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REPRESENTATIVE BASIN STUDIES: CHANGES IN LANDUSE/COVER AND ESTABLISHMENT OF SCS RUNOFF CURVE NUMBER FOR SUDDAGEDDA BASIN, A.P.

आपो हि ष्ठा मयोभुवः

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ABSTRACT

The landuse/cover are the most important surface characteristics of a basin. They are very dynamic features over space and time and it is difficult to get real time information through conventional means. For economic development of a region/basin, planners need to update knowledge of natural resources, which can be obtained quickly, economically and accurately through only remote sensing technique. Further, the landuse map of a basin/region provides hydrologically significant categories, which are essential prerequisite for estimation of reliable runoff from the basin, especially in ungauged basin.

As a part of representative basin studies, the hydrological landuse/cover mapping has been carried out through visual interpretation for the years December 1987, April 1989, December 1992 and November 1996 using IRS 1B-LISS II, LANDSAT 5-TM and IRS 1C-LISS III data. There is no much significant changes in landuse from the year 1987 to 1996. This landuse/cover maps along with soil map of the basin, the SCS runoff curve number has been established for these years and the same has been used for estimating surface runoff from the basin. Furthermore, the estimated surface runoff is compared with synthetic unit hydrograph method (CWC, 1987). The study reveals that the estimated CN of the basin could be used when there is no adequate hydrological data available.

1.0 INTRODUCTION

The understanding of the sources of water at or under the earth's surface and its consequent movement back to principal storage in the Oceans through various pathways is very important for all engineering hydrologists. In order to quantify various components of hydrological cycle, a basinwise approach is identified as appropriate hydrological unit. For hydrological studies large quantity of data are to be monitored and recorded properly. This needs very dense network of instrumentation in the basin. In order to overcome this problem the representative basin approach has been adopted by various countries. As defined by Toebes and Ouryvaeu (1970) representative basins are basins, which are selected as representative of a hydrological region i.e. a region within which hydrological similarity is presumed. They are used for intensive investigations of specific problems of the hydrological cycle (or part there of) under relatively stable natural conditions. Thus, a sparse network of representative basin may reflect general hydrological features of a given region and their variations over large natural zones.

A new means of research is being established in a growing number and within the scope of comprehensive investigations extending to large regions the network of representative area is formed (Szesztay, 1965). More details of representative basin in general and particularly about Suddagedda basin are discussed by Vijaykumar, et. al. (1993). The conventional method of interpreting past records for future probability of occurrence needs reconsideration, since it is well established that accounting for landuse/cover conditions is extremely important to a proper assessment of runoff. The role of remote sensing in runoff estimations has been generally to provide a source of input data for determining the values of coefficients and model parameters. Most of the works in adopting remote sensing to hydrologic modeling has been with the Soil Conservation Services (SCS) runoff Curve Number (CN) models. The empirical SCS-CN model has found widespread appeal for satellite data use because the major input parameters are defined in terms of land use and soil type and do not require hydrological data for calibration (Harveg, 1984; Engman, 1991). Many researchers (Jackson et. al., 1976; Chandhra and Sharma, 1978; Hawkins, 1975) have successfully used SCS-CN method for estimating surface runoff from small and medium sized catchments.

As a part of representative basin studies various studies have been carried out in the basin by Satyaji Rao, et. al. (1997 and 1998) and Sudheer et.al. (1998). In continuation of this program the hydrological landuse/cover mapping has been carried out using remote sensing technique. The remote sensing technique has been successfully used by a number of researchers for preparing landuse/cover maps (Bhar, et. al., 1986; Choubey, 1988; Goutham, et. al., 1983; Roy et. al., 1985; Satyaji Rao and Seethapathi, 1997; Kachhwaha, 1992) and many others. The basin landuse/cover maps and hydrological soil map of the basin have been used to establish the SCS Runoff curve number for the basin. These curve numbers have been used to estimate surface runoff from the basin and the same has been compared with synthetic unit hydrograph method (CWC, 1987).

2.0 THE STUDY AREA & DATA AVAILABILITY

2.1 The study area

Suddagedda is a typical east flowing river lying between rivers Godavari and Mahanadi and having its origin in Eastern Ghats and joining the Bay of Bengal without forming any delta. The basin lies between latitudes 17^0 09' 10" and 17^0 30' 45"N and longitudes 82^0 08'30" and 82^0 19'15"E. The study area is demarcated by the 20m and 720m contours, sloping towards south-south east. The total catchment area is 658 sq. km upto the river mouth. However, in the present study the catchment area of 337 sq. km upstream of Gollaprolu only has been considered. The catchment is ungauged and experiences frequent flood and land inundation. The location of the basin is shown in Fig.1.

2.1.1 Drainage

The stream origins at Vatangi reserved forest area in Rajavommangi mandal of East Godavari Dist., Andhra Pradesh at an elevation of 720m and flows southward and is joined by many rivulets on its way near Gokavaram where a reservoir called Subbareddy Sagar is constructed. Further, traveling southwards it is joined on its left bank by Konda Kalva near Tatiparthi village and is called 'Suddagedda River'. The drainage pattern in the basin is denditric in the upstream of the basin. However, the drainage pattern is not clear in the downstream side. The drainage network map of the basin upto Gollaprolu is shown in Figure 2.

2.1.2 Hydrogeology

Khondalites, Granites and Charnokites underlie a major portion in the basin. The central and western parts of the basin are underlain by alluvium. The southern part of the basin is underlain by Khondalite, basaltic formation of Tirupathi sandstones. Groundwater in the crystalline rock is restricted to weathered and fractured zones and is being exploited mostly by dugwells, dug-cum borewells (SGWD,1993).

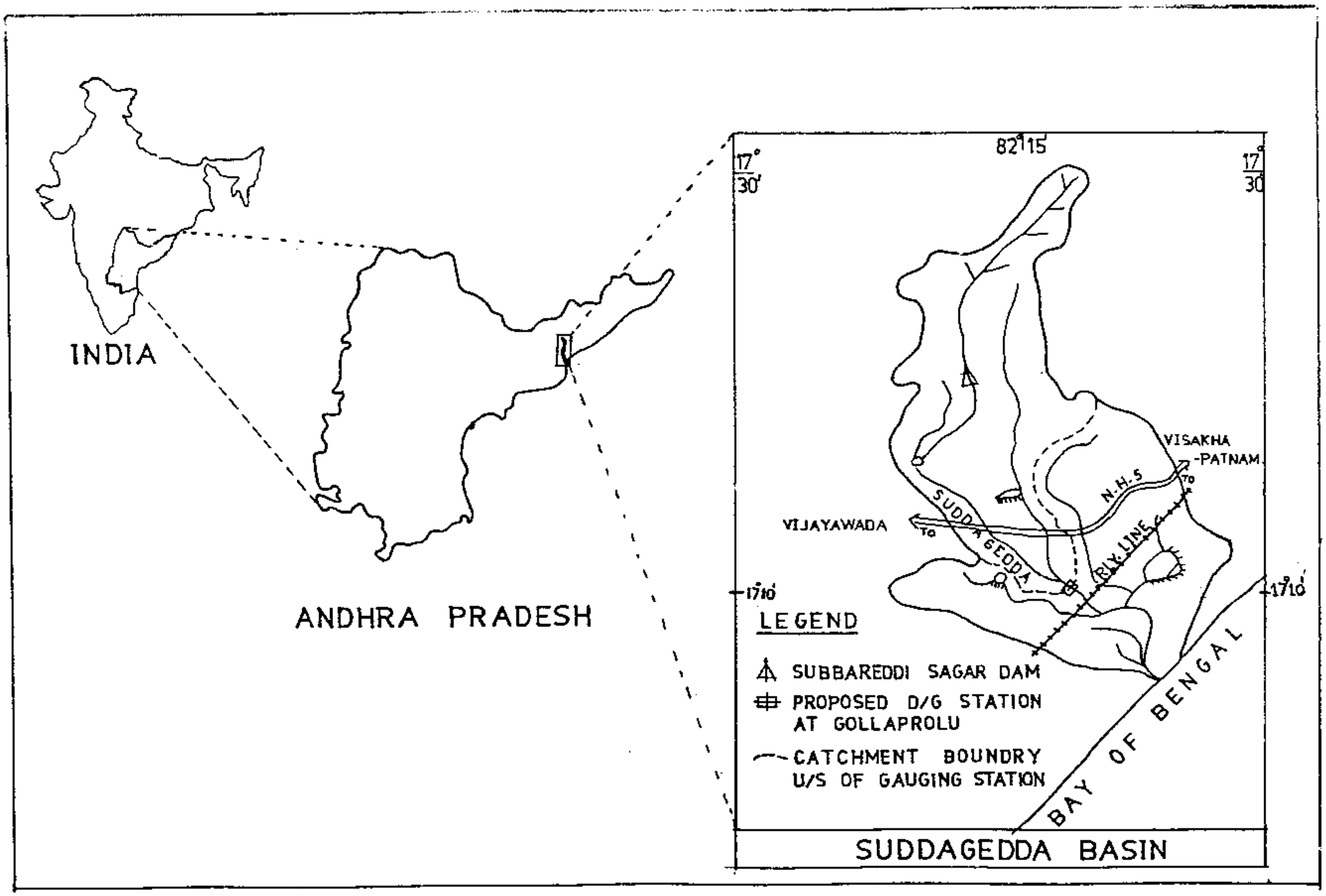
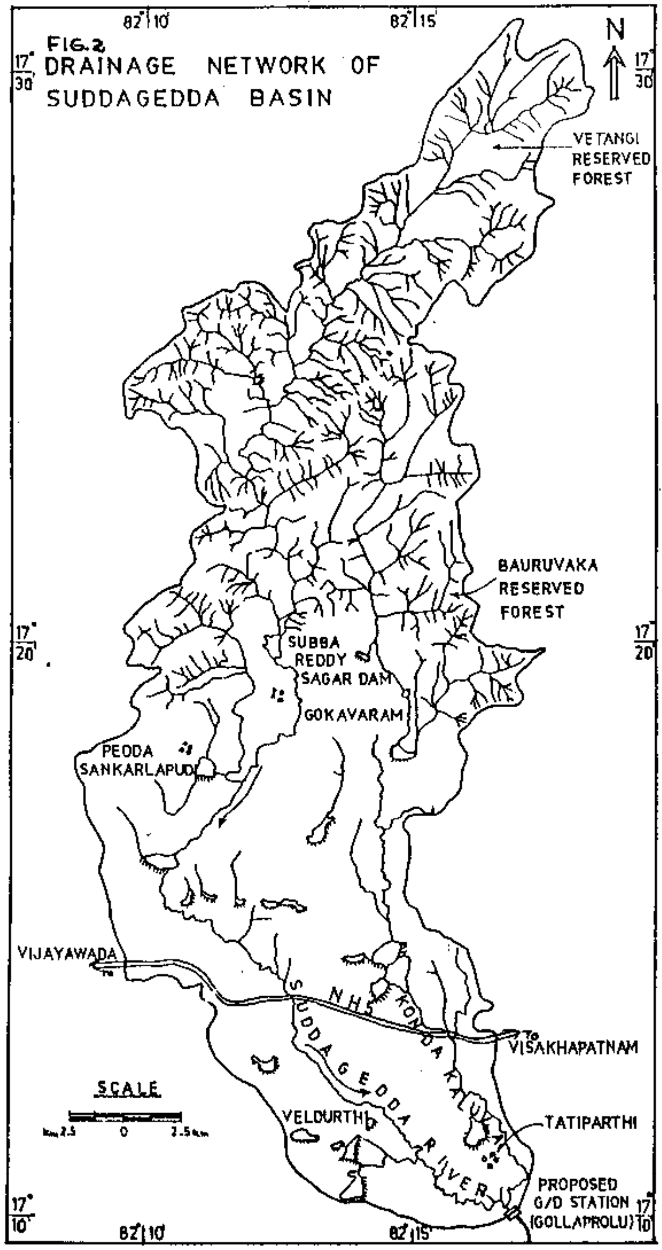


FIG.1 LOCATION MAP OF THE BASIN


82°10'
82°15'
FIG.2
DRAINAGE NETWORK OF
SUDDAGEDDA BASIN
N
17°30'
VETANGI
RESERVED
FOREST
BAURUVAKA
RESERVED
FOREST
17°20'
SUBBA
REDDY
SAGAR DAM
GOKAVARAM
PEDDA
SANKARLAPUDI
VIJAYAWADA
NH5
KONDA KALUVA
SUDDAGEDDA RIVER
TO VISAKHAPATNAM
SCALE
Km 2.5 0 2.5 Km
VELDURTHI
TATIPARTHI
PROPOSED
G/D STATION
(GOLLAPROLU)
17°10'

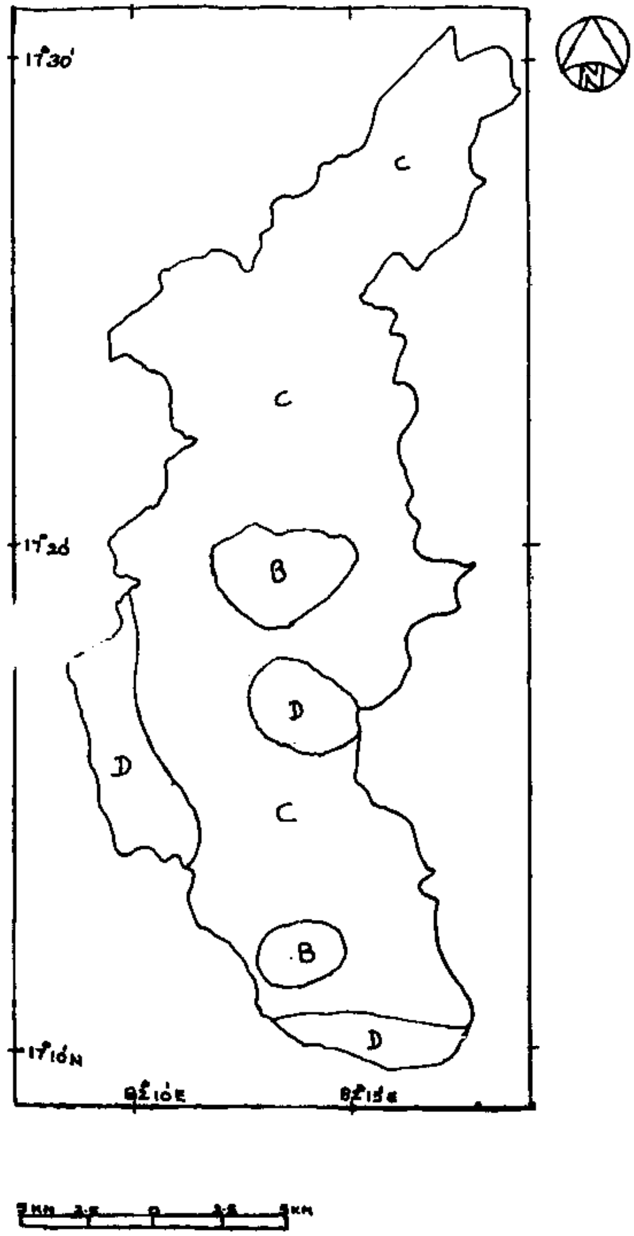


FIG. 3 HYDROLOGICAL SOIL CLASSIFICATION OF SUDDAGEDDA BASIN (SCS)

2.1.3 Soil and Land use

The predominant soils in the basin are black clay, red and light brown red soils. Towards the northern part of the basin, red soils are predominant in the hilly tracts and valley portions, whereas in the middle part of the basin light brown soils and in southern part black soils are predominant. The main crops are paddy, banana, sugarcane, chilly and cotton. The total area irrigated under surface water sources is 70 sq.km, out of which an extent of 18 sq. km is under minor irrigation tanks. The forest area covered at the upstream of the basin is approximately 145 sq.km (SGWD, 1993). The hydrological soil classification of the basin is shown in Figure 3.

2.1.4 Climate

The basin falls under tropical climate with hot summers and cold winters. The basin receives about 80% of the annual rainfall during the monsoon season (June-October). The region experiences four distinct seasons of climate viz., winter season (Nov-February), summer season (March-May), Southwest monsoon season (June-October) and post monsoon season (Nov-Dec). May is the hottest month with maximum daily temperature touching 40^0C. December is the coldest month with minimum temperature falling to 16^0C.

2.2 Data availability

The landuse/cover maps of the basin for different years have been prepared with the satellite data presented in Table 1.

Table 1. Details of satellite data used in the study.

Sl. NO.	Date	Path/Row	Satellite/Sensor	Product	Scale
1	29-12-87	141/48	LANDSAT 5-TM	Std FCC	1:250,000
2	09-04-89	22/56	IRS 1B-LISS II	-do-	-do-
3	22-12-92	22/56	IRS 1B-LISS II	-do-	-do-
4	18-11-96	103/60	IRS 1C, LISS III	-do-	-do-

The above data together with conventional data such as Survey of India toposheets 65K/3, K/4, K/7, K/8 and K/12, morphological parameters of the basin, hydrological soil map of the basin and other reference material about the basin have been used in the present study.

3.0 STATEMENT OF THE PROBLEM

Landuse/cover characteristics of a basin have a significant influence on the quality and quantity of runoff available from it. Various hydrological processes such as infiltration, evapotranspiration, soil moisture status, etc., are influenced by landuse/cover characteristics of a basin. Thus, it may form an important input to hydrologic models. Hydrologic phenomena are highly dynamic in nature and as such landuse/cover information may be required at frequent intervals for making hydrologic inferences. Remote sensing methods especially after the advent of satellites with various sensors have proved to be advantageous because of the capability to obtain synoptic and repetitive view of the area in the various bands of Electro-magnetic spectrum.

In this report the hydrological landuse/cover mapping of Suddagedda basin for various years have been carried out as a part of representative basin studies conducted by the Deltaic Regional Centre of NIH, Kakinada. The basin is ungauged and experiences frequent flood and land inundation. Therefore it is proposed to estimate surface runoff from the basin using SCS-CN model. Furthermore, the estimated surface runoff is also compared with synthetic unit hydrograph method. The estimated curve number for the basin is useful for estimation of surface runoff depth when adequate hydrological information is not available for the basin.

4.0 METHODOLOGY

The generation of remotely sensed data/image by various sensors flown aboard different platforms at varying heights above the terrain, at different times of the day and the year, does not lead to a simple landuse classification system. To date, the most successful attempt in developing a general classification has been attempted by Anderson et. al. (1976). However, for hydrological purposes, it can be modified to suite the requirements. The SCS classification scheme is adopted for preparing landuse/cover maps of the Suddagedda basin for the years December 1987, April 1989, December 1992 and November 1996. The classification includes poor crop, good crop, current fallow land, water bodies, forest and open land. These maps are compared for landuse/cover change detection in the basin. The morphometric analysis has been carried out in the basin, and estimated linear, areal and relief aspects of the basin on 1:50000 scale, Survey of India toposheets (Satyaji Rao, et. al. 1998). Intensive field experiments have been conducted in the basin (Infiltration tests, insitu permeability tests, sieve analysis) and hydrological soil map has been prepared (B, C, D Groups) according to SCS method (Sudheer et. al., 1998). The landuse maps of these years alongwith soil map of the basin have been used to estimate average curve number (CN) of the basin. The AMC III conditions and initial abstractions of 0.3S have been considered in the study. The following equation has been used to estimate surface runoff from the basin (USDA, 1972).

$$Q = (P - 0.3S)^2 / (P + 0.7\,S) \qquad (1)$$

Where

Q = surface runoff depth in cm.

P = areal rainfall in cm.

S = dimensionless index as expressed by Curve Number = (2540/CN) – 25.4

The estimated runoff (SCS-CN model) is compared with synthetic unit hydrograph method (CWC, 1987).

4.1 Procedure for surface runoff estimation by synthetic unit hydrograph (SUH) method

The following steps are to be carried out to estimate the design flood peak and flood hydrograph.

1. Preparation of catchment area plan of the ungauged catchment.
2. Determination of physiographic parameters viz.: the catchment area (A), the length of the longest stream (L), L_c the length of the longest stream opposite the C.G to point of study (upto Gollaprolu) and equivalent stream slope (S).
3. Determination of 1-hour synthetic unit hydrograph parameters i.e. peak discharge per sq. km. (q_p), the peak discharge of the basin (Q_p), the basin lag (t_p), the peak time of U.G (T_m), widths of the unit hydrograph at 50% and 75% of Q_p (W_{50} and W_{75}), widths of the rising limb of U.G at 50% and 75% of Q_p (W_{R50} and W_{R75}) and time base of unit hydrograph (T_B).
4. Drawing of a synthetic unitgraph
5. Estimation of design storm duration (T_D)
6. Estimation of point rainfall and areal rainfall for design storm duration (T_D)
7. Distribution of areal rainfall during design storm duration (T_D) to obtain rainfall increments for unit duration intervals.
8. Estimation of effective rainfall units after subtraction of prescribed design loss rate from rainfall increments
9. Estimation of baseflow
10. Computation of design flood peak
11. Computation of design flood hydrograph.

5.0 RESULTS AND DISCUSSIONS

In preparation of landuse/cover mapping the visual image interpretation technique has been used in the study. The landuse/cover classification includes poor crop, good crop, current fallow land, water bodies, forest and open land. The IRS 1C-LISS III satellite FCC print for the year November 1996 along with drainage network over lay is shown in Fig. 4. The landuse/cover maps of basin in the years December 1987, April 1989, December 1992, November 1996 are shown in Fig. 5, 6, 7 and 8 respectively. The area of each land use is measured with digital planimeter and grid paper. Further, these landuse/cover maps along with soil map of the basin have been used to estimate SCS runoff curve number for each combination of landuse and soil group in the basin. The details of landuse/cover, soil and SCS runoff curve number for AMC I, AMC II, AMC III conditions are shown in Table 2

Table 2. Landuse, soil type and corresponding curve numbers in the basin.

Land Use	Soil Group	Area (sq.km.)				Curve Number (CN)		
		Dec.1987	Apr.1989	Dec.1992	Nov.1996	AMC II	AMC I	AMC III
Poor Crop	B	10.0	8.80	12.0	10.5	76	58	89
	C	70.25	54.75	51.12	70.00	82	66	92
	D	23.13	21.25	9.87	15.50	84	68	93
Good Crop	B	0.5	0.50	0.0	0.00	72	53	86
	C	17.5	9.50	17.5	19.94	78	60	90
	D	8.75	8.75	8.75	8.0	82	66	92
Current Fallow	B	1.06	3.88	1.75	3.75	79	62	91
	C	19.38	33.0	53.12	21.83	85	70	94
	D	7.25	9.38	20.0	15.63	88	75	95
Water Bodies	B	1.13	0.50	0.63	0.63	95	87	98
	C	3.0	0.75	1.50	0.75	95	87	98
	D	1.13	0.63	1.12	1.25	95	87	98
Forest	B	6.88	5.0	6.87	5.63	40	22	60
	C	141.37	140.0	131.3	136.75	58	38	76
	D	1.88	3.13	3.37	2.38	61	41	78
Open land	B	1.75	2.38	0.25	1.00	44	25	64
	C	21.45	33.57	16.62	22.2	60	40	78
	D	0.63	0.50	1.18	0.25	64	44	81
Average CN AMC I		52	51	53	52			
Average CN AMC II		70	69	71	70			
Average CN AMC III		84	83	85	84			

SUDDAGEDDA BASIN

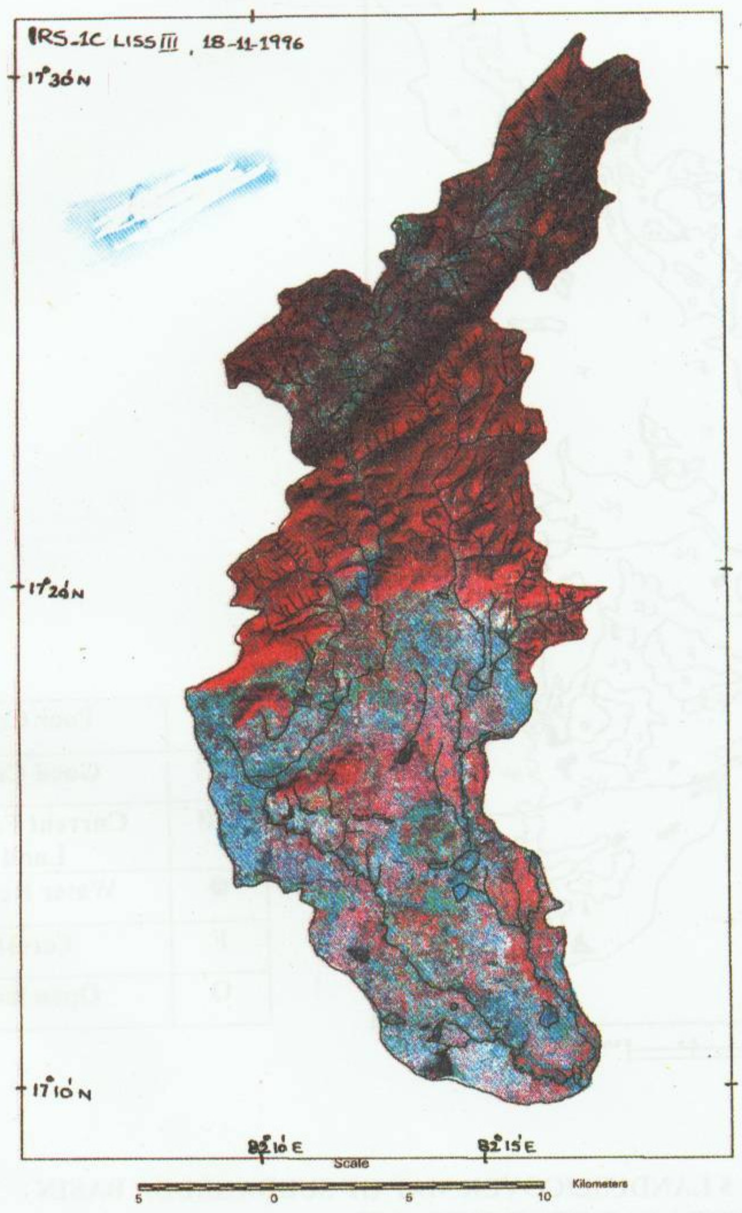
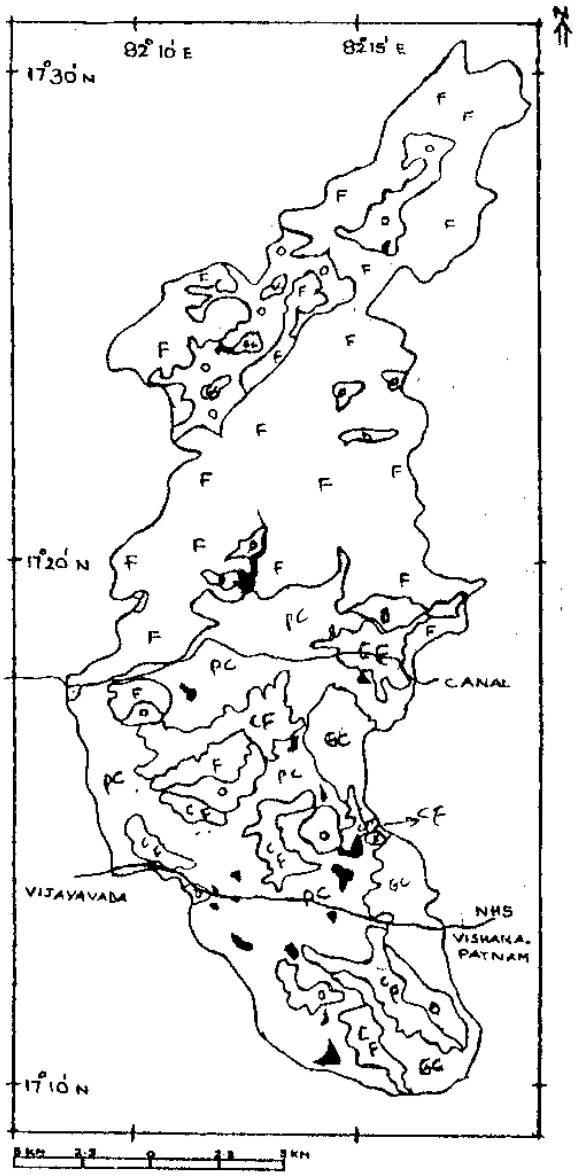
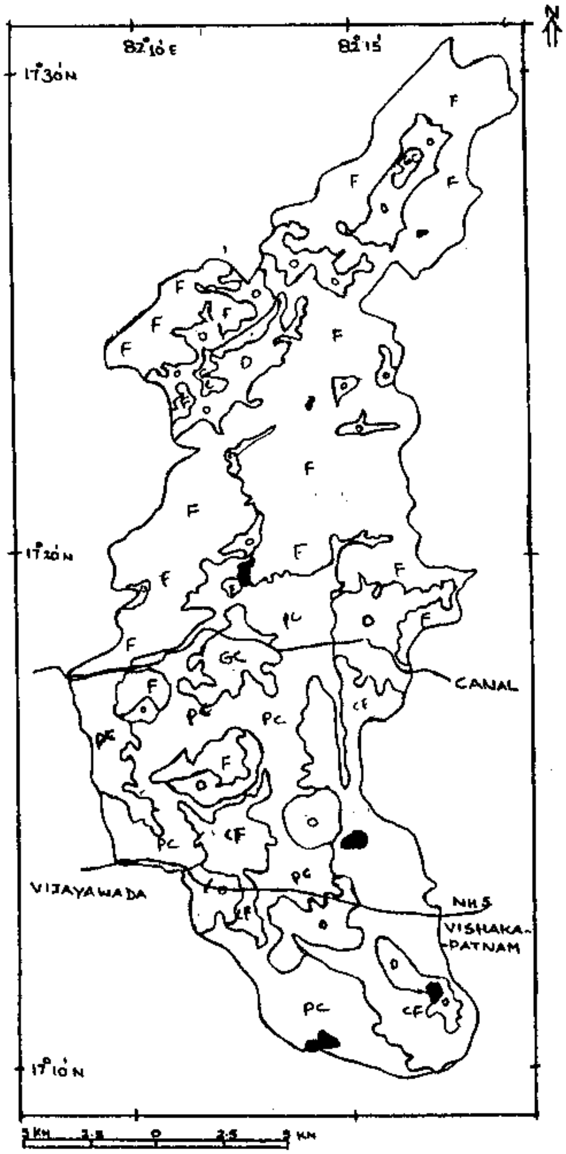


Fig. 4 Overlay of Drainage network on Satellite image (FCC)



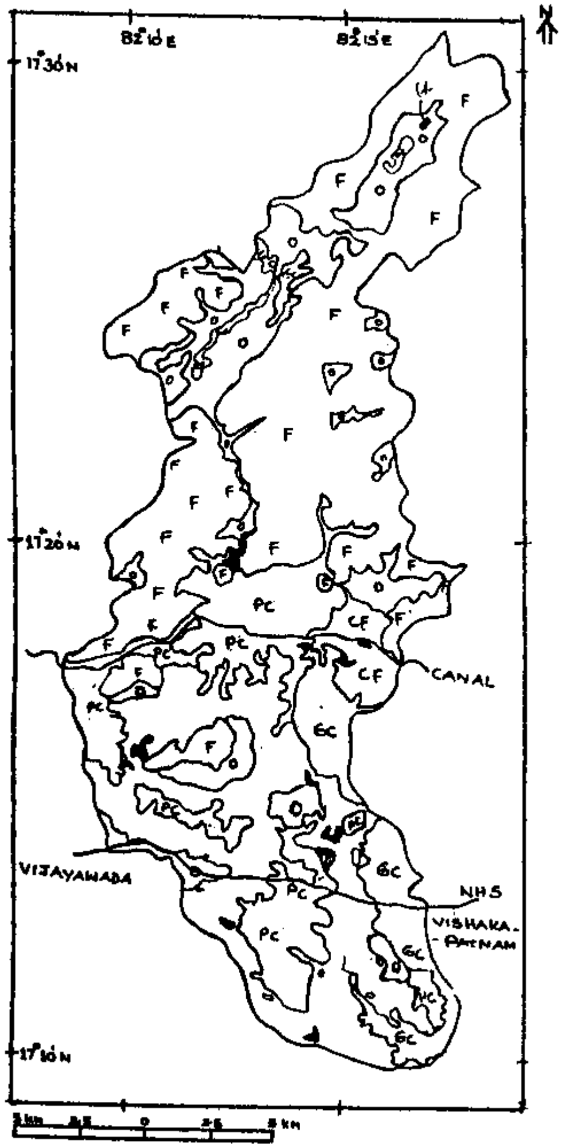
PC	Poor Crop
GC	Good Crop
CF	Current Fallow Land
●	Water Bodies
F	Forest
O	Open land

Fig. 5 LANDUSE/COVER MAP OF SUDDAGEDDA BASIN IN THE YEAR DECEMBER 1987



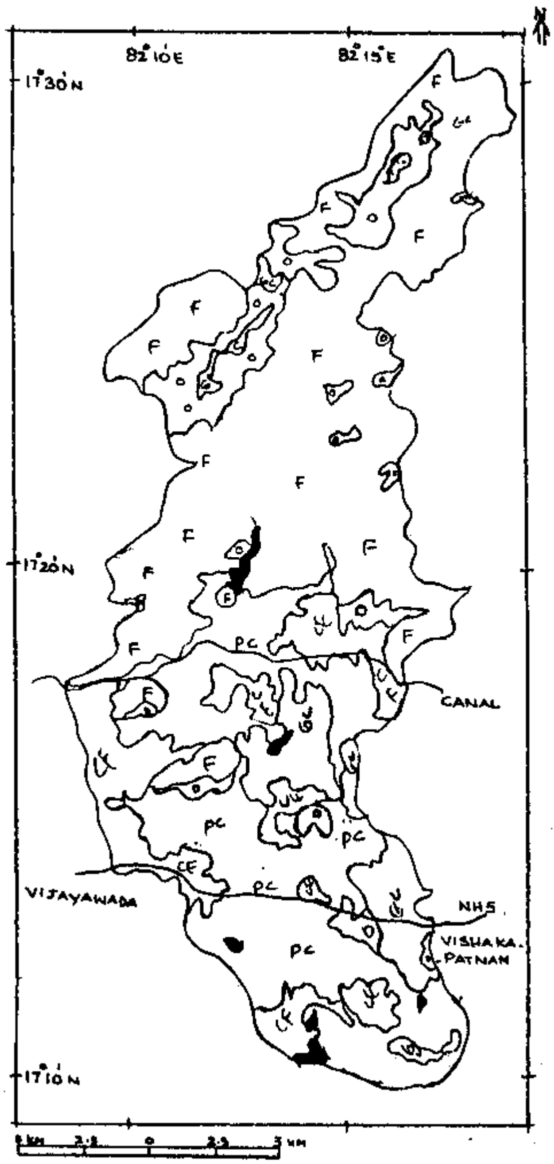
PC	Poor Crop
GC	Good Crop
CF	Current Fallow Land
●	Water Bodies
F	Forest
O	Open land

Fig. 6. LANDUSE/COVER MAP OF SUDDAGEDDA BASIN IN THE YEAR APRIL 1989



PC	Poor Crop
GC	Good Crop
CF	Current Fallow Land
●	Water Bodies
F	Forest
O	Open land

Fig. 7 LANDUSE/COVER MAP OF SUDDAGEDDA BASIN IN THE YEAR DECEMBER 1992



PC	Poor Crop
GC	Good Crop
CF	Current Fallow Land
●	Water Bodies
F	Forest
O	Open land

Fig. 8 LANDUSE/COVER MAP OF SUDDAGEDDA BASIN IN THE YEAR NOVEMBER 1996

It is observed that there are no significant changes in landuse/cover from the year 1987 to 1996. The average estimated curve number of the basin for the years 1987, 1989, 1992 and 1996 are 84, 83, 85 and 84 respectively (AMC III).

The Suddagedda basin falls under CWC subzone 4(a) and as per the recommended methodology the design storm duration of the basin is calculated by the following formula.

The design storm duration (T_D) = 1.1 * t_p (2)

Where

Basin lag (t_p) = $0.376 (L * L_c / (S)^{0.5})^{0.434}$

Where

L = length of the longest stream in km

L_c = length of the longest stream from a point opposite to C.G of catchment upto

Gollaprolu (km)

S = Equivalent stream slope (m/km)

The design storm duration of the basin is calculated as 6 hrs.

Due to non-availability of hourly rainfall data in the basin the 25 yr., 50 yr. and 100 yrs. return period point rainfall for design storm duration are taken to estimate flood peaks in the basin. The isohyetal maps of 6-hr point rainfall of these return periods are available in the CWC flood report (CWC, 1987). As per the CWC flood report the point rainfall has been converted into areal rainfall, effective rainfall and the same is given in Table 3.

Table 3. Areal and effective rainfall for different return periods in the basin.

Time (hr)	Areal rainfall (cm) for different return periods			Effective areal rainfall in cm (subtracting losses of 0.75 cm/hr)		
	R_{25}	R_{50}	R_{100}	R_{25}	R_{50}	R_{100}
1	6.183	6.775	7.650	5.43	6.03	6.90
2	2.290	2.500	2.830	1.54	1.75	2.08
3	1.367	1.510	1.700	0.62	0.76	0.95
4	0.694	0.750	0.850	0.0	0.0	0.1
5	0.686	0.750	0.850	0.0	0.0	0.1
6	0.230	0.260	0.290	0.0	0.0	0.0
Total	11.45	12.54	14.17			

Using the areal rainfall of the basin the surface runoff depth for different return periods is calculated with the Equation 1. The results are compared with synthetic unit hydrograph method.

5.1 Surface runoff estimation by synthetic unit hydrograph method.

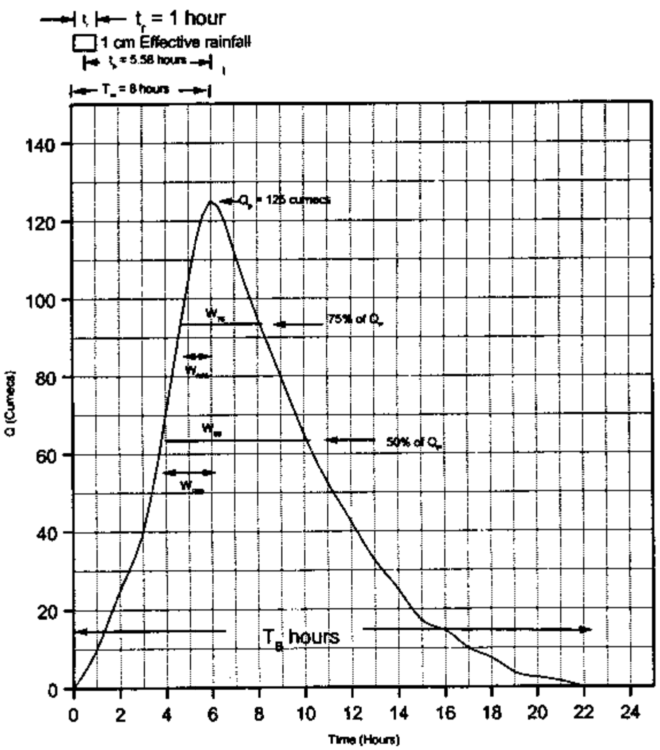
5.1.1 The physiographic parameters of the catchment are as follows.

1. Catchment area (A) = 337 sqkm
2. Length of the longest stream (L) = 60 km
3. Length of the longest stream from a point opposite to C.G of catchment upto Gollaprolu = 28.5 km
4. Equivalent stream slope (S) = 11.67 m/km
5. Design storm duration (T_m) = 6hrs
6. 6- hr point rainfall of 25 yr., 50 yr. and 100 yrs. return period are 14.5cm (R_{25}), 15.87cm (R_{50}) and 17.94 cm (R_{100}) respectively (Obtained from CWC Isohytal maps of subzone 4(a)).

5.1.2 Determination of Synthetic 1-hr unit hydrograph parameters

1. $t_p = 0.376\ (L * L_c / S^{0.5})^{0.434}$ = 5.58 hrs
2. $q_p = 1.215 /(t_p)^{0.691}$ = 0.37 cumec/sqkm
3. $W_{50} = 2.211/ (q_p)^{1.07}$ = 6.41 hrs
4. $W_{75} = 1.312/(q_p)^{1.003}$ = 3.56 hrs
5. $W_{R50} = 0.808/ (q_p)^{1.053}$ = 2.30 hrs
6. $W_{R75} = 0.542/ (q_p)^{0.965}$ = 1.41 hrs
7. $T_B = 7.621\ (t_p)^{0.623}$ = 22 hrs
8. $Q_p = q_p * A$ = 125 cumecs
9. $T_m = t_p + t_r/2$ = 6 hrs

Estimated parameters of above were plotted to scale and the same is shown in Fig. 9. Using the effective rainfall from Table 3 and 1-hr synthetic unit hydrograph ordinates, the flood hydrographs have been developed for 25 yr., 50 yr. and 100 yrs. return period. The procedure to develop flood hydrographs for these return periods is given in Table 4, 5, and 6 respectively. The flood hydrographs for these three return periods are shown in Fig 10. The baseflow from the basin has been calculated by the following formula.



Synthetic U H Parameters

C. A = 337 sq. km
t_p = 5.58 hours
T_B = 22 hours
Q_p = 125 cumecs
W_{50} = 6.41 hours
W_{75} = 3.56 hours
W_{R50} = 2.30 hours
W_{R75} = 1.41 hours
q_p = 0.37 cumecs
$L_{LC}/S^{0.5}$ = 500.59
d = 1 cm
T_m = 6 hours

$\Sigma Q_i = (A * d) / (t_r * 0.36)$
= 936 cumecs

Time in Hours	1-hr UH Ordinates
0	0
1	10
2	25
3	40
4	70
5	105
6	125
7	112
8	95
9	80
10	65
11	52.5
12	42.5
13	32.5
14	25
15	17
16	14.5
17	10
18	7.5
19	3.75
20	2.5
21	1.5
22	0
Total	936 Cumecs

Fig. 9. Derived 1-hr unit hydrograph for the Suddagedda Basin

Table No. 4 Computation of Flood Hydrograph for 6-hr., 25 Yr. Return Period of Rainfall (11.45 cm)

Time (Hr)	Synthetic Hydrograph Ordinates (Cumecs)	1-hr Effective Rainfall(cm)			Surface Runoff (Cumecs)	Baseflow (Cumecs)	Total Runoff (Cumecs)	Remarks
		0.62	5.43	1.54				
0	0	0			0	8.6	8.6	
1	10	15.4	0		15.4	8.6	24	
2	25	38.5	54.3	0	92.8	8.6	101.4	
3	40	61.6	135.75	6.2	203.55	8.6	212.15	
4	70	107.8	217.2	15.5	340.5	8.6	349.1	
5	105	161.7	380.1	24.8	566.6	8.6	575.2	
6	125	192.5	570.15	43.4	806.05	8.6	814.65	
7	112	172.48	678.75	65.1	**916.33**	8.6	**924.93**	**Peak**
8	95	146.3	608.16	77.5	831.96	8.6	840.56	
9	80	123.2	515.85	69.44	708.49	8.6	717.09	
10	65	100.1	434.4	58.9	593.4	8.6	602	
11	52.5	80.85	352.95	49.6	483.4	8.6	492	
12	42.5	65.45	285.08	40.3	390.825	8.6	399.425	
13	32.5	50.05	230.78	32.55	313.375	8.6	321.975	
14	25	38.5	176.48	26.35	241.325	8.6	249.925	
15	17	26.18	135.75	20.15	182.08	8.6	190.68	
16	14.5	22.33	92.31	15.5	130.14	8.6	138.74	
17	10	15.4	78.735	10.54	104.675	8.6	113.275	
18	7.5	11.55	54.3	8.99	74.84	8.6	83.44	
19	3.75	5.775	40.725	6.2	52.7	8.6	61.3	
20	2.5	3.85	20.363	4.65	28.8625	8.6	37.4625	
21	1.5	2.31	13.575	2.325	18.21	8.6	26.81	
22	0	0	8.145	1.55	9.695	8.6	18.295	
23	0	0	0	0.93	0.93	8.6	9.53	
24	0	0	0	0	0	8.6	8.6	
				Total	7106.138	215.0	7321.138	

Table No. 5 Computation of Flood Hydrograph for 6-hr., 50 Yr.Return Period of Rainfall (12.54 cm)

Time (Hr)	Synthetic Hydrograph Ordinates (Cumecs)	1 hr Effective Rainfall (cm)			Surface Runoff (Cumecs)	Baseflow (Cumecs)	Total Runoff (Cumecs)	Remarks
		1.75	6.02	0.76				
0	0	0			0	8.6	8.6	
1	10	17.5	0		17.5	8.6	26.1	
2	25	43.75	60.2	0	103.95	8.6	112.55	
3	40	70	150.5	7.6	228.1	8.6	236.7	
4	70	122.5	240.8	19	382.3	8.6	390.9	
5	105	183.75	421.4	30.4	635.55	8.6	644.15	
6	125	218.75	632.1	53.2	904.05	8.6	912.65	
7	112	196	752.5	79.8	**1028.3**	**8.6**	**1036.9**	**Peak**
8	95	166.25	674.24	95	935.49	8.6	944.09	
9	80	140	571.9	85.12	797.02	8.6	805.62	
10	65	113.75	481.6	72.2	667.55	8.6	676.15	
11	52.5	91.875	391.3	60.8	543.975	8.6	552.575	
12	42.5	74.375	316.05	49.4	439.825	8.6	448.425	
13	32.5	56.875	255.85	39.9	352.625	8.6	361.225	
14	25	43.75	195.65	32.3	271.7	8.6	280.3	
15	17	29.75	150.5	24.7	204.95	8.6	213.55	
16	14.5	25.375	102.34	19	146.715	8.6	155.315	
17	10	17.5	87.29	12.92	117.71	8.6	126.31	
18	7.5	13.125	60.2	11.02	84.345	8.6	92.945	
19	3.75	6.5625	45.15	7.6	59.3125	8.6	67.9125	
20	2.5	4.375	22.575	5.7	32.65	8.6	41.25	
21	1.5	2.625	15.05	2.85	20.525	8.6	29.125	
22	0	0	9.03	1.9	10.93	8.6	19.53	
23	0	0	0	1.14	1.14	8.6	9.74	
24	0	0	0	0	0	8.6	8.6	
				Total	7986.213	215.0	8201.213	

Table No. 6 Computation of Flood Hydrograph for 6-hr., 100 Yr. Return Period of Rainfall (14.17 cm)

Time (Hr)	Synthetic Hydrograph Ordinates (Cumecs)	1-hr Effective Rainfall (cm)					Surface Runoff (Cumecs)	Baseflow (Cumecs)	Total Runoff (Cumecs)	Remarks
		0.1	0.1	2.08	6.9	0.95				
0	0	0					0	8.6	8.6	
1	10	1	0				1	8.6	9.6	
2	25	2.5	1	0			3.5	8.6	12.1	
3	40	4	2.5	20.8	0		27.3	8.6	35.9	
4	70	7	4	52	69	0	132	8.6	140.6	
5	105	10.5	7	83.2	172.5	9.5	282.7	8.6	291.3	
6	125	12.5	10.5	145.6	276	23.75	468.35	8.6	476.95	
7	112	11.2	12.5	218.4	483	38	763.1	8.6	771.7	
8	95	9.5	11.2	260	724.5	66.5	1071.7	8.6	1080.3	
9	80	8	9.5	232.96	862.5	99.75	**1212.71**	**8.6**	**1221.3**	**Peak**
10	65	6.5	8	197.6	772.8	118.75	1103.65	8.6	1112.3	
11	52.5	5.25	6.5	166.4	655.5	106.4	940.05	8.6	948.65	
12	42.5	4.25	5.25	135.2	552	90.25	786.95	8.6	795.55	
13	32.5	3.25	4.25	109.2	448.5	76	641.2	8.6	649.8	
14	25	2.5	3.25	88.4	362.25	61.75	518.15	8.6	526.75	
15	17	1.7	2.5	67.6	293.25	49.875	414.925	8.6	423.53	
16	14.5	1.45	1.7	52	224.25	40.375	319.775	8.6	328.38	
17	10	1	1.45	35.36	172.5	30.875	241.185	8.6	249.79	
18	7.5	0.75	1	30.16	117.3	23.75	172.96	8.6	181.56	
19	3.75	0.375	0.75	20.8	100.05	16.15	138.125	8.6	146.73	
20	2.5	0.25	0.375	15.6	69	13.775	99	8.6	107.6	
21	1.5	0.15	0.25	7.8	51.75	9.5	69.45	8.6	78.05	
22	0	0	0.15	5.2	25.875	7.125	38.35	8.6	46.95	
23	0	0	0	3.12	17.25	3.5625	23.9325	8.6	32.533	
24	0	0	0	0	10.35	2.375	12.725	8.6	21.325	
25	0	0	0	0	0	1.425	1.425	8.6	10.025	
						Total	**9484.213**	**215.0**	**9707.8**	

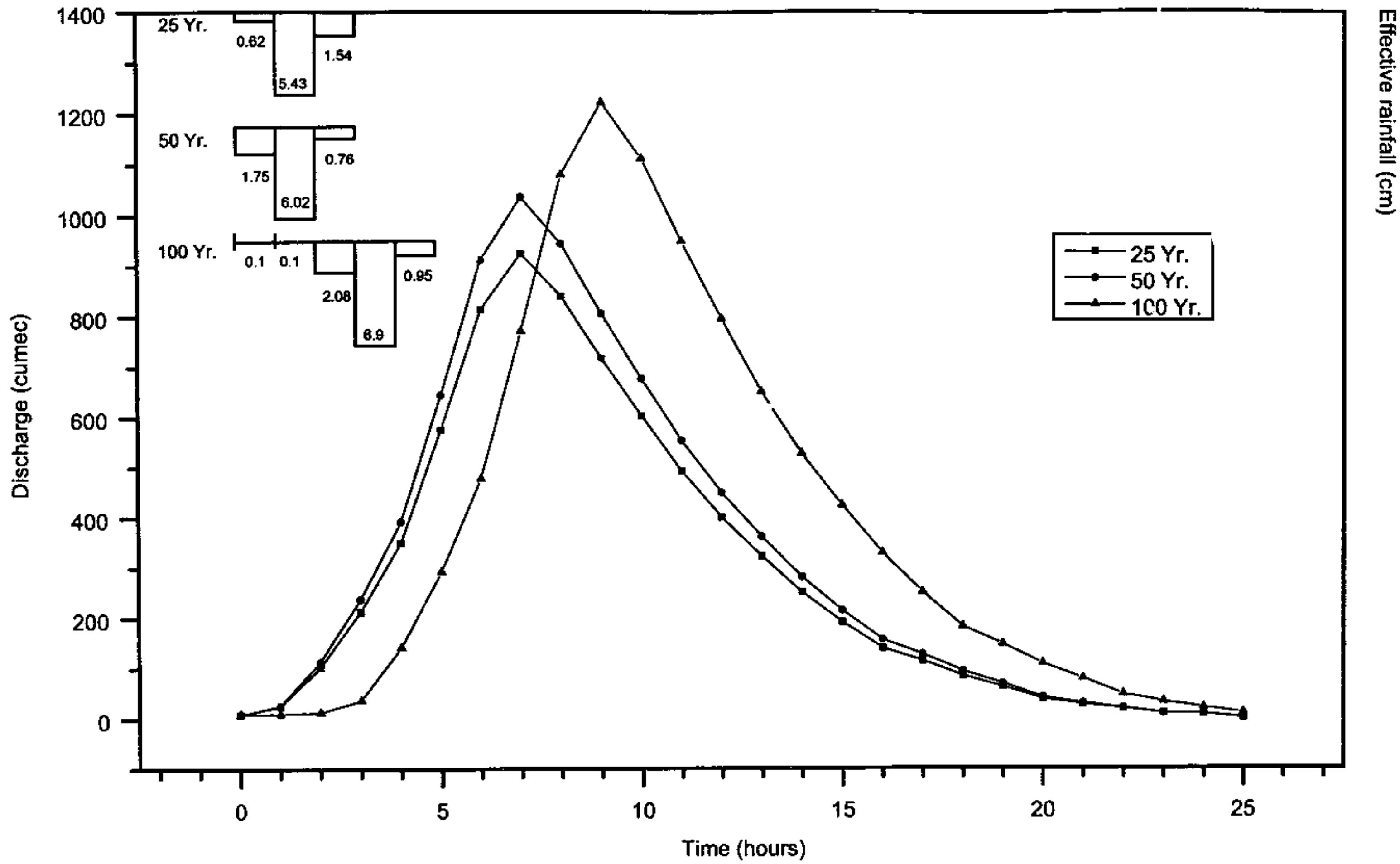


Fig 10. Flood hydrograph for different return periods

$Q_b = 0.536 /(A)^{0.523} = 1.2$ cumecs/sq.km (3)

Total baseflow = 337 * 1.2 = 8.6 cumecs

The ordinates of total runoff hydrograph have been obtained by adding baseflow component to the each surface runoff ordinates. The comparison of surface runoff depth by SCS-CN model and SUH method is shown in the Table 7.

Table 7. Comparison of surface runoff depths in the basin

Return period	Surface runoff depth (cm)			
	SUH Method	SCS-CN Method (AMC III)		
25 yr	7.59	6.74	6.48	7.00
50yr	8.53	7.72	7.45	7.99
100yr	10.13	9.21	8.93	9.50

The percentage deviation in estimated surface runoff depth between above methods varies between 6 to 17. The variations in estimating surface runoff by SCS-CN model is depending on existed landuse conditions of the basin, which is more realistic in nature. Therefore, it is always necessary to integrate physiographic, storm and soil-landuse characteristics of the basin to estimate reliable flood in ungauged catchment. The SCS-CN method could also be used for flood estimation in ungauged catchment when adequate hydrological information is not available. The study recommends to measure discharge at Gollaprolu for few rainfall events to understand rainfall-runoff processes in the basin and further validation of results obtained from the study.

6.0 CONCLUSIONS

The landuse/cover maps have been prepared for Suddagedda basin for the years 1987, 1989, 1992 and 1996 using remote sensing technique. It is observed that there are no much significant changes in landuse from the year 1987 to 1996. The average SCS curve number in AMC III conditions of the basin varies between 83 to 85 in the study period. These curve numbers have been used to estimate surface runoff from the basin and the same has been compared with synthetic unit hydrograph method. The comparison showed that the percentage of deviation is between 6 to 17. Therefore, the SCS-CN model could be used to estimate surface runoff when adequate hydrological information is not available. The study recommends to measure discharge for few rainfall events in the basin and further validation of results obtained from the study.

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