20
1979-80	1489.06	139.67	6484.60	823.76	13229.69	1845.90	20370.41	2957.09	27642.59	4125.17
1980-81	1845.91	332.61	11359.94	1941.23	20587.62	2169.26	29902.82	3075.85	39399.82	3982.44
1981-82	1173.30	466.32	4752.58	1941.23	18552.52	3377.16	28441.30	4824.06	37838.68	6277.37
1982-83	1761.78	851.85	10633.85	2025.55	21341.40	3417.25	31078.85	4815.19	40316.29	6218.97
1983-84	627.69	322.50	9277.27	1508.33	19211.04	2827.54	28307.32	4200.57	37403.62	5604.34
1984-85	996.49	597.81	9785.94	1951.94	18361.30	3358.68	26955.41	4758.84	37381.69	6169.14
1985-86	1009.21	425.73	11780.60	2313.23	21254.13	3927.89	30751.12	5547.28	40248.15	7169.82

* N = Narsingpur

* W = Wadakual

TABLE 4: ANNUAL MAXIMUM DEFICIENCY VOLUME OF LOW FLOW SPELLS

Threshold % average daily flow	Volume in cumec days									
	10%		30%		50%		70%		90%	
Period	T	Y	T	Y	T	Y	T	Y	T	Y
1967-68	38.73	2153.00	671.49	12441.85	1560.78	23313.05	2464.35	34396.99	3612.75	45612.17
1968-69	52.94	3947.55	308.08	16594.70	751.13	30233.81	1215.26	46006.62	1707.19	61283.20
1969-70	21.13	3233.67	346.66	14953.34	742.03	29288.61	1385.56	44079.83	1963.27	58954.85
1970-71	42.17	3427.91	465.62	16750.97	1515.04	34433.80	2347.55	46575.18	3188.42	61948.47
1971-72	110.02	3634.32	693.85	16739.58	1369.98	30986.24	2110.88	45609.08	2882.28	60359.18
1972-73	139.26	6381.38	681.56	20251.51	1590.57	39586.23	2310.29	56949.23	3032.27	74359.27
1973-74	61.68	2767.72	482.24	14263.94	1114.86	27307.22	2833.29	40764.17	2957.98	54659.79
1974-75	67.38	1716.08	462.48	10228.22	1028.91	24417.03	1739.59	37655.57	2441.36	51382.00
1975-76	22.21	1848.42	182.18	10741.22	574.20	22464.93	1026.73	35153.72	1536.36	48441.11
1976-77	58.75	3508.47	503.80	17190.75	1366.25	33030.39	2439.62	49343.74	3655.35	66376.64
1977-78	52.96	494.29	407.84	8130.41	1026.68	16036.28	2034.11	23975.19	2987.85	44416.28
1978-79	45.06	2599.81	537.73	12639.62	1079.18	24227.54	1629.55	36405.59	2592.98	53270.11
1979-80	34.01	2341.62	325.74	10380.28	855.46	21376.24	2102.50	33256.38	3083.62	45469.93
1980-81	70.71	3895.71	517.22	18864.04	1112.23	34539.59	1719.10	50847.04	2342.57	67281.94
1981-82	17.97	2373.53	325.35	12934.13	986.13	25973.92	1559.58	39363.69	2905.95	55720.43
1982-83	91.29	4824.50	583.22	18093.78	1149.23	31747.53	1943.47	45569.93	2699.24	49429.17
1983-84	57.51	2825.27	321.35	15430.62	1422.09	29446.91	2349.38	44192.24	3374.09	49220.62
1984-85	185.34	2540.47	833.47	17415.41	1571.61	31788.52	2668.02	46419.79	3658.42	61322.63
1985-86	292.95	6224.43	919.23	21762.82	1670.79	37707.89	2427.16	53768.77	3188.61	69913.22

* T = T.Ramapuram

* Y = Yadgir

TABLE 5: ANNUAL MAXIMUM DURATION OF LOW SPELLS

Threshold limit % average daily flow	Duration in days																			
	10%				30%				50%				70%				90%			
	N.	W	T	Y	N.	W	T	Y	N	W	T	Y	N	W	T	Y	N	W	T	Y
1967-68	129	38	33	81	164	86	118	154	164	86	148	158	168	87	157	160	168	87	170	162
68-69	191	166	36	164	222	197	70	192	223	200	81	201	227	200	81	218	228	201	88	220
69-70	144	95	22	135	200	160	69	181	234	195	69	211	250	198	99	213	257	199	103	214
70-71	173	129	35	162	218	181	96	205	220	201	145	215	220	207	146	219	225	213	147	222
71-72	189	145	65	152	211	193	111	200	216	204	119	208	217	209	132	211	218	212	136	212
72-73	203	206	65	196	207	208	97	201	208	208	125	[illegible]	208	208	126	250	256	253	126	251
73-74	164	129	52	113	193	178	72	176	207	192	102	190	210	194	145	196	212	203	170	202
74-75	69	98	46	95	187	174	85	125	198	190	104	186	203	197	120	196	206	200	124	298
75-76	143	46	14	92	176	92	43	162	202	180	72	174	206	190	84	187	208	194	90	193
76-77-	129	197	44	130	189	135	98	223	234	234	158	231	237	248	191	236	247	248	205	246
77-78	16	70	44	30	92	147	73	113	196	158	111	114	174	163	158	114	177	167	172	171
78-79	168	150	41	117	181	185	94	157	199	192	95	172	203	196	97	176	203	199	143	197
79-80	116	51	22	97	131	132	72	131	176	157	106	167	180	165	165	173	182	172	174	178
80-81	151	118	34	157	228	130	86	223	232	131	105	231	237	131	107	236	237	131	110	236
81-82	81	158	18	108	102	206	70	179	233	209	97	191	242	210	163	194	242	210	165	224
82-83	136	195	43	182	203	200	97	195	243	202	101	198	243	202	130	199	243	203	132	199
83-84	74	103	34	140	205	180	57	194	227	195	143	205	227	201	172	213	227	207	183	216
84-85	103	189	93	140	214	197	126	204	214	202	132	207	215	203	169	214	230	204	174	214
85-86	70	135	98	219	236	232	130	226	237	234	132	230	237	234	132	231	237	235	133	232

* N = Narsingpur A.D.F. = 200.4 Cumec * T = T.Ramapuram A.D.F. = 28.4 Cumec

* W = Wadakual A.D.F. = 34.6 Cumec * Y = Yadgir A.D.F. = 384.2 Cumec

TABLE 6: DROUGHT INTENSITY IN DIFFERENT LOW FLOW SPELLS

Threshold Unit & ADF Year	Drought intensity in Cumecs								Cumecs
	10%		30%		50%		70%		90%
	W	N	W	N	W	N	W	N	W	N
1967	7.26	38.47	17.20	119.86	31.01	208.21	45.64	266.09	58.44	358.97
1968	3.35	40.09	16.90	81.81	29.65	162.78	44.28	214.69	58.91	300.49
1969	5.14	39.94	13.39	108.07	27.80	166.74	42.44	259.62	57.07	352.48
1970	3.41	21.57	13.51	98.15	24.27	191.03	38.91	283.91	48.99	376.78
1971	6.20	30.03	20.48	102.81	34.71	195.68	49.34	275.09	63.98	367.97
1972	6.52	40.84	19.86	115.59	34.51	200.12	49.14	287.14	63.77	380.02
1973	4.55	36.27	16.85	110.58	29.81	210.31	43.05	271.44	55.36	364.32
1974	5.39	35.10	14.68	124.67	28.47	196.53	42.25	289.42	55.60	382.30
1975	6.79	17.17	18.57	98.72	33.20	176.00	47.83	246.78	56.81	331.30
1976	7.12	17.41	17.50	91.48	31.28	140.51	42.76	221.58	57.89	303.71
1977	5.76	35.89	19.78	111.50	29.18	204.38	43.81	286.65	58.45	379.52
1978	2.70	12.36	11.61	101.54	26.90	159.08	40.31	251.96	54.95	338.02
1979	7.26	35.59	21.15	123.10	35.78	215.98	50.41	272.10	65.05	359.63
1980	2.51	35.59	13.41	94.80	27.02	168.65	41.06	261.53	55.70	366.20
1981	6.36	18.60	19.70	90.93	33.53	172.28	46.62	257.50	61.25	330.74
1982	6.65	40.75	20.77	133.62	33.05	226.50	47.68	309.76	62.18	372.30
1983	7.04	35.93	21.68	125.22	36.31	218.10	50.94	303.76	65.58	348.80
1984	7.31	31.97	21.95	124.85	36.58	158.65	48.65	251.52	62.29	344.40
1985	6.59	38.41	21.22	131.22	34.41	224.10	46.79	306.13	61.71	394.78

*N = Narsingpur *W = Wadakwal

TABLE 7: DROUGHT INTENSITY IN DIFFERENT LOW FLOW SPELLS

Threshold Unit & ADF Year	Drought intensity in Cumecs									
	10%		30%		50%		70%		90%	
	T	Y	T	Y	T	Y	T	Y	T	Y
1967	2.92	71.49	8.70	223.53	15.97	245.56	24.37	440.40	33.50	592.44
1968	1.68	71.08	10.35	145.97	19.57	292.06	29.40	414.68	37.93	566.72
1969	2.04	47.98	9.23	160.83	12.87	304.80	22.35	421.62	32.17	573.66
1970	1.55	9.63	9.60	61.59	16.48	270.50	24.39	408.14	34.09	560.18
1971	2.29	27,35	9.08	152.02	17.23	239.46	27.06	359.74	36.89	494.40
1972	1.72	63.95	8.28	215.99	17.25	368.03	25.54	520.07	34.93	672.11
1973	4.81	76.02	6.98	188.17	14.25	340.21	23.51	361.40	32.82	630.02
1974	2.50	21.62	10.36	114.72	18.71	224.16	28.54	376.20	38.37	499.27
1975	1.92	61.55	9.54	133.93	19.39	266.48	29.22	384.25	39.05	536.29
1976	4.50	75.43	8.67	107.13	16.93	207.40	24.35	314.49	29.37	457.49
1977	1.33	52.48	9.36	171.18	18.84	283.94	27.83	403.10	32.47	457.33
1978	2.91	12.55	11.27	121.31	21.10	212.20	30.92	354.13	40.75	506.17
1979	2.21	55.35	11.42	186.32	18.16	346.88	27.99	498.91	37.82	601.25
1980	3.03	73.05	10.93	133.01	16.16	260.14	25.99	380.87	34.75	532.91
1981	2.34	63.02	10.34	215.05	18.01	367.09	27.84	260.42	35.78	394.20
1982	2.30	42.77	12.57	159.44	22.40	305.93	21.03	257.98	30.86	595.72
1983	2.57	60.35	10.87	212.39	20.22	364.43	29.58	476.74	39.41	668.50
1984	4.56	67.02	14.39	219.05	24.22	361.54	34.04	457.17	43.87	609.21
1985	4.72	56.32	14.02	144.85	23.25	289.99	33.08	454.31	42.91	606.35

*T = T. Ramapuram
*Y = Yadgir