CHAPTER TWO

LITERATURE REVIEW

The concept of synthetic generation of streamflows is quite an old one. Hydrologists and researchers concerned with water resources development have tried to overcome the problem of lacking of historical streamflow records for many years. It was first the work of HAZEN (1914), by using the annual flows from 14 individual streams to form an extended sequence of 300 years duration. The drawbacks of this method are that the 14 records are samples from different populations and there is likely to be correlated between various streams, therefore, it is not precisely applicable to any particular stream.

Sudler (1927) attempted to approximate the stochastic nature of the reservoir inflows, by writing the observed flows on cards, shuffling them and then drawing a series of cards at random. This series is used to represent a sequence of inflows, however, it does not provide flows more extreme than the flows in the card deck and the autocorrelation or persistence in streamflows is not taken into account because the series are shuffled at random.

Barnes (1954) used a method similar to that of sudler, but he assumed that annual flows are normally distributed and do not exhibit serial correlation. The synthesis sequence was obtained from a table of random numbers in such the way that it resembles the observed records in terms of the mean and variance.

Julian (1961) who first recognized the fact that natural streamflows seens to show persistence, i.e. high flows following high flows and low flows following low flows, or generally termed as "serial correlation" or "autocorrelation". He, thus, took into account the serial correlation by using a simple auto-regressive model, or called a first-order Markov Process given by

$$X_t = \rho X_{t-1} + \epsilon_t \qquad \text{.....................} \qquad (2.1)$$

in which X_t - annual flow in year t

X_{t-1} - annual flow in year t-1

ρ - lag one autocorrelation coefficient

ϵ_t - a random uncorrelated component

Brittan (1961) used a normal distribution for the random component and the model is given by

$$X_t = \mu + \rho(X_{t-1} - \mu) + \sigma(1-\rho^2)^{1/2}\epsilon_t \qquad \text{............} \qquad (2.2)$$

where X_t, X_{t-1} - annual flows in year t and t-1, respectively

μ - mean annual flow in the record period

σ - standard deviation of record

ρ - lag one autocorrelation coefficient

ϵ_t - random normal variate with zero mean and unit variance

He found that generated flow sequences contained negative values and reasoned that this may be because of incorrect assumption of normal distribution.

Thomas and Fiering (1962), based on the linear regression analysis, they proposed a first order autoregresssive model in which the variate at the i-th time is comprised of a component linearly related to that at the (i-1)-th time and a random additive component - for the generation of monthly streamflows. For streams with high monthly serial correlations and large skew this model is unsatisfactory. However, the Thomas-Fiering model has been the most extensively used so far.

Yagil (1963), based on the assumption that all monthly flows are normally distributed, showed that the Thomas-Fiering model preserves the means, variance and serial correlation of the historical flow sequence. This means that the generated sequence will statistically resemble the historical one.

Harms and Campbell (1967) extended the Thomas-Fiering model (Thomas and Fiering, 1962) for the sequential generation of monthly streamflows so as to preserve the monthly as well as the annual parameters.

Mandelbrot and Wallis (1969a) proposed two approximations of discrete fractional Gaussian noise (called types I and II), which consisted of weighted moving averages of independent Gaussian variables. Because of serveral drawbacks of the approximations, Mandelbrot (1971) suggested the fast fractional Gaussian noise generator (ffGn). The ffGn is basically the sum of a short memory Markov process and a long memory Markov process. To improve the high frequency properties of type II approximation.

Mejia et al. (1972) considered the sample broken line process of Ditlivsen(1969), and developed the more complicated broken line process for hydrological use; the latter is the sum of simple broken line processes, and these derive from the linear interpolation between uniformly spaced independent Gaussian variables.

Valencia and Schaake (1973) developed a scheme to disaggregate the yearly values in such a way that the statistics at different time resolutions are preserved. Their model presents the capability of disaggregation of yearly multivariate sequences which may come from any of the available models for annual streamflow data generation.

Spolia and Chander(1974) proposed an auto-regressive model developed from the existing one so that it is computationally easier, parsimoneous in number of model parameters, more stable in statistical characteristics and it can preserve the mean and standard deviation of historical record. Data used in this model must be chronologically rearranged to obtain a new sequence for computing some parameters.

Spolia and Chander(1977) introduced a stochastic process in cannonical expansion form. A model based on these expansion was proposed for streamflow synthesis and was shown that it not only reproduces the mean, but also the entire correlation - cross -correlation matrix, which implied the reproduction of total persistence. Furthermore, it was more parsimonieous in parameters than an equivalent auto-regressive model.

Sen(1978) developed the model which is a mixture of the stationary lag-one Markov model and the seasonal Thomas-Fiering model. All the necessary analytical expressions of the correlation structure of the model were derived.