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Estimation of Reservoir Storage Capacity by using Residual Mass Curve

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Abstract: **The objective of this study is to estimate the reservoir storage capacity for the proposed Dibang Multipurpose Dam site in the Dibang River Basin, Arunachal Pradesh. The flow data of the Dibang River Basin at the proposed Dam site for various years are used to estimate the reservoir capacity. Residual Mass curve is used in determining the reservoir storage capacity. Advantages of using residual mass curve instate of using reservoir mass curve is also presented in this paper.**

Keywords: **reservoir storage capacity, residual mass curve, reservoir mass curve.**

1. INTRODUCTION

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.The Dibang Multipurpose Project is located on river Dibang, a major tributary of river Brahmaputra. Intrastate rivers are one of the main sources of surface water supply. To ensure an adequate and dependable water supply, one of the following means is used: in-channel dams, which create storage reservoirs; low-channel dams (which create enough storage to meet a few weeks' demand during very low stream flow conditions) on rivers with relatively sustained flows; side-channel reservoirs into which water is pumped from rivers during moderate or high-flow conditions; and sometimes auxiliary or standby ground-water wells.

The adequacy and reliability of the water supplies from surface water resources are largely dependent upon the ability of these reservoirs to provide sufficient water storage during the critical dry periods. However, these surface water reservoirs face many problems that may result in the decrease of their safe yields and thus in an inadequacy to supply sufficient water in the next 10 to 40 years. Some of these problems are: (a) increases in water demand because of increases in population, industry, or per capita water use; (b) gradual loss of reservoir capacity and yield because of sedimentation in the reservoirs; and (c) emerging demands for recreation and for mandatory low-flow releases from the reservoirs for maintaining stream water quality, ecology, and aquatic habitats.

2. METHODOLOGY

During high flows, water flowing in a river has to be stored so that a uniform supply of water can be assured, for water resources utilisation like irrigation, water supply, power generation, etc. during periods of low flows of the river. The methods of estimation of reservoir storage capacity presented in this paper are:

A. Reservoir mass curve

A mass curve (or Ripple diagram, 1882) is a cumulative plotting of net reservoir inflow (Fig. 1), and is expressed as

$$V(t) = \int_0^t Q(t)\, dt \qquad (1)$$

Where V (t) = Volume of runoff
Q (t) = Reservoir inflow, both as function of time.

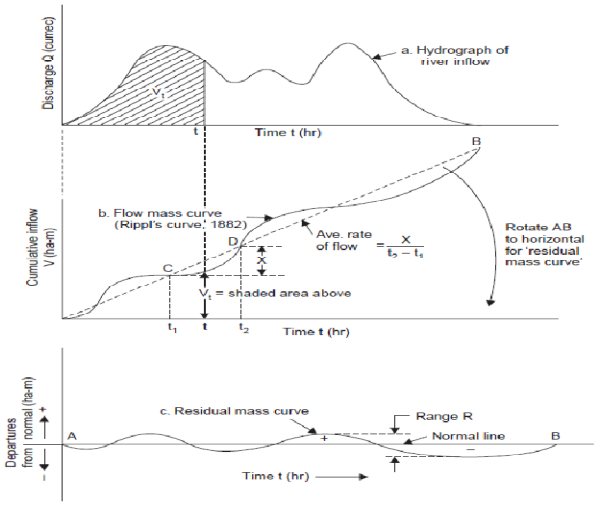

Fig. 1. Reservoir and Residual mass curve

The instantaneous rate of flow at any point on the mass curve is given by the slope of the tangent at the

Point, i.e.

$$Q(t) = dV(t)/dt \quad (2)$$

The reservoir mass curve has many useful applications in the design of a storage capacity, such as determination of reservoir capacity, operations procedure and flood routing.

B. Residual mass curve

Instead of plotting a mass curve, the departure of the mass curve from the normal (AB) may be plotted against time. In other words, the mass curve is plotted about a horizontal axis obtained by rotating the average slope line AB of the mass curve, to the horizontal (Fig. 1). Such a plot is called a 'residual mass curve'. This method of plotting saves the additional space needed for plotting a continuously rising mass curve and to accentuate more clearly the crests and troughs of the cumulative flow records.

The difference between the maximum and the minimum values of a residual mass curve for a given period of 'n' is known as the 'range' for the period of 'n'. If R is the range of a period of n years of annual – runoff record, whose sample standard deviation is σ, then according Hurst (1951, 1956) and Klemes (1974).

$$R = \sigma (n/2)^{k} \quad (3)$$

Where, k varies from 0.5 to 1 with an average value of 0.73. Here' R' will be the required storage if a steady discharge equal to the mean over a period of n years is to be produced.

3. SELECTION OF RESERVOIR CAPACITY

The determination of the required capacity of a storage reservoir is usually called an 'operation study' using a long-synthetic record. An operation study may be performed with annual, monthly, or daily time intervals; monthly data are commonly used.

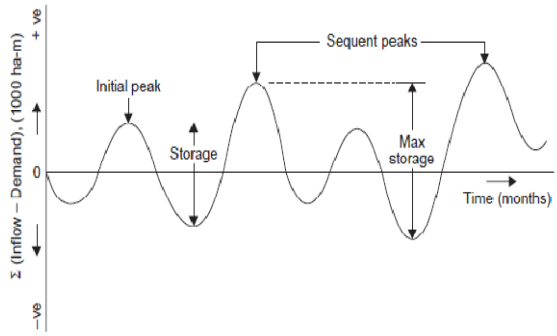

Fig. 2. Sequent-peak algorithm

When the analysis involves lengthy synthetic data, a computer is used and a sequent-peak algorithm is commonly used. Values of the cumulative sum of inflow minus withdrawals taking account the precipitation, evaporation, seepage, water rights of the downstream users, etc., are calculated, (Fig. 2). The first peak and the next following peak, which is greater than the first peak, i.e., the sequent peak are identified.

The maximum difference between this sequent peak and the lowest trough during the period under study is taken as the required storage capacity of the reservoir.

4. ANALYSIS

The water availability series available in "Feasibility Report of Dibang Multipurpose Project CWC (2003)" has been modified and updated by Central Water Commission 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 Optimization of Project Parameters, Brahmaputra Board (Jan-2005)". This series has been finally adopted in the DPR of Dibang Multipurpose Project. Monthly variation of the river flow from the year 1986 to 2002 is shown the Fig .3

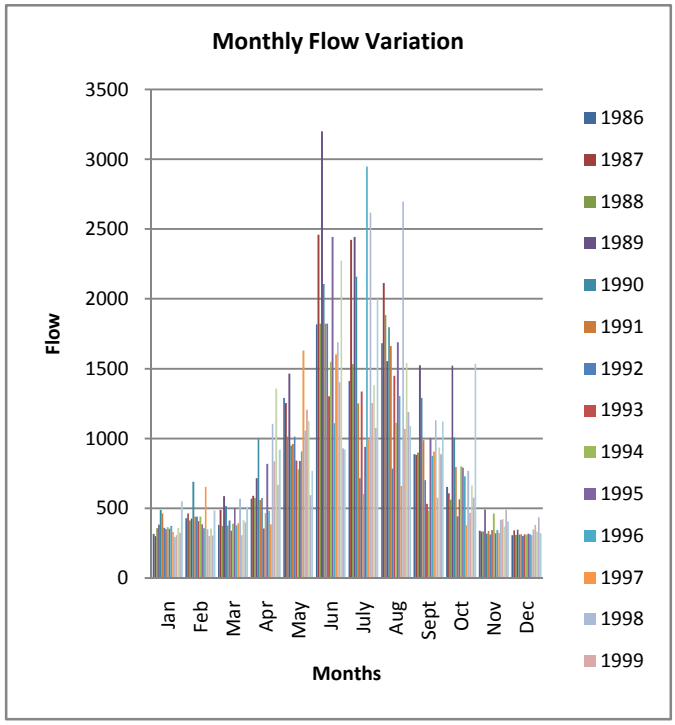

Fig. 3. Monthly Variation of the Dibang river flow from the year 1986 to 2002

Residual mass curve is carried out for the monthly variation flow data and graphs are plotted, discharge against months for each years.

5. RESIDUAL MASS CURVE

The reservoir storage capacity is calculated for monthly variation flow in the year 1986 and the values are presented in table 1.

TABLE 1: Residual mass curve for the year 1986

Cumulative mean flow throughout the year (ha-m) (5)	Residual mass (ha-m) (6)
$ 217764.72	@ -135494.64
435529.44	-242269.92
653294.16	-361564.56
871058.88	-431974.08
1088823.6	-315552.24
1306588.32	-61909.92
1524353.04	86289.84
1742117.76	304525.44
1959882.48	316567.44
2177647.2	267982.56
2395411.92	138008.88
2613176.64	0

Months (1)	Monthly flow (m^3/sec) (2)	Monthly Flow Volume (ha-m) (3)	Cumulative Inflow (ha-m) (4)
Jan	317.4	*82270.08	82270.08
Feb	428.2	110989.44	°193259.52
Mar	379.9	98470.08	291729.6
Apr	568.5	147355.2	439084.8
May	1289.3	334186.56	773271.36
Jun	1818.7	471407.04	1244678.4
July	1411.9	365964.48	1610642.88
Aug	1682.1	436000.32	2046643.2
Sept	886.6	229806.72	2276449.92
Oct	652.7	169179.84	2445629.76
Nov	338.7	87791.04	2533420.8
Dec	307.7	79755.84	2613176.64
Sum	**10081.7**	**2613176.64**	

1 .* 317.4 m^3/sec X 30 days = 317.4 (30 X 86400)/10^4 = 82270.08 ha-m

2. 82270.08 + 110989.44 = 193259.52 ha-m

3. $ 2613176.64/12 = 217764.72 ha-m

4. @ 82270.08 – 217764.72 = - 135494.64 ha-m

5. Similarly the residual mass curves values are calculated for the years 1987 to 2002 and the graph is plotted between time (months) and residual mass which is shown in Fig. 4.

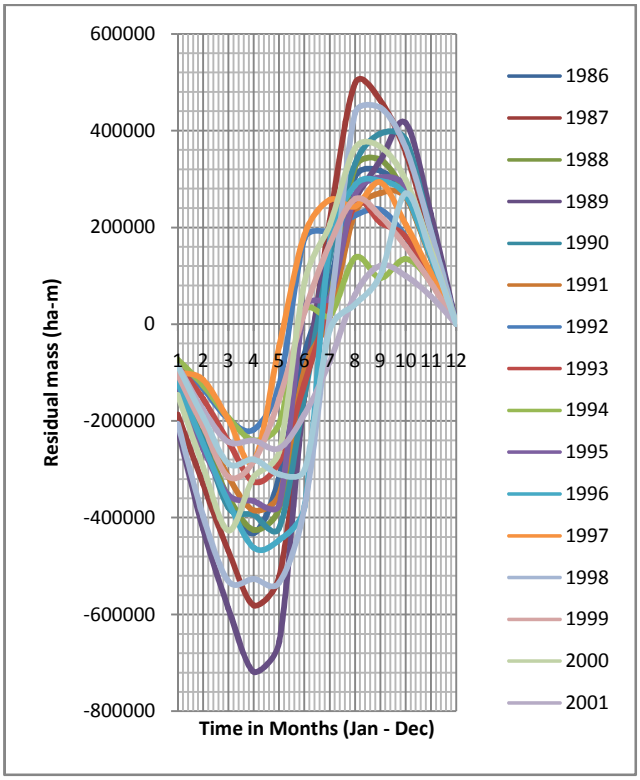

Fig. 4 Residual mass curve for the years 1986 to 2002

6. RESULT

From the Fig. 4, it is observed that in the year 1989, the graph shows the maximum storage capacity.
i.e. (719133.2 + 415994.40) ha-m
= 1135127.52 (ha-m)

Therefore the reservoir storage capacity for the proposed Dibang Multipurpose Dam site in the Dibang River Basin is 1135127.52 (ha-m).

7. CONCLUSION

Reservoir storage capacity is of crucial importance and the major aspect of hydrologic design. It is extremely crucial for reservoir design and management. In the present paper, reservoir capacity for the different years monthly variation flow have been computed by using residual mass curve. Residual mass curve saves the additional space needed for plotting a continuously rising reservoir mass curve and to accentuate more clearly the crests and troughs of the cumulative flow records. From the residual mass curve for the years 1986 to 2002, it is observed that in the year 1989 shows

maximum reservoir storage capacity. Therefore the reservoir storage capacity for the proposed Dibang Multipurpose Dam site in the Dibang River Basin is 1135127.52 (ha-m).

REFERENCES

[1] Hurst H.E., Long-term Storage Capacity of Reservoirs, Trans. ASCE, Vol. 116, pp. 770-808, 1951.

[2] Klemes V., The Hurst Phenomenon-a Puzzle ? Wat. Res. Research 10, pp. 675-689, 1974.

[3] Pumnia.B.C;"irrigation and water power engineering"; Laxmi publication (P) ltd; New Delhi, 2009.

[4] Raghunath.H.M; 'Hydrology'' New age international (P) limited, publishers, New Delhi, 2006.

[5] Singh.P.Krishan,Durgunoglu ali; " A new method for estimating future reservoir storage capacity" Volume.25, Number 2, water Resourse Bulletin, pp. 263, April 1989.