INTRODUCTION CHAPTER 1

1.1 General

There are many cataclysmic events which hit India regularly over the time and floods are one of the major disastrous event that, normally, hit around the monsoon and post-monsoon periods, i.e., around June till October. Flood are created through arbitrary incident of a few meteorological factors Such as excessive rainfall, melting of glaciers, etc, however man's utilization of the stream catchments additionally has an effect upon the seriousness and results of the occasions. A flood can be treated as a risk if has the potential danger to people and their welfare. The danger of floods is treated as risks in the event that it has the predefined peril event. Consequently the flood hazard maps ideally ought to portray the degree and the probability of a particular flood with specific normal recurrence intervals.

A precise Prediction of extreme event at a particular location is much of the time required for the protected and financial plan of different waterway building works. With the end goal of structure of little scaffolds, ducts and so on it necessary to gauges the supreme immediate discharge the structure needs to go amid its financial life-period. One method for appraisals the flood of explicit analysis of the recorded annual pinnacle discharge over number of years & to finding the pinnacle discharge for their recurrence interval at the certain location. By and large in frequency analysis, a suitable statistical dissemination work is utilized to fit past accessible records and afterward surmisings are used for the future likely streams.

Two fundamental outlook are accessible for flood estimation viz., deterministic outlook and statistical outlook. Deterministic proposal accept that input say, the precipitation is identified with the yield, i.e., discharge. While the statistical proposal provides the connection between procedures as represented by hypothesis of measurements. The connection joining procedures that built up for the proportion of relationship.

Flood frequency analysis utilizes chronicled records of pinnacle streams to create direction about the normal conduct flooding in future. Essential uses frequency of flood investigations used to foresee conceivable floods size over the specific timeframe for to gauge the floods frequency with which of a specific extent may happen.

1.2 BASIC ASSUMPTION

while doing the flood frequency analysis on river Yamuna in delhi, There are certain assumption to follow because its provides us better accuracy & precision. Afterwards, predicting the discharge with their corresponding return period.

ASSUMPTIONS:

- Discharge data should be statistically random or it should be time independent or it should not dependent one over the other.
- Changes with time due to manmade (e.g. urbanisation) or natural process do not alter the relationship of frequency – time related trend in data (stationary).

1.3 OBJECTIVE OF THE STUDY

Main objective of this studies is to evaluating discharge of river Yamuna with their corresponding return period by using statistical approach in which using the various distribution. The specific objective of this study are:-

- To Estimate the Statistical Parameters Such as Mean, coefficient of variance ,Standard Deviation , Coefficient of Kurtosis, Coefficient of Skewness, for Both Normal and Log Transformed Annual Flood Series.
- To estimate flood magnitudes for different return period for gauged Catchments.
- To check the Test of Independent from the goodness of fit test ,by using known probability distribution used the various distribution to predicting the discharge.

1.4) ORGANISATION

This Dissertation consists of background studies on flood frequency analysis on River Yamuna on three barrages followed by Methodology in which various distribution is used to evaluate the results and conclusion. In the background studies, special emphasis is given on the various distribution from which helps to predict the flood peak at the different return period and the goodness of fit test which compare all the distribution which we used over there.

LITERATURE REVIEW CHAPTER 2

2.1 General

In frequency analysis of flood, statistical approach is most popular way to proceed the active research in a desired direction Many of them uses this approach to find the solution for their problem. The development in these areas which includes the Annual maximum flood Series. In this we discuss the review of literature is given below.

2.2 So many studies have been conducted various researchers as follows:-

A**nnual maximum series (AMS)** It is a sequence of annual floods, with annual flood defined as the maximum peak discharge of the year of records. Many candidate have been suggested distribution for annual maximum series includes Extreme Type I, Extreme Type II, Extreme Type III, Two Component EV, Log Normal, Normal, Pearson Type III, Log Pearson Type III, and many more.

Thomas (1949) and chow (1951) gave the concept of frequency factor K_T and distribution free models & they are provide the general equation to find the flood discharge to their corresponding Return period and vice-versa. Jenkinsion (1955) gave concepts of General Extreme Value distribution and applied the same to maximum and minimum values of annual metrological elements.

Pande & Lal (1978) Flood estimating by using the simple gumbel distribution Iraqi River, they are trying to used the modified frequency factor without using the predefined tables & prediction of the present method compares favorably Powell's modification of Gumbel Distribution & also plotted the discharges on the graph conclude that the slope between them is 45 degree reasonably, also the values of discharge obtained from the powell's modification is lesser than the simple version of Gumbel method.

Smith A. James (1989) frequency analysis of flood by using by using suitable distribution by applying maximum likelyhood and apply the Lognormal and Distribution of generalized Pareto to estimates discharge and best fit model Generalized Pareto model.

Yadav and Pande (1998) Analysis of flood prediction on River Rapti in eastern Uttar pradesh. it estimate the flood foe various return period by using various distribution extreme value ,gamma, normal , pearson type III log normal and it also plotted it's histogram . from the criteria of fitness test that is chi-square test and recommended i.e., log normal distribution is the best prediction distribution for the expected flood flow on river Rapti by using annual maximum data series from 1960 to 1989 . Indian Journal of Engineering & Material Sciences (PP 22 -27)

Jaiswal & Goel (2002) use the statistical approach L-moment of methods had been used for frequency analysis modeling while doing the flood frequency on the beas river in punjab and suggested that GEV distribution estimation of probable floods for Beas River & annual maximum discharge data collection from the department of state & CWC in New delhi.

Vijayalakshmi and Jinesh (2010) An ideal package that could flood-plain areas and flood water surface-elevation for various design storms with different return periods. Flood plain Modeling materials and Methods that used in advanced technology for hydraulic and hydrologic analyses that are needed to be find out to prediction the flood surface-water elevations for any ungauged watershed. This modeling HEC-GeoRAS (Hydrologic Engineering Centre Geological River Analysis System) using this software for to study the unsteady flow of river.

Jha and Bairagya (2012) (journal of water resources and engineering) Tilpara Barrage in West Bengal mayurkishi river basin is used to to carried out the floodplain studies by using statistical proposal. It used the maximum flow data (from the year 1954 to 1976) to predict inunduation over the adjoining areas they uses the Gumbel distribution and found out the discharge of 100 year return period. Also predicted the dangers flood zones near around the mayurkishi river which is very helpful to assessment and management of flood plain in mayurkishi river basin at tilpara.

Nabi & Ahamed (2012) Frequency Analysis of flood on River Jhelum were log normal, pearson & log Pearson distribution, gumbel, log gumbel Distribution for future prediction discharge flow with corresponding return periods. They used the fitness of test i.e., K.S test which found that the Gumbel distribution is suitable to predicting the flood peak on Jhelum river at chinnari station.

Sathe et all., (2012) journal of Engineering , flood frequency analysis on River Upper Krishna basin by using statistical technique for predicting the expected flow in the river . they also used the annual pinnacle flow data length of ten years vary over a period length 1965-2010 for seven station & out of seven gauging station two were most important from the flash point of view . they used logarthmic pearson typeIII distributions model to predicting the flood flows & also conclude that the arjunwad gauging station having the highest discharge flow of the river.

Solomon and Prince (2013) frequency analysis of flood on River Osse at Igouriakhi station near benin city, using Gumbel distribution carried out for 20 years annual peak flow data from 1989 to 2008 its necessity was for protection of the downstream from devastating river discharge. From the equation of the trend line which gives the values of 0.940 which shows that the pattern as scattered i.e., narrow and also provides the discharge equations by using graphical approach i.e, 22x+2100 the Gumbel distribution is best suited for predicting the flow of river.

Gohil and Chowdhary (2013) frequency analysis of flood on Tan river at station i.e., Amba suituated in Gujarat the present study analysis by using annual maximum flow data series which was assigned from state water data centre of 20 years from 1993 to 2012 & the maximum discharge occurred in 2008 i.e; 1450cumecs . four method in statistical proposal were used in the study namely Foster and Gumbel distribution, Log Pearson type III distribution & Ven Te Chow method and. From four methods The Gumbel distribution recommended for practical use.

Khan Mujiburrehman(2013) Analysis of flood discharge at Garudeshwar Station on River Narmada in Gujarat by using various distribution. Annual maximum data series used upto 30 Years (1949 - 1979), they used the various distribution log normal ,pearson type III ,Normal, Gumbel distribution to identifies the optimum model for monthly pinnacle flood analyses. From the fitness of test (D INDEX) & results i.e., Normal Distribution having best suited for Predicting peak flow in Narmada. It also prepare the histogram which is also helpful to choose best fit distribution . it also evaluate the 95% confidence limit

Kumar Mukherjee (2013) flood frequency analysis on river subarnarekha in Jharkhand at kharkai station & generate the mathematical model of discharge with their return period. They uses the past discharge upto 32 years & used the statistical approach with Gumbel distribution with their 95% & 99% confidence interval which helped to understand the variation of discharge within its limits or our predicted discharge with their corresponding return period, and also found out the value fitness of test i.e; chi-square tests 9.219.

Odunga Shakirudin & Raji Sahid (2014) , flood distribution study for mapping undulation River lower ogun basin in Nigeria by using remote sensing and geographical information system data and some useful images and they implemented the two distribution which is based in statistical approach that is log pearson type III and gumbel distribution they conclude that the gumbel distribution is best fitted distribution for future flood and also concluded that the unduated area is increased by 30 % from the initial for most of the scenario (Journal of water and hydraulics engineering).

Gohin et al., (2014) journal of international academic research for multi disciplinary , they made model by using gumbel distribution on river bhandar in Gujarat from which we found out the precipitation depth for various return period of storms & generates the frequency of intensity-duration (idf) curve for rainfall data on daily basis for various return periods . they also uses the annual average data of rainfall from the year 1961-2006 & also found intensity of rainfall for various return period i.e; 2, 3, 5, 10, 25, 50, 100, 200. & the maximum intensity used for generation of the flood hydrograph is 90.3325mm/hr.

Ware & Lad (2014) flood frequency analysis of waimakarri river which located on south island of New Zealand. Flood protection works was constructed for protect the chirstchurch & kaipoi. Statistical approach has been used by using different distribution with their 95% confidence interval limits from which it also conclude that the true vaue lies between them, data is collected from 1930 to 1966. Using the L moment & finding the Results of various distributions in terms of accuracy and precision.

MacCullen & Galloway (2015) The accuracy of release figured frequency from a examination of annual maximum arrangement relies upon various components i.e., record length. when flood frequencies examination used the past floods records to anticipate desires for the size and frequency of event of future floods. Utilizing certainty interims for surveying accuracy of flood frequency evaluations isn't settled upon, a graphical methodology was grown in this to empower a client to evaluate the accuracy at multi-year extents anticipated from a logarithmic Pearson TypeIII investigation.

Prasad & sah (2015) frequency analysis of flood on kosi river in uttrakhand by adopting statistical proposal in which they use the annual maximum data series of flow from period 1985 to 2014 that is 30 year were obtain from the irrigation department of ram nagar . they use the various distribution that is pearson type III, normal , gumbel , log normal, log pearson type III, log gumbel and from the criteria of fitness test i.e., D index and chi square test that concludes the log gumbel distribution method has been founded that best suited distribution for prediction the future flood flow in river Kosi at uttrakhand (kumao region of uttrakhand), International journal of research and technology.

Guru & Jha (2015) Annual maximum series & threshold peak over flood series were carried out flood frequencies study at Tel Basin on koraput district in odissa River Mahanadi . the analyses were carried out on 2 stations kesing aand kantamal of tel basin they carried the flood data for 31 years and suggested the generalized pareto distribution shows the best result for expected flood flow from the fitness of test. i.e., K.S test and chi square test. **(**International conference on water resources ,coastal and ocean engineering)

Krishna & Roy (2016) journal of indian water resources, For the flood frequency analysis on kosi river which is in bihar & barrage site namely birpur , baltana . for the present study annual maximum data series is used from the period of 1964 to 2008 which is obtained from govt. of bihar to predict the flood flow on river kosi by using various distribution technique which uses the statistical approach. Common approaches are gumbel ,log pearson type III, normal, log normal ,. from the fitness of test it recommended the logarthmic pearson typeIII distribution for predicting flood flow in river kosi at its barrage sites .

2.3 CONCLUSION

After going through the literature review we mainly go through with the statistical approach in which we faced the various distributions which is commonly used namely Normal distributions, Log normal distributions, Pearson type III distributions, Log Pearson type III distributions, Gumbel distributions, Log Gumbel distributions for predicting the future discharge values with their corresponding return period and Goodness of fit Test i.e; D-Index method which is very helpful for considering the best distribution among all the distribution.

METHODOLOGY CHAPTER 3

In this chapter, The discharge which is in the form of annual maximum discharge data series of (1978 – 2017) years. Firstly arranged the discharge data in descending order & providing the position number as highest discharge is having the first position and least discharge having the last position afterwards we also transform the discharge data into logarithmic series we consider both the discharge series with predicting the discharge flow at 3 station on river Yamuna by using various distribution namely; Normal, Extreme value type I, Log extreme value type I, Pearson type III, Log pearson type III distribution, Log normal, with 95% confidence limits of each distribution.

3.1 STUDY AREA

In the present study, Delhi region is selected in which the river Yamuna passes from it. Yamuna river enters into Delhi from Haryana and exit from the Okhla barrage. The discharge data of river Yamuna are available at Wazirabad Barrage, Indraprastha barrage & Okhla Barrage having length of year 1978 - 2017 which signifies the annual pinnacle discharge data of 37 years.

Figure 3.0 Wazirabad, Indraprastha (ITO), Okhla Barrage on River Yamuna in Delhi

As in the past, Delhi also suffering from the eight major flood out of which some of them were,

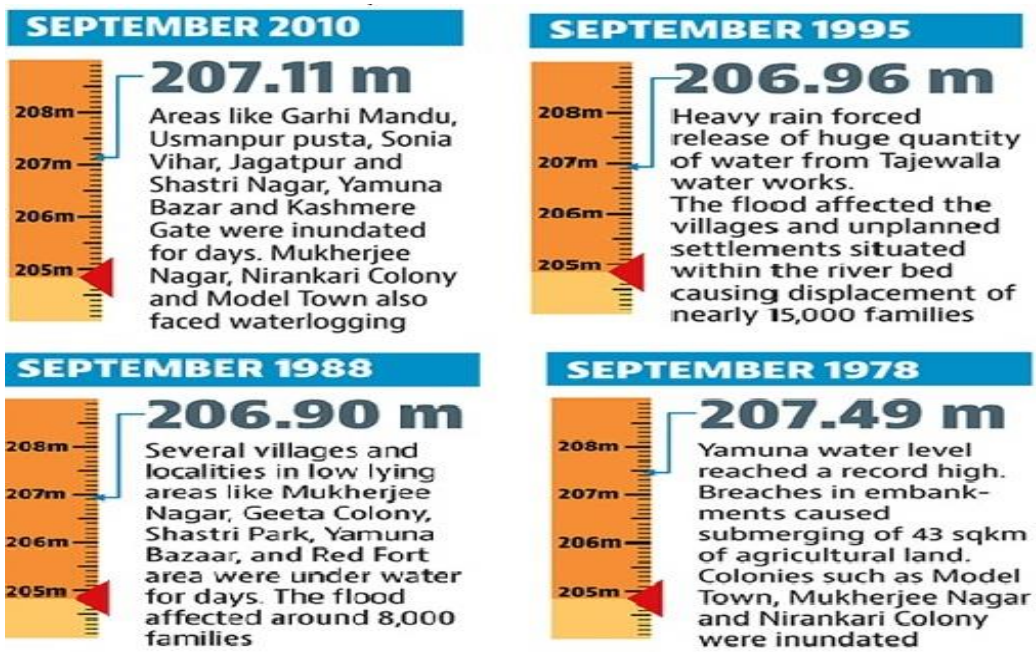

Figure 3.1 Effect of Past flood peak in Delhi

3.2 Data Availability

The data used for the analysis have been taken from the annual maximum flood discharge records maintained at the various barrage offices under the Irrigation & Flood Control department.. This discharge flow was collecting from Irrigation and Flood Control Department(I&F) in Delhi. The area of cathchment of basin is 1485 kilometer square.

Wazirabad barrage, discharge flow is having from length of year 1978-2017 i.e., 37 years. Maximum discharge on wazirabad barrage 15281.738 cumecs & minimum discharge is about 64.087 cumecs.

Indraprastha barrage the discharge flow is having from the 1978 to 2017 with the record length of 37 years , the maximum discharge is 7277.34 cumecs & the minimum discharge is about 99.11 cumecs.

Okhla barrage the discharge flow is having from the 1978 to 2017 with the record length of 37 years, the maximum discharge 10349.371 cumecs & the minimum discharge is about 502.33 cumecs.

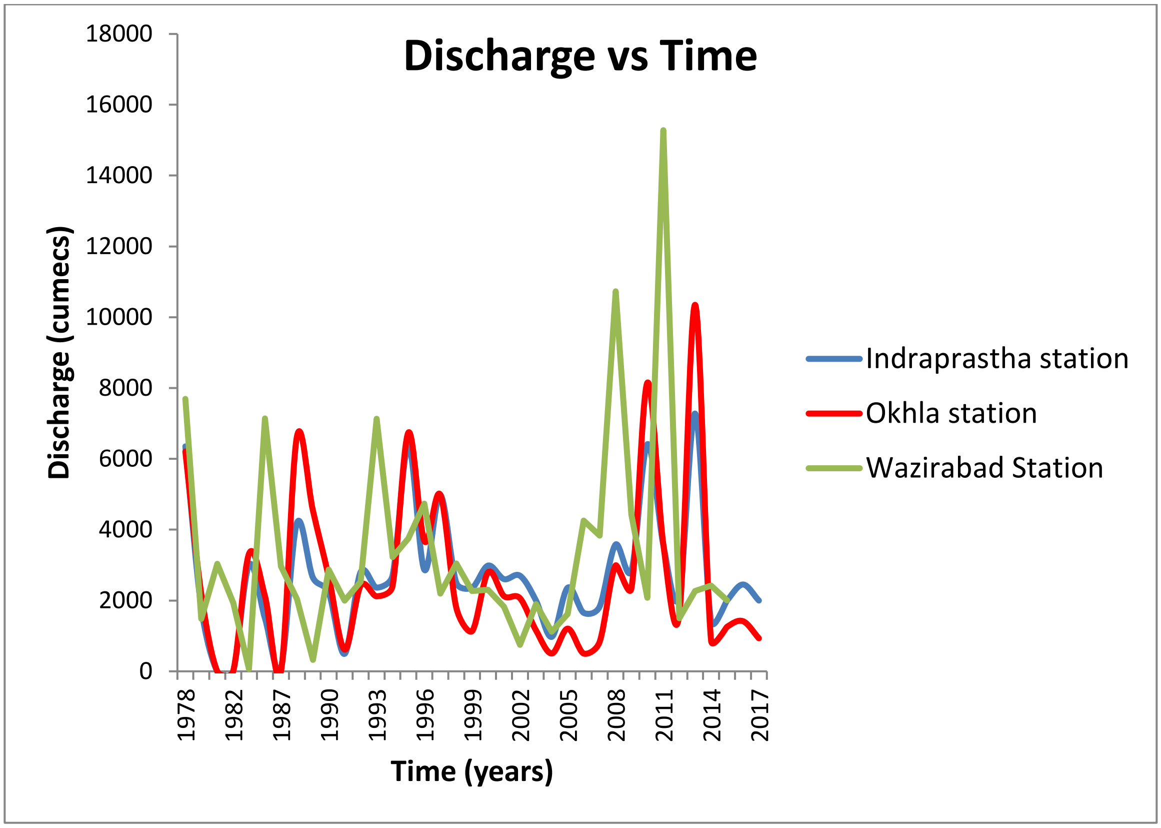

Figure 3.2 Annual Peak discharge data at three Barrages on River Yamuna

3.3 Screening of Data Sets

It is necessary to screening the data which you will analysis further, otherwise your prediction of discharge will be incorrect, the peak flood data used for frequency analysis should meet the following requirement are:

- The data of discharge should be independent or random.
- The discharge data should homogeneous.
- The sample size such that the population parameters can be estimates from it.

3.3.1 Anderson's Correlogram Test

- To test the discharge data for randomness as the subsequent analysis the series should be independent**.**
- Most standarad test of statistical approach depends on randomness. Validity of this test concludes directly link to the acceptance of the randomness assumption.
- First, Calculate lag one serial coefficient r.

$$r = \frac{\sum_{t=1}^{N-1}(Y_t-\overline{Y)(Y_{t+1}-\overline{Y})}}{\sum_{t=1}^{N}(Y_t-\overline{Y})}$$

- If 'r' lies between the tolerance limit than we can say that, our Discharge Data is Random otherwise it is not fit for further computation.
- Tolerance limit to test the hypothesis of zero auto correlation.
- $$\frac{-1-U_{1+\frac{a}{2}}(n-k-1)}{(n-k)} \quad \text{and} \quad \frac{-1+U_{1+\frac{a}{2}}(n-k-1)}{(n-k)}$$

Where, n= number of sample

k= Lag

$U_{1+\frac{a}{2}}$ = normal reduced variate

- For 95% tolerance limit the value of normal reduced variate = 1.96

3.4 Methods of Moments

It used the facts that if all moments of a distribution are already known then whole about that distribution was known. Each & every distribution having four moments parameters which are sufficient all method of moments.

$$X_T = \mu + K_T\sigma$$

In which,

X_T = Discharge which corresponding to the T year return periods.

K_T = Frequency factor that corresponding to T years.

σ and μ = Standard deviation and mean of the population.

Various Distribution is used for analyses Flood peak with their corresponding Return Period.

3.4.1 Extreme Value Type - I Distribution

It having two parameter which used in distribution i.e., widely used in meteorology and hydrology:

The probability density function (PDF) is given by

$$f(x) = \frac{1}{a}\ e^{-(x-u)/a} - e^{-(x-u)/a}$$

In the above equation 'a' and 'u' are known as shape and location parameter of distribution.

The Cumulative density funcition (CDF) is given by

$$F(X) = e^{-e^{-(x-u)/a}}$$

The parameter of that distribution estimated from the following equation using method of moments.

$$U = \bar{x} - 0.577a$$

$$a = (\sqrt{6} * s)/\pi$$

where, $\bar{x}$= mean

s= standarad deviation

Y=(x-u)/a transformation

So, Cumulative probability distribution function is

F(Y)=$e^{-e^{Y}}$

Solving for y

$$Y = -\ln\left\{ln\left(\frac{T}{T-1}\right)\right\}$$

where, T = Recurrence interval in years

3.4.2 Log Extreme Value Type 1 Distribution

(Here we use log transformed series to evaluate these values.)

PDF $$f(X) = \frac{1}{\alpha}\left[1 - K\left(\frac{X-\mu}{\alpha}\right)\right]^{\frac{1}{K}-1} e\left[1 - K\left(\frac{X-\mu}{\alpha}\right)\right]^{\frac{1}{K}}$$

CDF $$\mathrm{F(X)} = \mathrm{e}^{-\left(1-\mathrm{K(X}-\mu)\right)/\alpha^{1/\mathrm{K}}}$$

where α is scale parameter

K is shape parameter.

μ is location parameter

3.4.3 Normal Distribution

This distribution parameter which describes the characteristics of given data consisting of N values are computed as:

$$\sigma = \left[\frac{1}{N}\sum_{i=1}^{N}(X_i - X_{avg})\text{^}2\right]$$

N = number of year

σ = Standard deviation

Xi= the ith variate of series

Xav=mean of series

- Where the peak of flood calculated through

$$x_t = \bar{x} + k_t\sigma$$

3.4.4 Log Normal Distribution

Chow (1964) theoretically related the standard deviation and mean of the given series with the standard deviation and mean of log transformed series and thus enabling to find frequency factor expression K of log domain in terms of original domain statistics.

In this distribution the coefficient of skewness is Zero.

$$K = \frac{e^{\sigma_{y}K_{y}-\sigma_{y}^{2}/_{2}} - 1}{(\mathrm{e}^{\sigma_\mathrm{y}} - 1)\text{^}0.5}$$

Where,

y = the log transformed series

Ky = the standard normal deviate

K = Frequency factor

σy = ‘y’ series standard deviation

The value of frequency factor had been calculated from predefined tables which is between the coefficient of skewness & their corresponding values of frequency factor.

We here to calculate the value of frequency factor with respect to Zero coefficient of skewness to there corresponding return period. After many calculations and interpolation between the value we got the results which is shown on the next page.

3.4.5 Pearson Type III Distribution

Pearson type III distribution is a three parameter distribution. This is also known as gamma distribution with three parameters, the PDF and CDF of the distribution is given by:

(PDF) $$f(X) = \frac{(X-X_0)^{\gamma-1}}{\beta^{\gamma}(\gamma)} e^{-(X-X_0)/\beta}$$ &

(CDF) $$F(X) = \frac{\int_{X_0}^{X} (X-X_0)^{\gamma-1} e^{-(X-X_0)/\beta} \, dx}{\beta^{\gamma}(\gamma)}$$

where,

X_0= Location parameter

β= Scale parameter; γ=Shape parameter

The reduced variate is given as

$Y=(X-Xo)/\beta$

3.4.6 Log Pearson Type III Distribution

It has been very popular & widely used in hydrology, it widely acceptable in U.S & used to predicting discharge for various recurrence intervals . The U.S. Council of water resources recommends the used of the log Pearson type III distribution to attempt & promote consistent and uniform approach for frequencies analysis of flood.

It's probability density function is given by

$$f(X) = \frac{1}{|\beta|(\gamma).X}\left[\left[\frac{log_e X - y_0}{\beta}\right]^{\gamma-1}\right] \exp\left[\frac{-log_e X - y_0}{\beta}\right]$$

yo is the Location parameters,

β is the Scale parameter and

γ is the Shape parameter.

There are some important points we need to careful about these:

- Find out coefficient of skewness of our Discharge Data Series.
- Evaluate the frequency Factor corresponding coefficient of skewness.
- Using the expression $\boldsymbol{x_t = \bar{x} + k_t \sigma}$ and find out the flood discharge data with their corresponding return period.

3.5 D-INDEX

To compare the rélative fitness of test among various distributions of hydrological data**.** The exceedence of probability of an observation is found by using plotting position Wéibull formula.

P(X>x) = m/(N+1)

Where,

P = probability exceedance

m = flood rank arrange in descendịng order

N= number of observation.

Flood peaks are estimates for a specified series of recurrence intervals viz., 10, 25, 50, 100, 200, 500 and 1000 years. The D index for comparison purposes of the fit of different distribution is given as.

$$\mathbf{D - INDEX} = \frac{\sum_{i=1}^{6} \mathbf{ABS}(\mathbf{X_i observed} - \mathbf{X_i computed})}{\bar{\mathbf{X}}}$$

Instead of using flood discharge values corresponding to various return intervals of 10, 25, 50, 100, 500 and 1000 years, we used the first highest six observations of flood values, as the aim to used, to see the fit of the distribution at three barrages. It has been found appropriate to use largest six observations and the corresponding values based on the fitted distribution in calculating the D-Index. The distribution which gives minimum D-Index is considered as the best fit distribution

3.6 CONCLUSION

In this chapter, Using the statistical approach for the present study is carried out on River Yamuna in the Delhi region. In Delhi River Yamuna passes from the three barrages i.e. Wazirabad, Indraprastha, and Okhla barrage. Discharge data is collected in form of annual maximum discharge of 37 years from the Irrigation & Flood Control Department of Delhi. We also discuss the past Destructive floods in Delhi. Before using the Various Distribution you have to check the Randomness of the Data or test the independency of the discharge data by using the Anderson's Correlogram Test. The Method of Moments which having the various types of distribution i.e. EV type I Distribution, log EV type I Distribution, Normal Distribution, Log Normal Distribution, Pearson type III Distribution, Log Pearson type III Distribution with their probability distribution function and their Cumulative Distribution function and found out the general Expression which is used to Evaluate the results in form of tables and also using the graphical approach which also gives the coefficient of Determination for all the Six distribution which is discussed above. After getting all the results from the various distribution & than applying the Goodness of fit test i.e. D-Index test which is used to compare all the Distribution or saying that the which distribution is best fit among these six distribution by using the D-index values of all the distribution .

RESULTS & ANALYSIS CHAPTER 4

4.1 General:

The result of annual maximum discharge data series by using various distribution of all the three barrages from the Delhi region taken for study. At first checked out, that our discharge data is independent or not, it also saying that the our discharge data is random or not. It is essential for the further computation by using the statistical approach. Later on, applying the Flood frequency formulae using different distribution which used to compute or evaluate the discharge for corresponding return Period. The results of statistics & Goodness of fit will be discussed here.

4.2 Screening of data set

The annual peak discharge data of all the three barrages are collected from the Irrigation & Flood Control Department which works under Delhi Govt. Anderson's Correlogram Test is used to check the Randomness of the discharge data. The test results of each barrage is described below.

4.2.1 Anderson's correlogram Test

For testing the independencies or randomness of yearly flood series of past year records of discharge of individual are first experienced by Anderson's Correlogram test which clearly showed that yearly flood data information gathered for all three barrages on Yamuna river in Delhi, It's clealy visible from the results of correlogram's test that the discharge data is random at all the three barrages.

Table 4.0 Anderson's correlogram results

Station Name	**Station Year**	**r (Coefficient of Correlogram)**	**95% Significance Level**		**Remark**
			r_k (Upper Significance Limit)	**r_k (Lower Significance Limit)**	
Wazirabad	37	0.351	1.87	-1.93	Random
Indraprastha	37	0.2952	1.87	-1.93	Random
Okhla	37	o.7435	1.87	-1.93	Random

4.3 Assessing the release for various recurrence period for proposed frequency analysis of flood for various return period within it's 95 % certainty limit. Expectation of flood crest for various profit period is based for the factual methodology. These accessible information are reasonably predicated for estimation of outrageous occasion for 1000, 500, 200, 100, 50, 25 and 10 years individually for flood frequency analysis. We register the discharge for all the three floods on River Yamuna in Delhi by utilizing various distributions. Calculation of standard error of quantile gauges for as far as possible at 95% significance level for the arrival time frame. Estimation of various return period's flood and along with its 95% certainity error on Wazirabad Barrage.

Table 4.1 EV Type I Distribution for Wazirabad Barrage

EV Type I Distribution for Wazirabad Barrage				
Return Period (Years)	**Probability (P)**	**Qmax (Cumecs)**	**Xtu (95%Upper Significance Limit)**	**Xtl (95% Lower Significance Limit)**
10	0.1	6996.2944	9182.32	4810.259
25	0.04	9142.4134	12115.123	6169.703
50	0.02	10734.527	14300.279	7168.781
100	0.01	12314.885	16474.607	8155.153
200	0.005	13889.476	18643.193	9135.767
500	0.002	15966.85	21508.173	10425.527
1000	0.001	17536.88	23674.897	11398.863

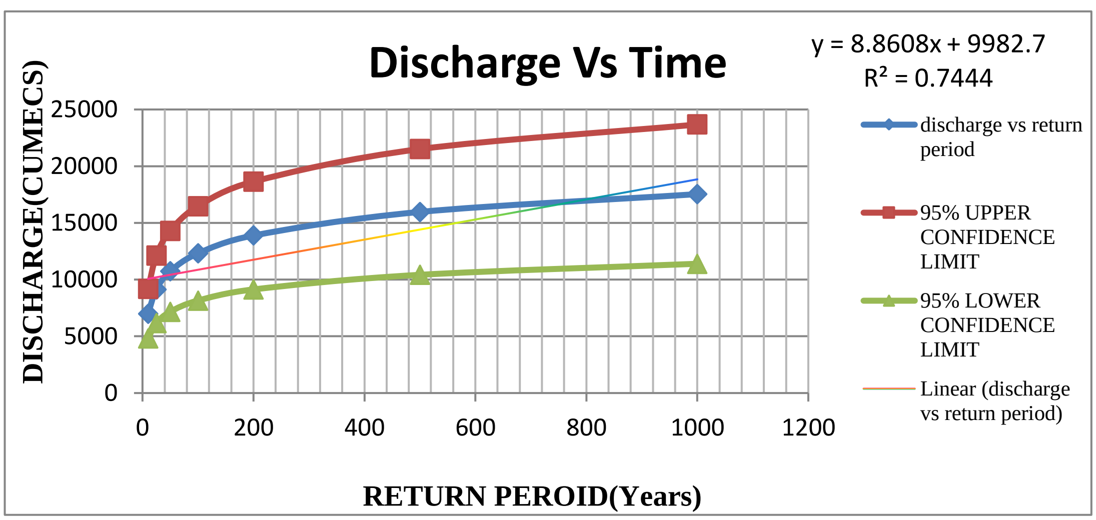

figure 4.1 EV Type I Distribution for Wazirabad Barrage

Table 4.2 Log EV Type I Distribution for Wazirabad Barrage

Log EV Type I Distribution for Wazirabad Barrage				
RETURN PERIOD (Years)	**PROBABILITY (P)**	**Qmax (Cumecs)**	**Xtu (95%Upper Significance Limit)**	**Xtl (95% Lower Significance Limit)**
10	0.1	8.6787	9.436	7.9214
25	0.04	9.422215	10.45209	8.392335
50	0.02	9.973796	11.2091	8.738496
100	0.01	10.52131	11.96244	9.080175
200	0.005	11.06682	12.71372	9.419916
500	0.002	11.78651	13.70621	9.866814
1000	0.001	12.33045	14.4571	10.2038

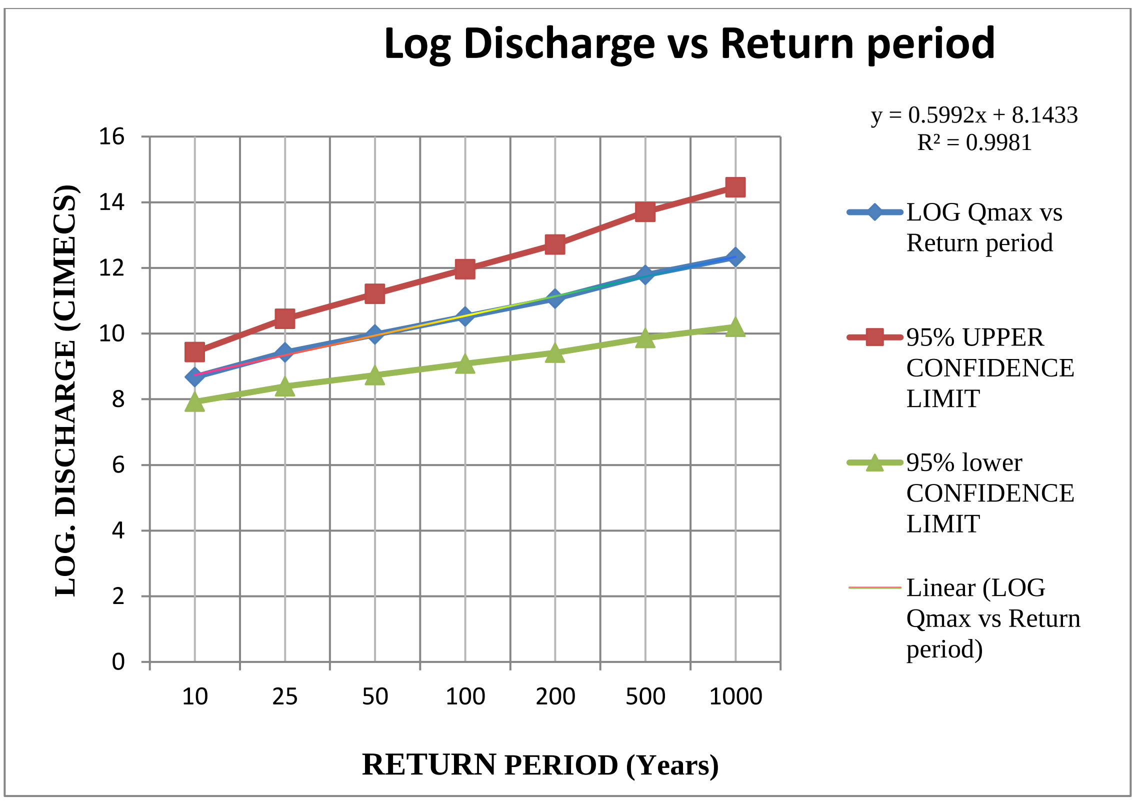

Figure 4.2 Log EV Type I Distribution for Wazirabad Barrage

Table 4.3 Normal Distribution for Wazirabad Barrage

Normal Distribution for Wazirabad Barrage			
Return Period (Years)	**Qmax (Cumecs)**	**Xtu (95%Upper Significance Limit)**	**Xtl (95% Lower Significance Limit)**
10	6930.3427	7556.1967	6304.488
25	8291.838	9054.776	7528.9
50	9171.4394	10024.414	8318.464
100	9961.0486	10895.548	9026.548
200	10686.7918	11696.623	9676.977
500	11563.95	12665.231	10462.669
1000	12178.921	13344.557	11013.2851

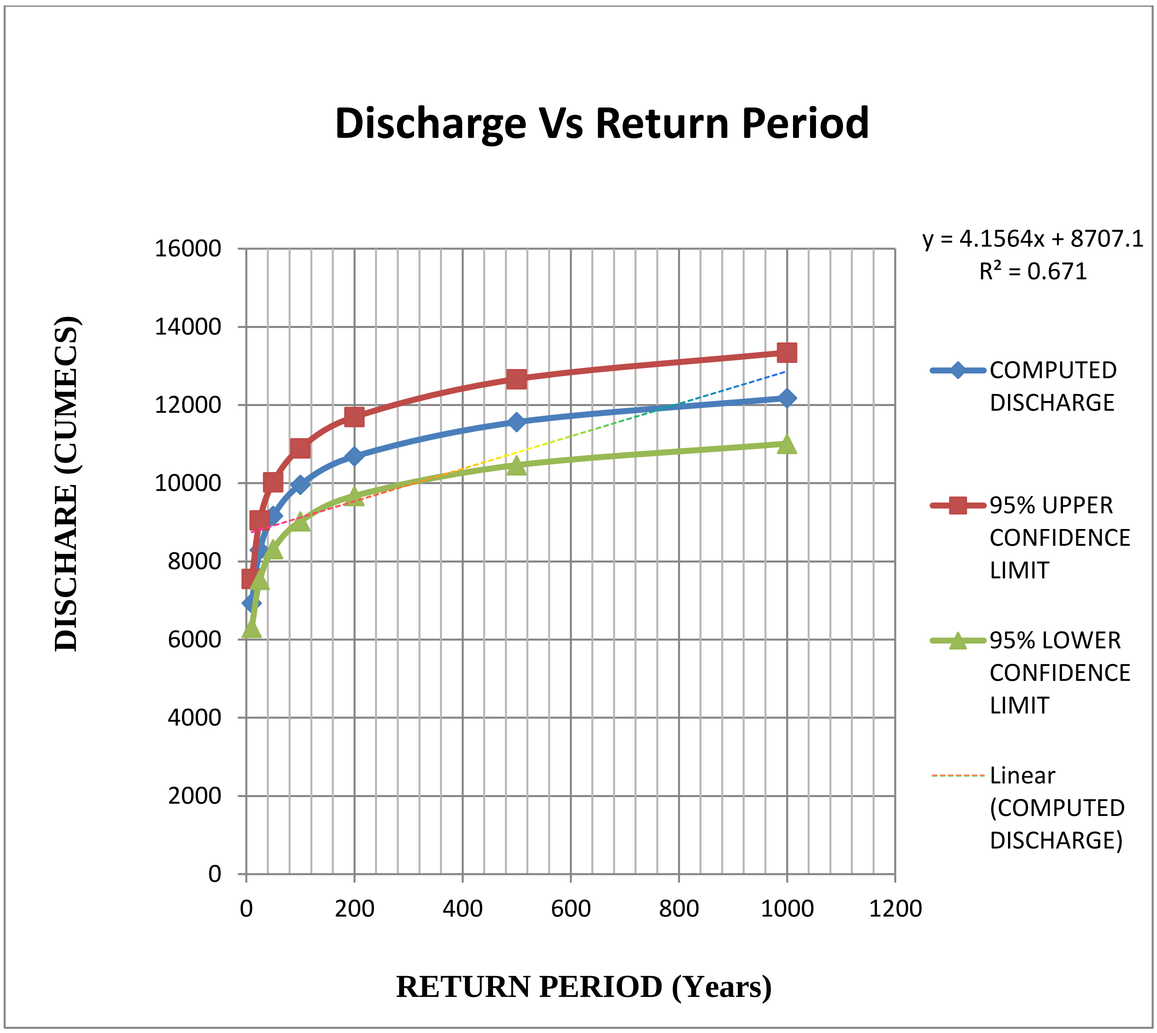

Figure 4.3 Normal Distribution for Wazirabad Barrage

Table 4.4 Log Normal Distribution for Wazirabad Barrage

Log Normal Distribution For Wazirabad Barrage			
Return Period (Years)	**Qmax (Cumecs)**	**Xtu (95%Upper Significance Limit)**	**Xtl (95% Lower Significance Limit)**
10	8.6555	9.3409	7.9701
25	9.1295	9.963	8.292
50	9.4322	10.3662	8.4982
100	9.7055	10.729	8.6821
200	9.9565	11.0625	8.8505
500	10.2605	11.4665	9.0544
1000	10.4742	11.7508	9.1976

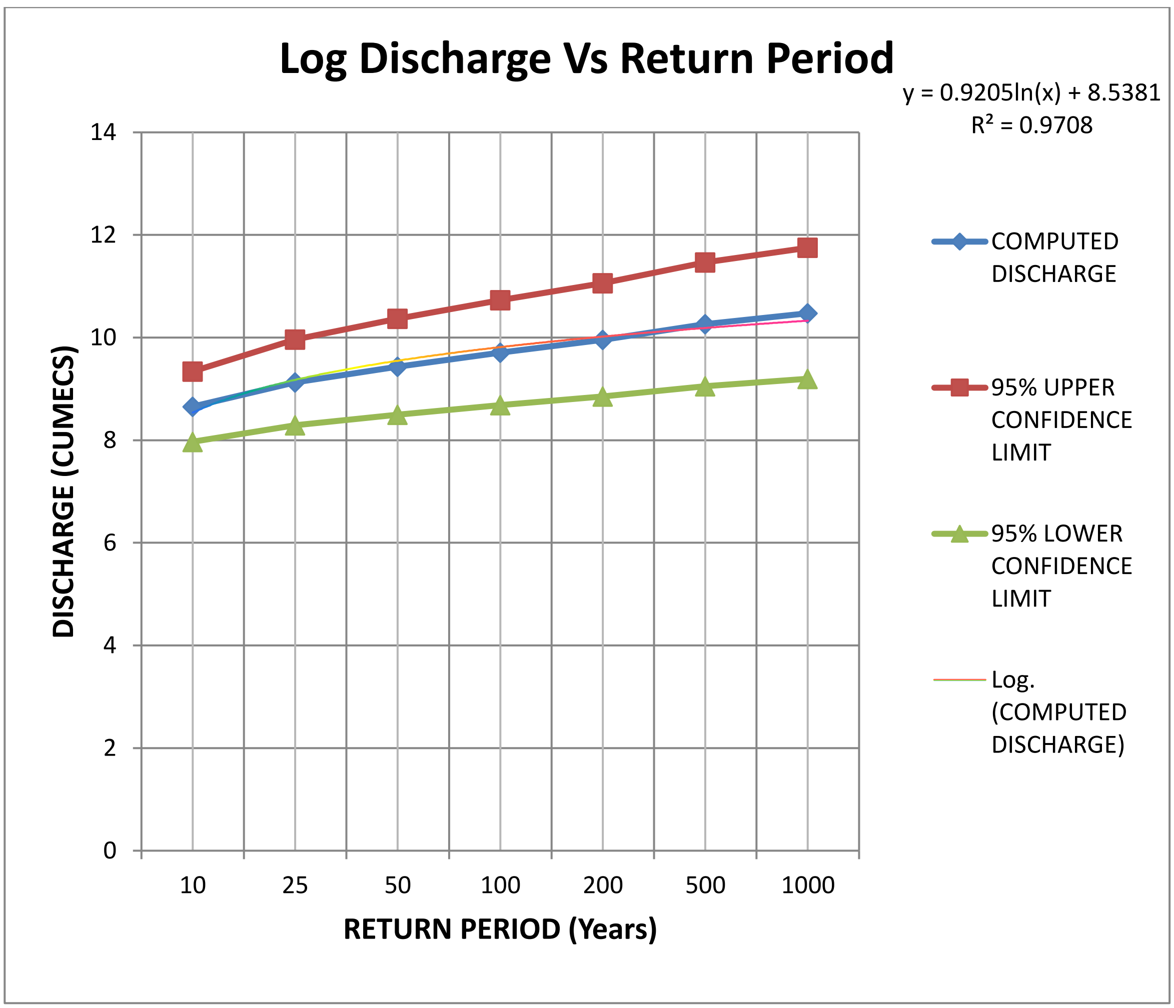

Figure 4.4 Log Normal Distribution for Wazirabad Barrage

Table 4.5 Pearson Type III Distribution for Wazirabad Barrage

Pearson Type III Distribution for Wazirabad Barrage				
RETURN PERIOD (Years)	**FREQUENCY FACTOR (K)**	**Qmax (Cumecs)**	**Xtu (95%upper Significance limit)**	**Xtl (95% Lower Significance limit)**
10	1.216	6738.7464	8657.3504	4820.1424
25	2.269	9795.579075	12695.32508	6895.833075
50	3.097	12199.24238	15884.72638	8513.758375
100	3.9438	14657.48161	19166.11961	10148.84361
200	4.804	17154.6207	22497.6377	11811.6037
500	5.956	20498.8479	26963.4119	14034.2839
1000	9.805	31672.39868	41897.27968	21447.51768

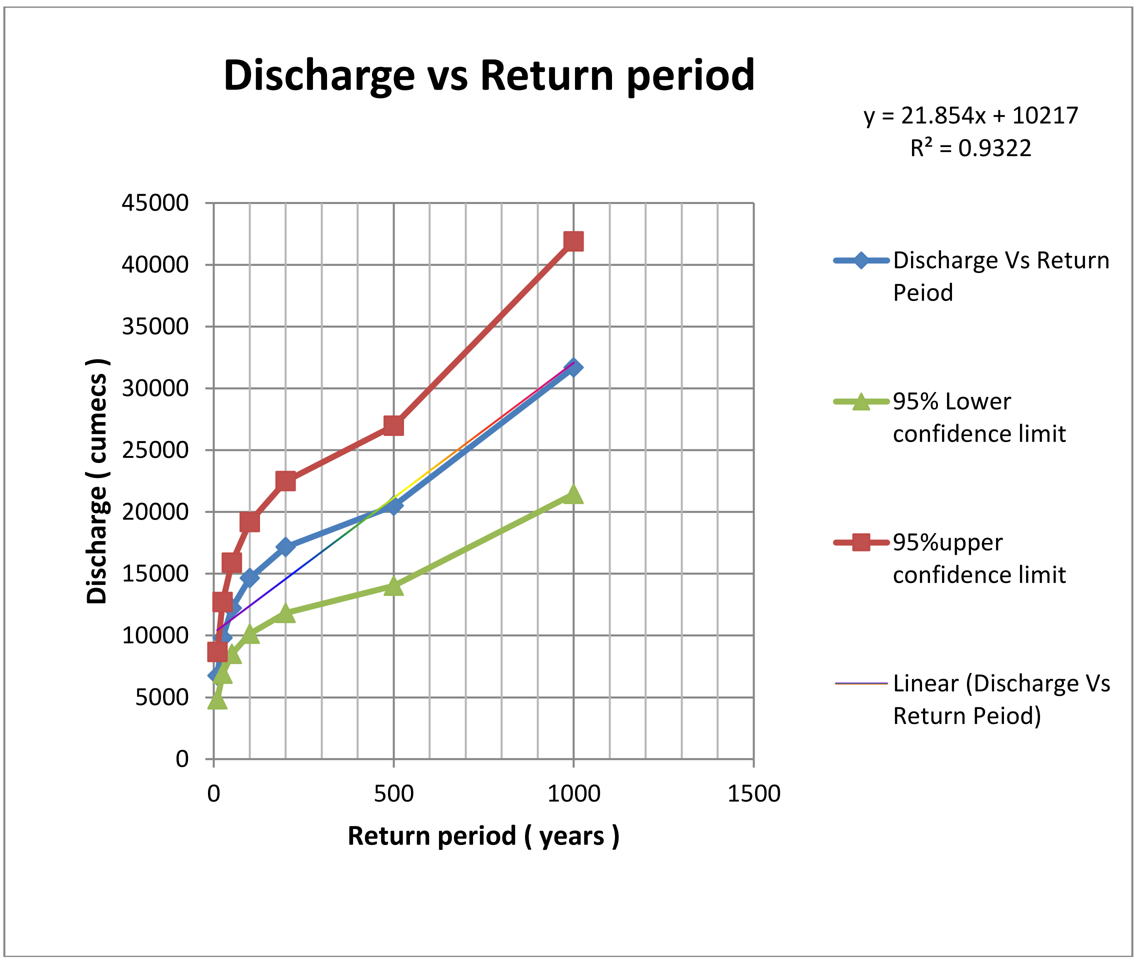

Figure 4.5 Pearson Type III Distribution for Wazirabad Barrage

Table 4.6 Log Pearson Type III Distribution for Wazirabad Barrage

Log Pearson Type III Distribution for Wazirabad Barrage				
Return Period (Years)	**Frequency Factor (K)**	**Qmax (Cumecs)**	**Xtu (95%Upper Significance Limit)**	**Xtl (95% Lower Significance Limit)**
10	1.275	8.64881575	9.33181575	7.96581575
25	1.731	9.10742863	9.93442863	8.28042863
50	2.0243	9.402409239	10.32540924	8.479409239
100	2.285	9.66460305	10.67260305	8.65660305
200	2.5243	9.90524239	10.99187424	8.818674239
500	2.8115	10.1941199	11.3761199	9.012119895
1000	3.0131	10.39687506	11.64687506	9.146875063

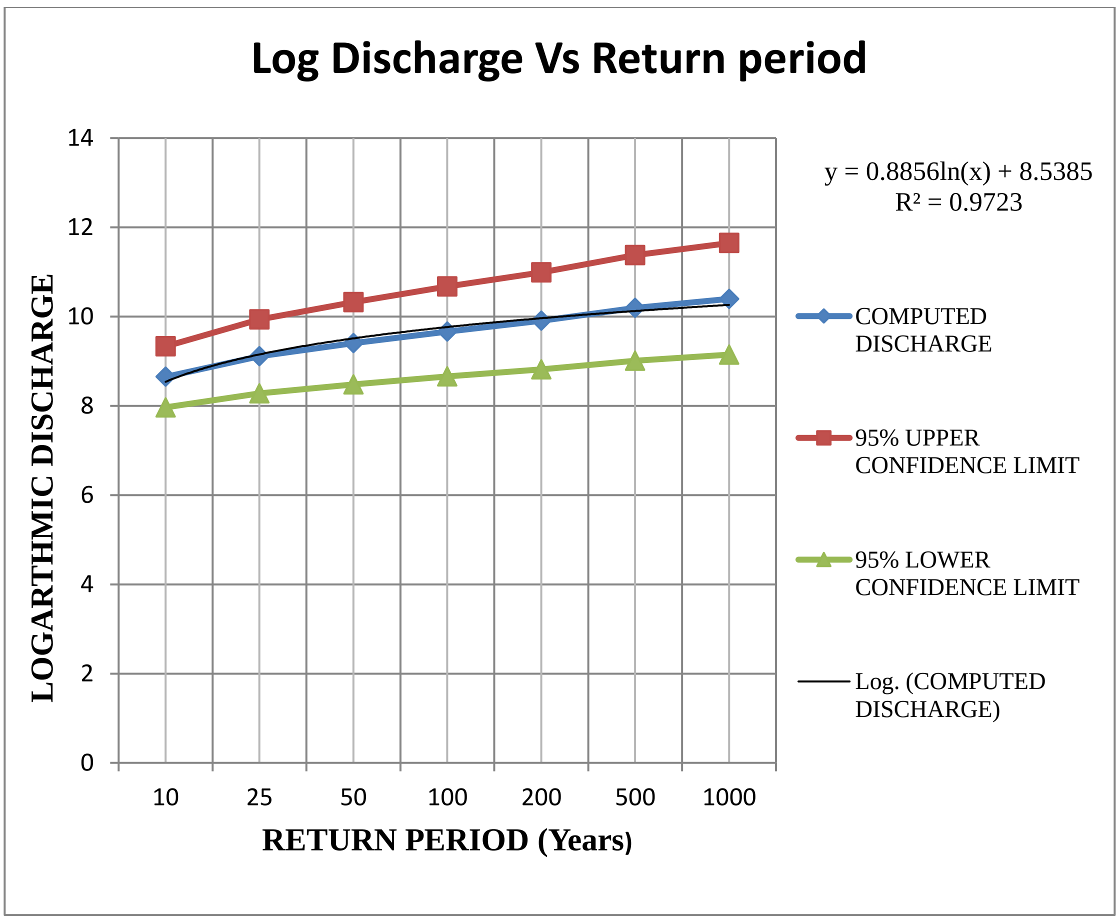

Figure 4.6 Log Pearson Type III Distribution for Wazirabad Barrage

* Estimation of T-Year Flood and its Standard Error on Indraprastha Barrage

Table 4.7 EV Type I Distribution for Indraprastha Barrage

EV Type I Distribution for Indraprastha Barrage				
RETURN PERIOD (Years)	**PROBABILITY (P)**	**Qmax (Cumecs)**	**Xtu (95%upper Significance limit)**	**Xtl (95% Lower Significance limit)**
10	0.1	6996.2944	9182.32	4810.259
25	0.04	9142.4134	12115.123	6169.703
50	0.02	10734.527	14300.279	7168.781
100	0.01	12314.885	16474.607	8155.153
200	0.005	13889.476	18643.193	9135.767
500	0.002	15966.85	21508.173	10425.527
1000	0.001	17536.88	23674.897	11398.863

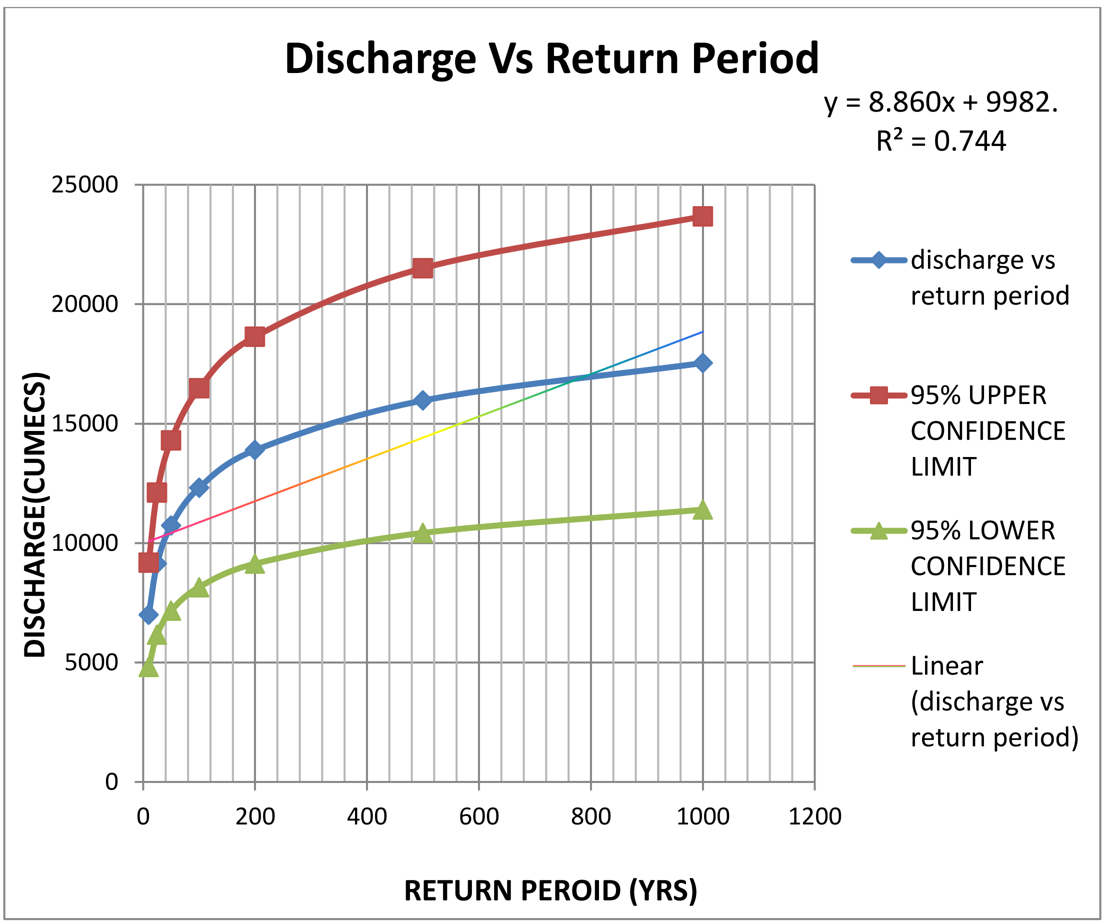

Figure 4.7 EV Type I Distribution for Indraprastha Barrage

Table 4.8 Log EV Type I Distribution for Indraprastha Barrage

Log EV Type I Distribution for Indraprastha Barrage				
RETURN PERIOD (Years)	**PROBABILITY (P)**	**Qmax (Cumecs)**	**Xtu (95%upper Significance confidence limit)**	**Xtl (95% Lower Significance limit)**
10	0.1	8.6787	9.436	7.9214
25	0.04	9.422215	10.45209	8.392335
50	0.02	9.973796	11.2091	8.738496
100	0.01	10.52131	11.96244	9.080175
200	0.005	11.06682	12.71372	9.419916
500	0.002	11.78651	13.70621	9.866814
1000	0.001	12.33045	14.4571	10.2038

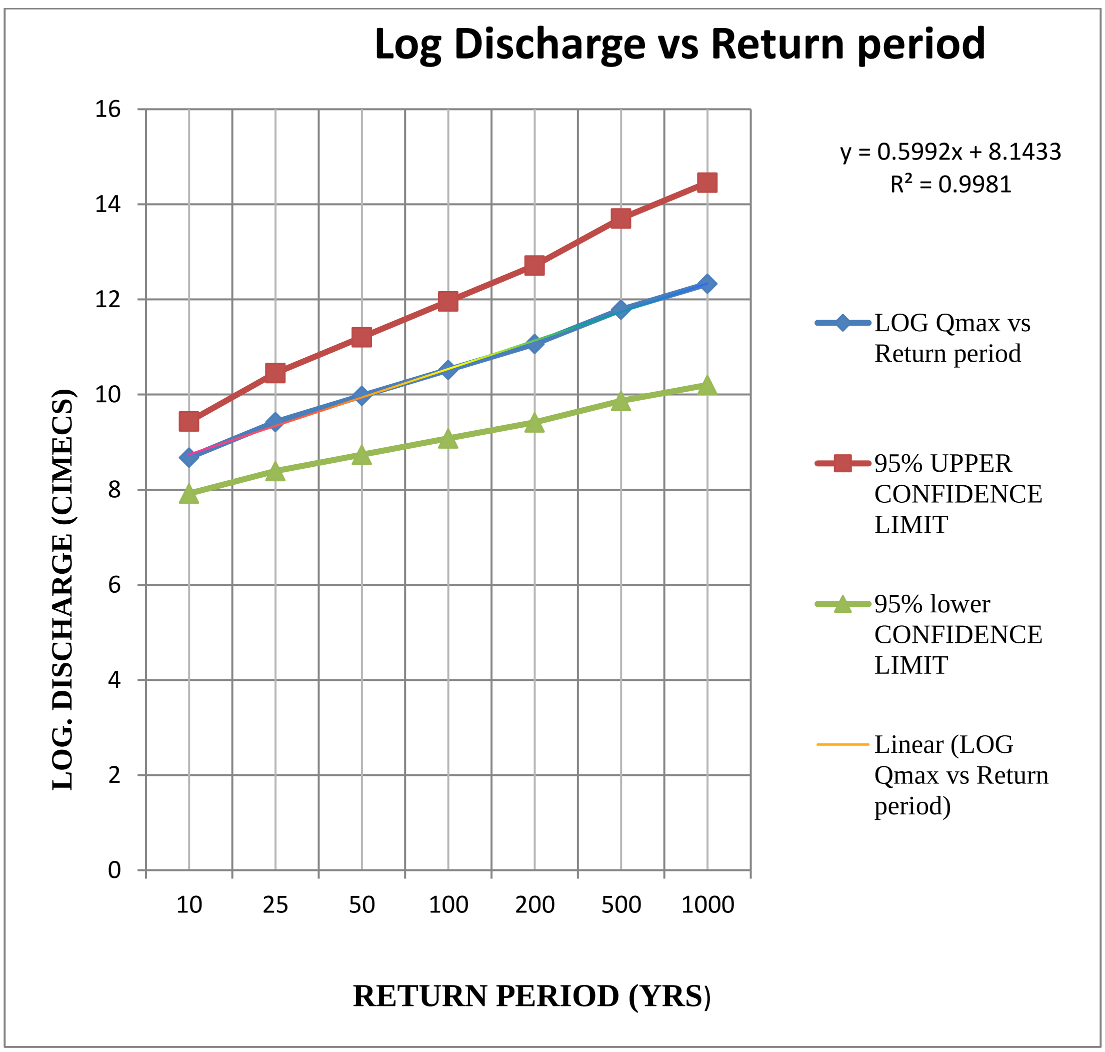

Figure 4.8 Log EV Type I Distribution for Indraprastha Barrage

Table 4.9 Normal Distribution for Indrprastha Barrage

Normal Distribution for Indrprastha Barrage			
RETURN PERIOD (Years)	**Qmax (Cumecs)**	**Xtu (95%upper Significance limit)**	**Xtl (95% Lower Significance limit)**
10	6930.3427	7556.1967	6304.488
25	8291.838	9054.776	7528.9
50	9171.4394	10024.414	8318.464
100	9961.0486	10895.548	9026.548
200	10686.7918	11696.623	9676.977
500	11563.95	12665.231	10462.669
1000	12178.921	13344.557	11013.2851

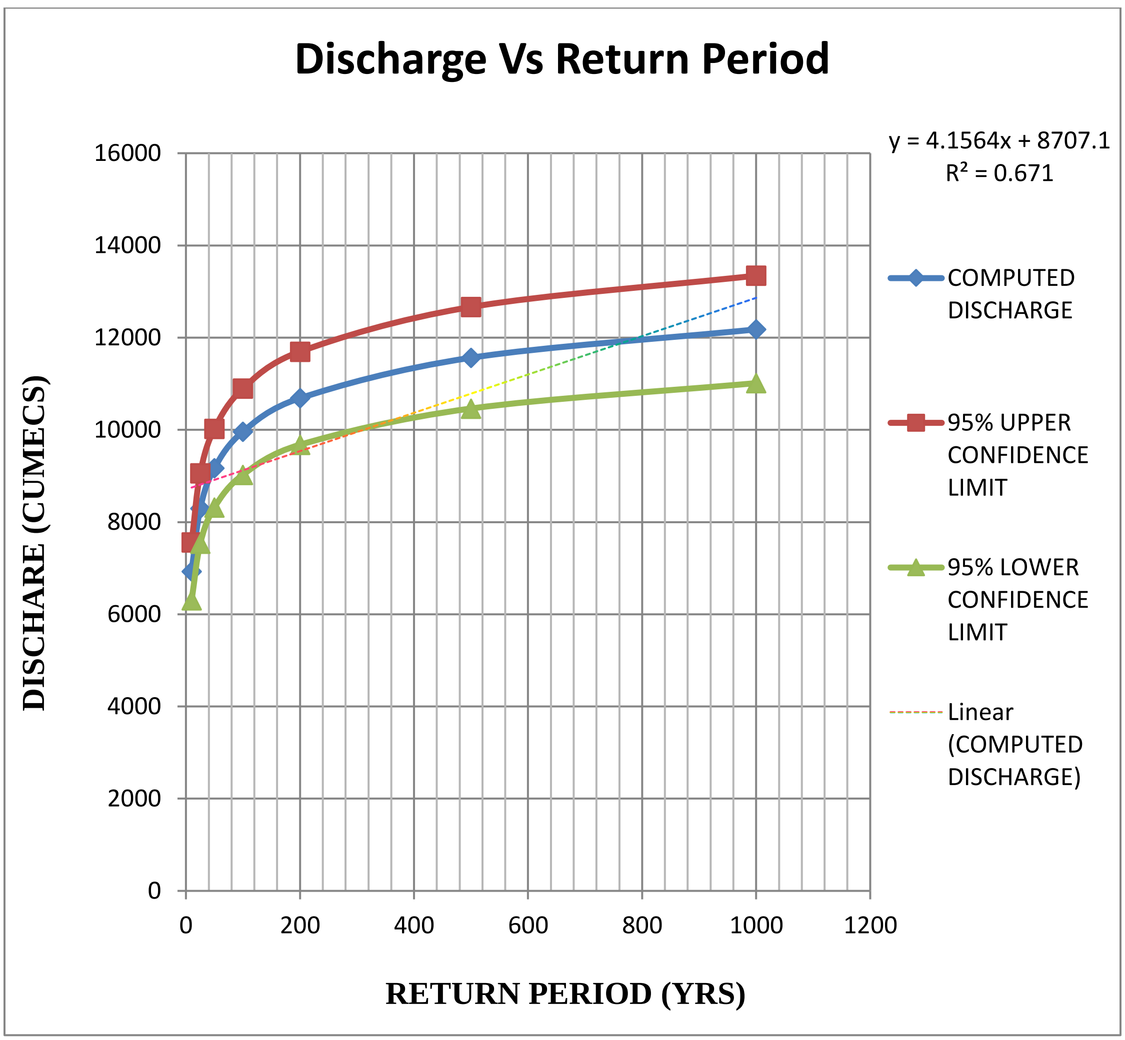

Figure 4.9 Normal Distribution for Indrprastha Barrage

Table 4.10 Log Normal Distribution for Indrprastha Barrage

Log Normal Distribution for Indrprastha Barrage			
Return Period (Years)	**Qmax (Cumecs)**	**Xtu (95%Upper Significance Limit)**	**Xtl (95% Lower Significance Limit)**
10	8.6555	9.3409	7.9701
25	9.1295	9.963	8.292
50	9.4322	10.3662	8.4982
100	9.7055	10.729	8.6821
200	9.9565	11.0625	8.8505
500	10.2605	11.4665	9.0544
1000	10.4742	11.7508	9.1976

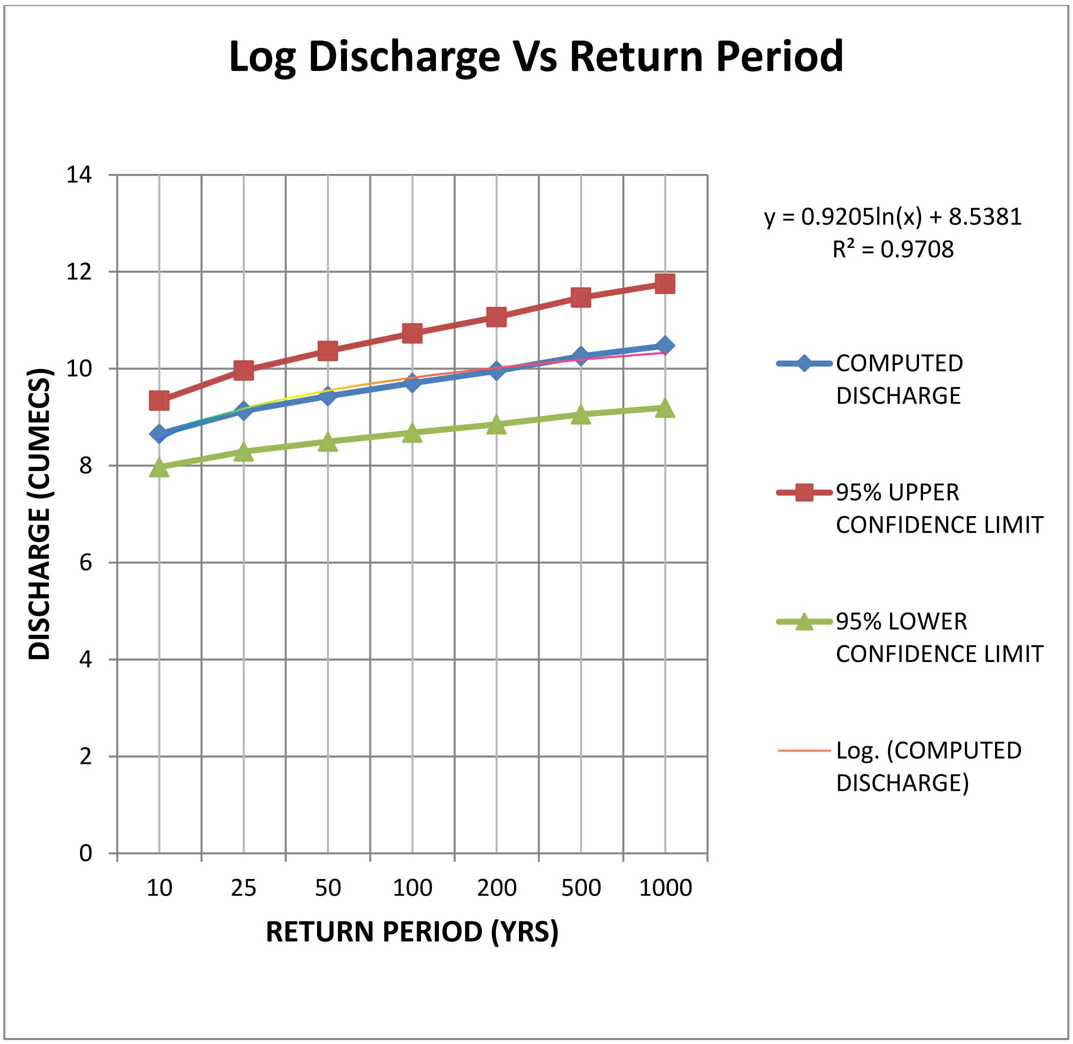

Figure 4.10 Log Normal Distribution for Indrprastha Barrage

Table 4.11 Pearson Type III Distribution for Indraprastha Barrage

Pearson Type III Distribution for Indraprastha Barrage				
RETURN PERIOD (Years)	**FREQUENCY FACTOR (K)**	**Qmax (Cumecs)**	**Xtu (95%upper Significance limit)**	**Xtl (95% Lower Significance limit)**
10	1.216	6738.7464	8657.3504	4820.1424
25	2.269	9795.579075	12695.32508	6895.833075
50	3.097	12199.24238	15884.72638	8513.758375
100	3.9438	14657.48161	19166.11961	10148.84361
200	4.804	17154.6207	22497.6377	11811.6037
500	5.956	20498.8479	26963.4119	14034.2839
1000	9.805	31672.39868	41897.27968	21447.51768

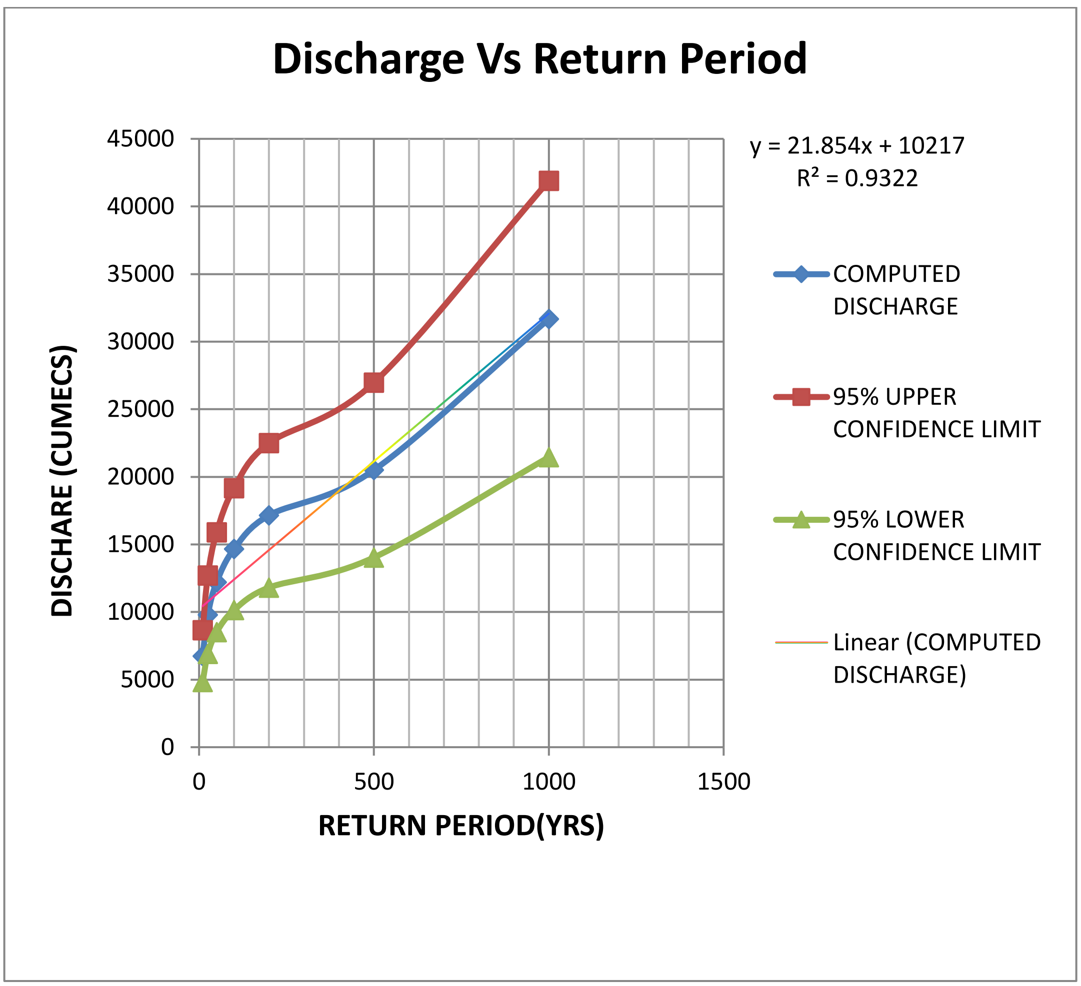

Figure 4.11 Pearson Type III Distribution for Indraprastha Barrage

Table 4.12 Log Pearson Type III Distribution for Indraprastha Barrage

Log Pearson Type III Distribution for Indraprastha Barrage				
Return Period (Years)	**Frequency Factor (K)**	**Qmax (Cumecs)**	**Xtu (95%Upper Significance Limit)**	**Xtl (95% Lower Significance Limit)**
10	1.275	8.64881575	9.33181575	7.96581575
25	1.731	9.10742863	9.93442863	8.28042863
50	2.0243	9.402409239	10.32540924	8.479409239
100	2.285	9.66460305	10.67260305	8.65660305
200	2.5243	9.90524239	10.99187424	8.818674239
500	2.8115	10.1941199	11.3761199	9.012119895
1000	3.0131	10.39687506	11.64687506	9.146875063

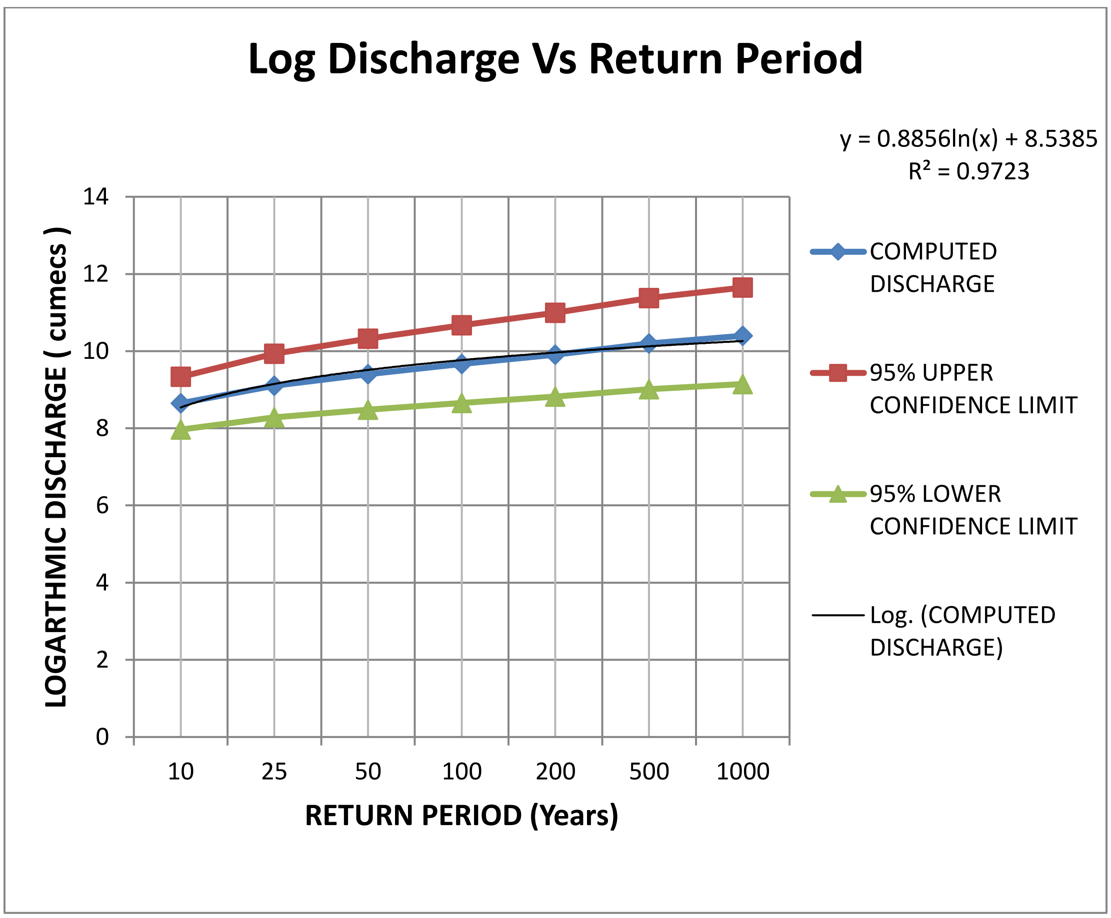

Figure 4.12 Log Pearson Type III Distribution

* Estimation of T-Year Flood and its Standard Error on Okhla Barrage

Table 4.13 EV Type I Distribution for Okhla Barrage

EV Type I Distribution for Okhla Barrage			
Return Period (Years)	**Qmax (Cumecs)**	**Xtu (95%upper Significance limit)**	**Xtl (95% Lower Significance limit)**
10	6665.934536	7898.64	5433.22
25	9030.459962	10707.008	7353.911
50	10784.6	12796.116	8773.083
100	12525.78774	14872.315	10179.25
200	14260.62218	16942.498	11578.746
500	16549.4068	19675.242	13423.571
1000	18279.21599	21741.368	14817.063

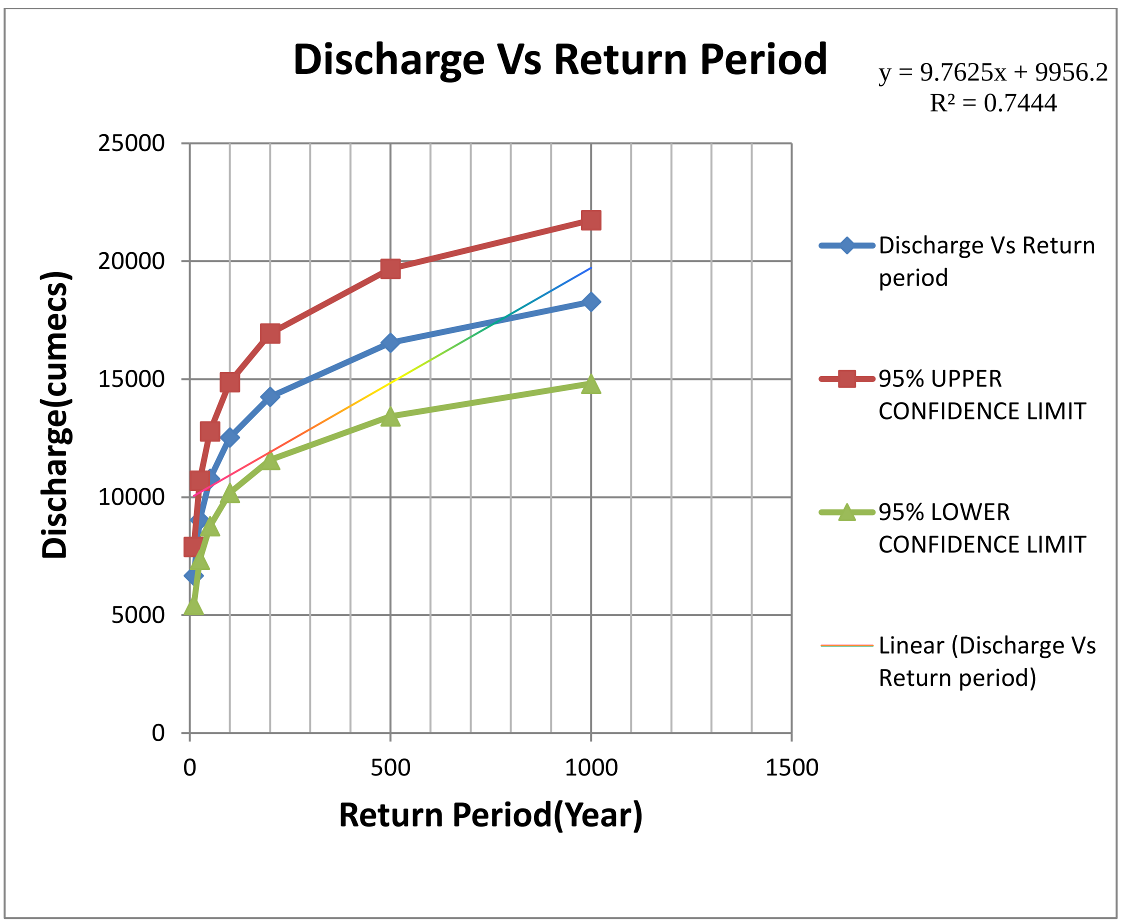

Figure 4.13 EV Type I Distribution(Discharge Vs Return Period)

Table 4.14 Log EV Type I Distribution for Okhla Barrage

Log EV Type I Distribution for Okhla Barrage			
Return Period (Years)	**Qmax (Cumecs)**	**Xtu (95%upper significance limit)**	**Xtl (95% Lower significance limit)**
10	8.4335	8.7569	8.1101
25	9.0536	9.4934	8.6138
50	9.513	10.041	8.986
100	9.9702	10.585	9.354
200	10.4252	11.1287	9.721
500	11.02549	11.8454	10.205
1000	11.4791	12.3873	10.5709

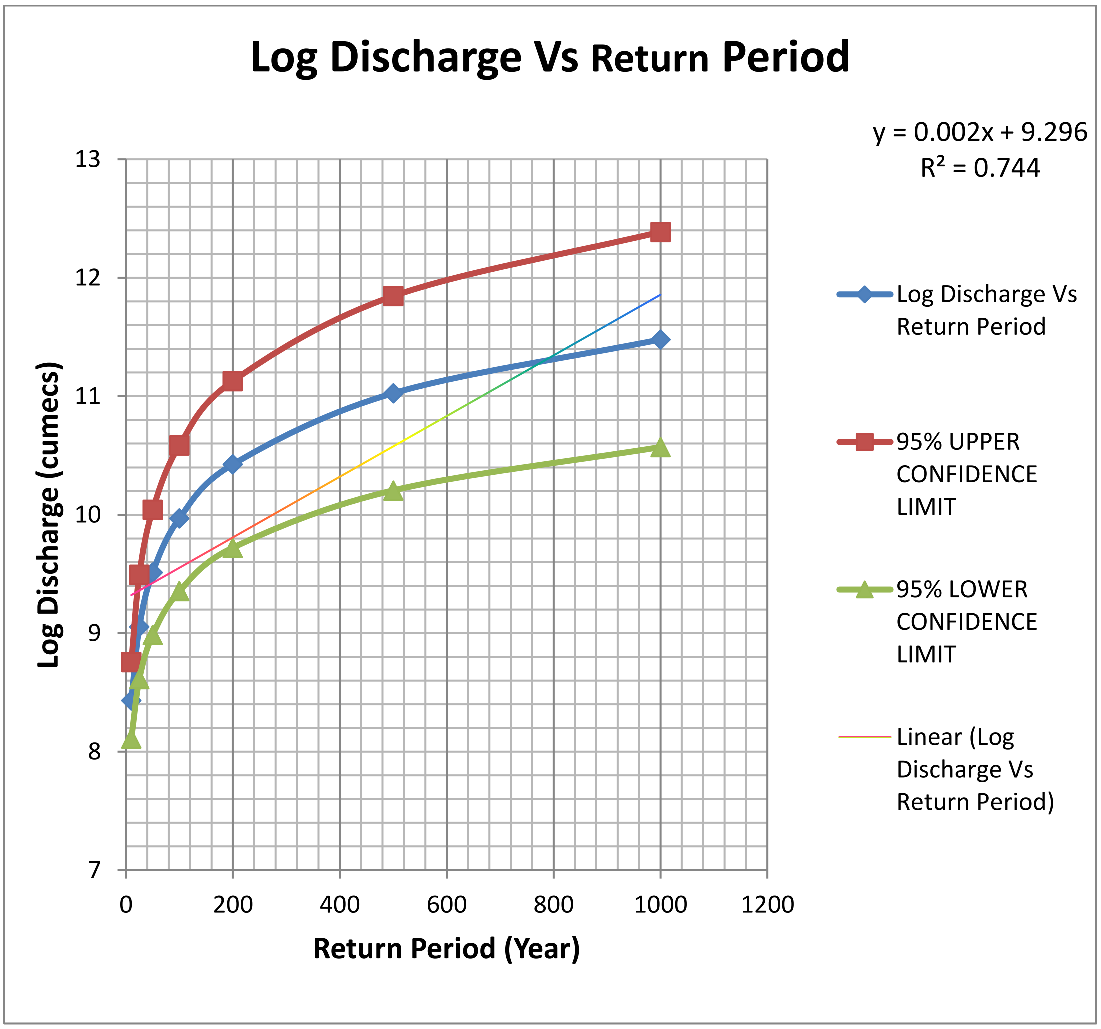

Figure 4.14 Log EV Type I Distribution (Log Discharge Vs Return Period)

Table 4.15 Normal Distribution for Okhla Barrage

Normal Distribution for Okhla Barrage			
Return Period (Years)	**Qmax (Cumecs)**	**Xtu (95%Upper Significance Limit)**	**Xtl (95% Lower Significance Limit)**
10	6796.2891	7907.4025	5685.175
25	8295.986	9650.595	6941.376
50	9264.533	10779.0601	7750.006
100	10135.592	11795.131	8476.0525
200	10932.707	12725.6967	9139.717
500	11898.6301	13854.0718	9943.1888
1000	12576.157	14645.937	10506.3789

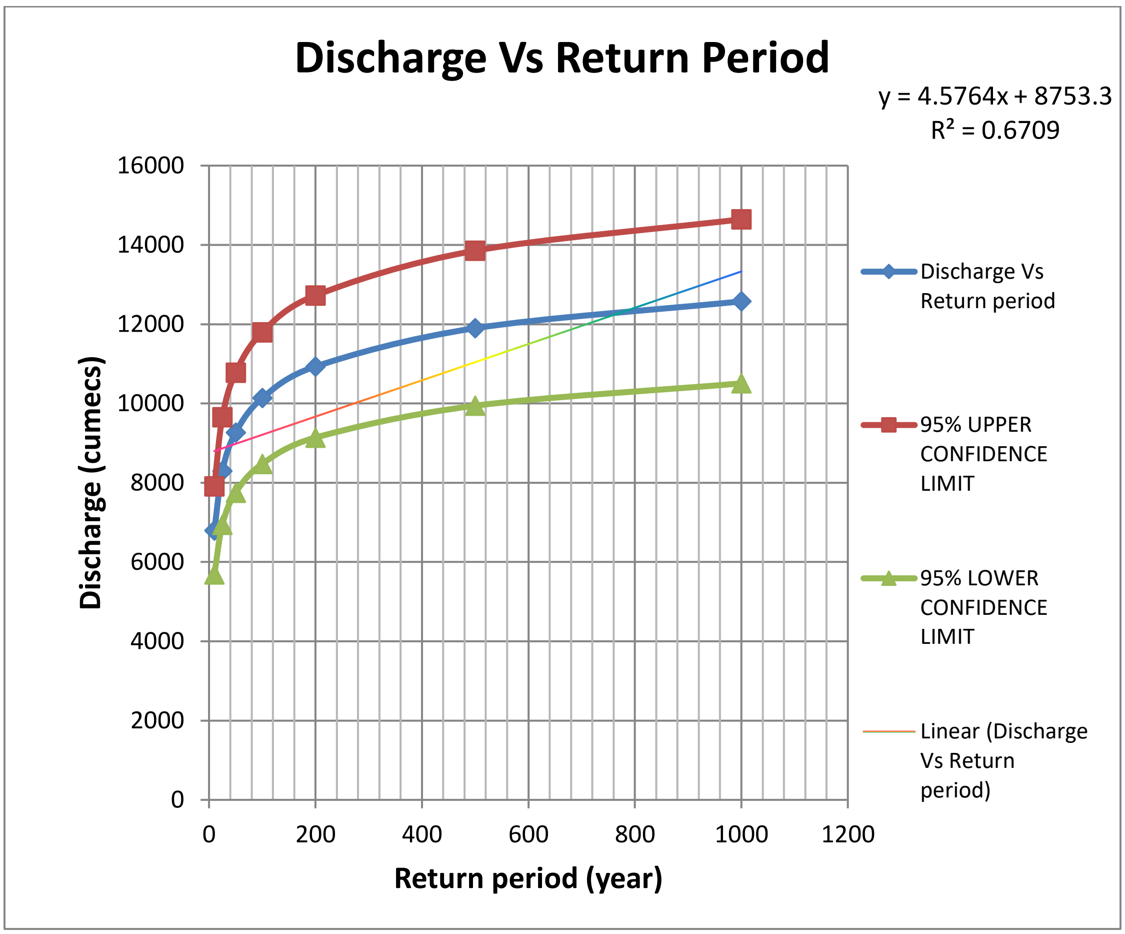

Figure 4.15 Normal Distribution(Discharge Vs Return Period)

Table 4.16 Log Normal Distribution for Okhla Barrage

Log Normal Distribution for Okhla Barrage			
Return Period (Years)	**Qmax (Cumecs)**	**Xtu (95%Upper Significance Limit)**	**Xtl (95% Lower Significance Limit)**
10	8.4148	8.7066	8.123
25	8.8083	9.164	8.452
50	9.0626	9.4602	8.664
100	9.2908	9.7264	8.855
200	9.5005	9.9713	9.029
500	9.7539	10.2673	9.2405
1000	9.9318	10.475	9.388

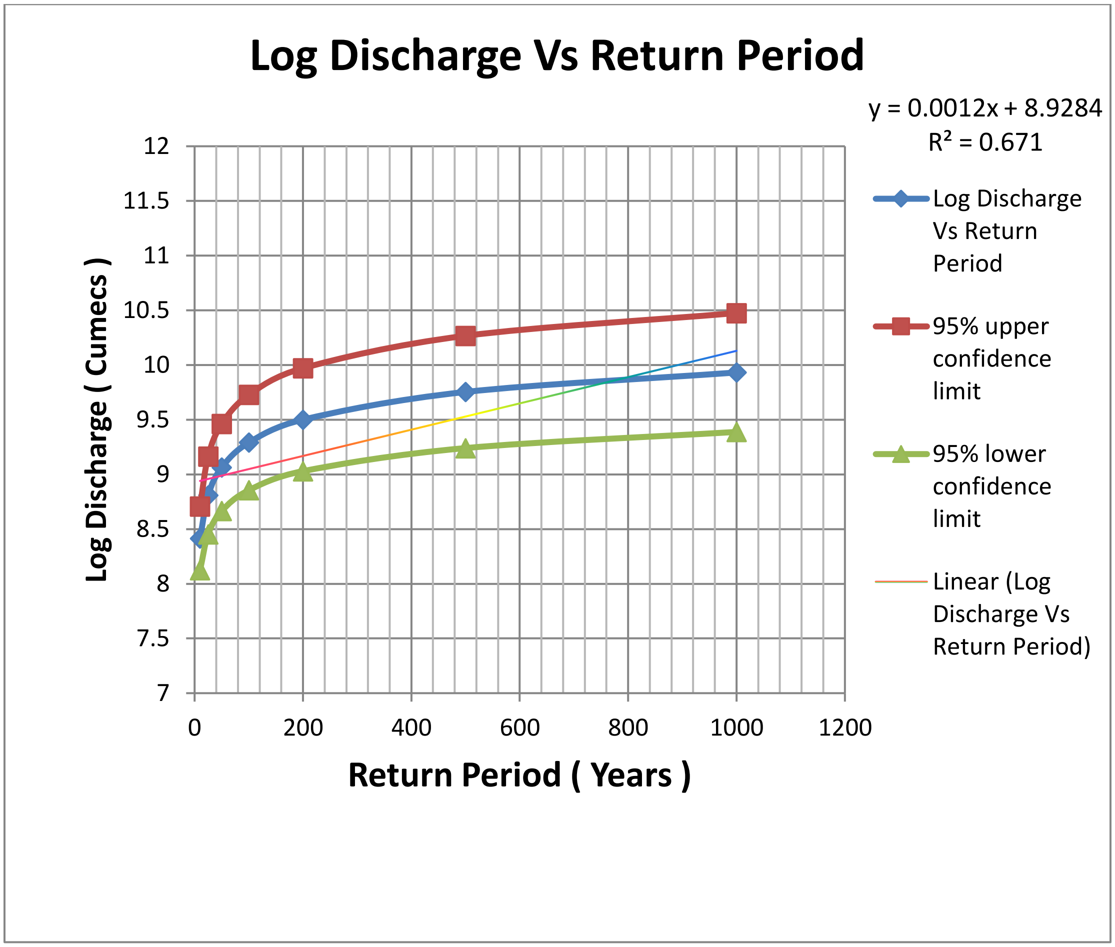

Figure 4.16 Log Normal Distribution(Log Discharge Vs Return Period)

Table 4.17 Pearson Type III Distribution for Okhla Barrage

Pearson Type III Distribution for Okhla Barrage				
RETURN PERIOD (Years)	**FREQUENCY FACTOR (K)**	**Qmax (Cumecs)**	**Xtu (95%upper Significance limit)**	**Xtl (95% Lower Significance limit)**
10	1.329	6953.735	8090.0991	5817.3720
25	2.163	9621.206	11194.994	8047.418
50	2.78	11594.622	13498.858	9690.386
100	3.388	13539.253	15772.0038	11306.502
200	3.99	15464.693	18024.450	12904.936
500	4.515	17143.856	19989.735	14297.977
1000	5.393	19952.0567	23277.7586	16626.3544

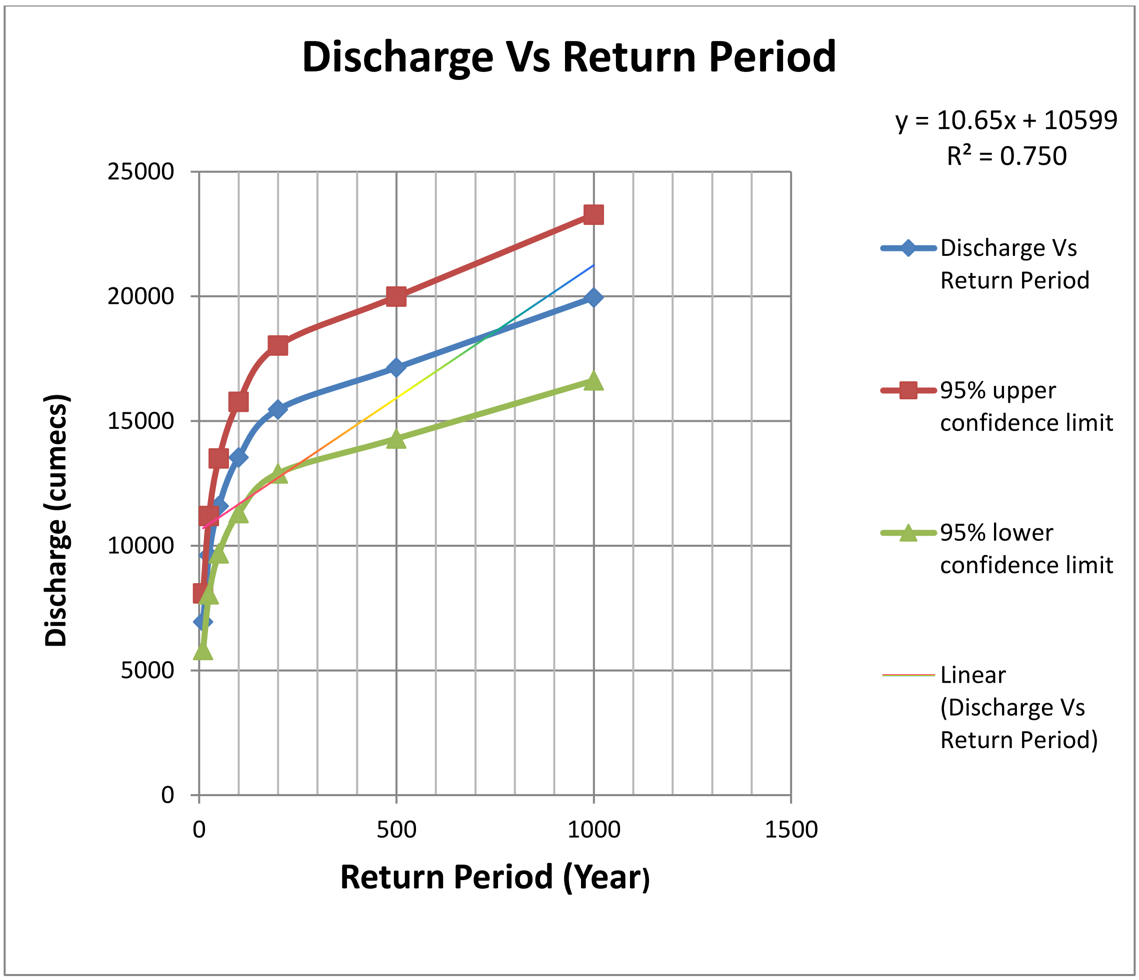

Figure 4.17 Pearson Type III Distribution (Discharge Vs Return Period)

Table 4.18 Log Pearson Type III Distribution for Okhla Barrage

Log Pearson Type III Distribution for Okhla Barrage				
Return Period (Years)	**Frequency Factor (K)**	**Qmax (Cumecs)**	**Xtu (95%Upper Significance Limit)**	**Xtl (95% Lower Significance Limit)**
10	1.273	8.407	8.697	8.116
25	1.718	8.780	9.131	8.429
50	2.028	9.0407	9.434	8.646
100	2.297	9.266	9.698	8.834
200	2.478	9.418	9.875	8.961
500	2.865	9.743	10.254	9.231
1000	2.975	9.835	10.362	9.308

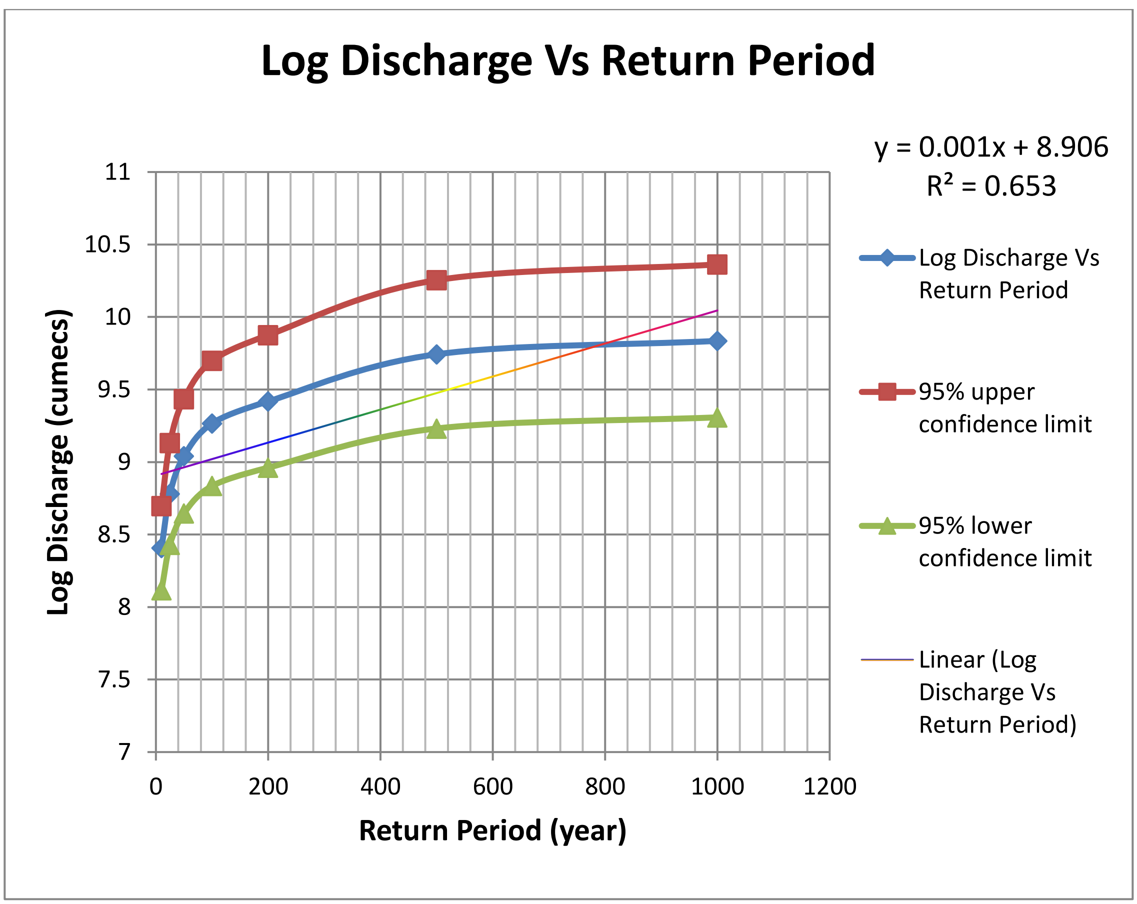

Figure 4.18 Log Pearson Type III Distribution (Discharge Vs Return Period)

From the figure no 4.1 which describes the Graphical representation of Discharge Vs Return period for the Extreme value type I distribution at the wazirabad barrage in which 95% upper and lower significance limit is also plotted which is concluded that the predicted discharge is lies within the 95% probability. It's also represents the value of the coefficient of determination i.e $R^2 = 0.744$ which states that the scattering of discharge is narrow.

Figure no. 4.2 the graphical representation of the Logarthmic Extreme value type I distribution at the wazirabad barrage in which 95% upper and lower significance limit is also plotted which is concluded that the predicted discharge is lies within the 95% probability. It's also represents the value of the coefficient of determination $R^2 = 0.9981$ which states that the scattering of discharge is narrow.

Figure no. 4.3 the graphical representation of the Normal distribution at the wazirabad barrage in which 95% upper and lower significance limit is also plotted which is concluded that the predicted discharge is lies within the 95% probability. It's also represents the value of the coefficient of determination i.e $R^2 = 0.671$ which states that the scattering of discharge is narrow.

Figure no. 4.4 the graphical representation of the Logarthmic Normal distribution at the wazirabad barrage in which 95% upper and lower significance limit is also plotted which is concluded that the predicted discharge is lies within the 95% probability. It's also represents the value of the coefficient of determination i.e $R^2 = 0.9708$ which states that the scattering of discharge is narrow.

Figure no. 4.5 the graphical representation of the Pearson type III distribution at the wazirabad barrage in which 95% upper and lower significance limit is also plotted which is concluded that the predicted discharge is lies within the 95% probability. It's also represents the value of the coefficient of determination i.e $R^2 = 0.9322$ which states that the scattering of discharge is narrow.

Figure no. 4.6 the graphical representation of the Logarthmic Pearson type III distribution at the wazirabad barrage in which 95% upper and lower significance limit is also plotted which is concluded that the predicted discharge is lies within the 95% probability. It's also represents the value of the coefficient of determination i.e $R^2 = 0.972$ which states that the scattering of discharge is narrow.

From the figure no 4.7 which describes the Graphical representation of Discharge Vs Return period for the Extreme value type I distribution at the Indraprastha barrage in which 95% upper and lower significance limit is also plotted which is concluded that the predicted discharge is lies within the 95% probability. It's also represents the value of the coefficient of determination i.e $R^2 = 0.744$ which states that the scattering of discharge is narrow.

Figure no. 4.8 the graphical representation of the Logarthmic Extreme value type I distribution at the Indraprastha barrage in which 95% upper and lower significance limit is also plotted which is concluded that the predicted discharge is lies within the 95% probability. It's also represents the value of the coefficient of determination i.e $R^2 = 0.998$ which states that the scattering of discharge is narrow.

Figure no. 4.9 the graphical representation of the Normal distribution at the Indraprastha barrage in which 95% upper and lower significance limit is also plotted which is concluded that the predicted discharge is lies within the 95% probability. It's also represents the value of the coefficient of determination i.e $R^2 = 0.671$ which states that the scattering of discharge is narrow.

Figure no. 4.10 the graphical representation of the Logarthmic Normal distribution at the Indraprastha barrage in which 95% upper and lower significance limit is also plotted which is concluded that the predicted discharge is lies within the 95% probability. It's also represents the value of the coefficient of determination i.e $R^2 = 0.97$ which states that the scattering of discharge is narrow.

Figure no. 4.11 the graphical representation of the Pearson type III distribution at the Indraprastha barrage in which 95% upper and lower significance limit is also plotted which is concluded that the predicted discharge is lies within the 95% probability. It's also represents the value of the coefficient of determination i.e $R^2 = 0.932$ which states that the scattering of discharge is narrow.

Figure no. 4.12 the graphical representation of the Logarthmic Pearson type III distribution at the Indraprastha barrage in which 95% upper and lower significance limit is also plotted which is concluded that the predicted discharge is lies within the 95% probability. It's also represents the value of the coefficient of determination i.e $R^2 = 0.972$ which states that the scattering of discharge is narrow.

From the figure no 4.13 which describes the Graphical representation of Discharge Vs Return period for the Extreme value type I distribution at the Okhla barrage in which 95% upper and lower significance limit is also plotted which is concluded that the predicted discharge is lies within the 95% probability. It's also represents the value of the coefficient of determination i.e $R^2 = 0.74$ which states that the scattering of discharge is narrow.

Figure no. 4.14 the graphical representation of the Logarthmic Extreme value type I distribution at the Okhla barrage in which 95% upper and lower significance limit is also plotted which is concluded that the predicted discharge is lies within the 95% probability. It's also represents the value of the coefficient of determination i.e $R^2 = 0.744$ which states that the scattering of discharge is narrow.

Figure no. 4.15 the graphical representation of the Normal distribution at the Okhla barrage in which 95% upper and lower significance limit is also plotted which is concluded that the predicted discharge is lies within the 95% probability. It's also represents the value of the coefficient of determination i.e $R^2 = 0.6709$ which states that the scattering of discharge is narrow.

Figure no. 4.16 the graphical representation of the Logarthmic Normal distribution at the Okhla barrage in which 95% upper and lower significance limit is also plotted which is concluded that the predicted discharge is lies within the 95% probability. It's also represents the value of the coefficient of determination i.e $R^2 = 0.671$ which states that the scattering of discharge is narrow.

Figure no. 4.17 the graphical representation of the Pearson type III distribution at the Okhla barrage in which 95% upper and lower significance limit is also plotted which is concluded that the predicted discharge is lies within the 95% probability. It's also represents the value of the coefficient of determination i.e $R^2 = 0.75$ which states that the scattering of discharge is narrow.

Figure no. 4.18 the graphical representation of the Logarthmic Pearson type III distribution at the Okhla barrage in which 95% upper and lower significance limit is also plotted which is concluded that the predicted discharge is lies within the 95% probability. It's also represents the value of the coefficient of determination i.e $R^2 = 0.653$ which states that the scattering of discharge is narrow.

4.4 Goodness of fit test

Fitness of test, an important tool to compare among all the distribution among all of them. Using the D-Index test which is used to compare all the distribution which already used above .It describe that which distribution is best fitted to evaluate or predict the discharge for their corresponding return period. We calculate the D-index values for all the distribution for all the three barrages i.e. wazirabad, Indraprastha, and okhla barrage.

Table 4.19 D-Index Values

Type of Distribution	Wazirabad station	Indraprastha station	Okhla station
EV Type I Distribution	2.589	2.589	5.068
Log EV Type I Distribution	0.1539	0.1539	0.205
Normal Distribution	3.3191	3.3191	2.699
Log Normal Distribution	0.1184	0.1184	0.152
Pearson Type III Distribution	1.6682	1.6682	2.86
Log Pearson Type III Distribution	0.7387	0.7387	0.18

4.5 Conclusion

In this chapter, we already discussed about the Anderson's correlogram test which is utilized to check the randomness of the hydrological data like discharge or the independencies one over the other. Afterwards, it's followed the various distributions in which, evaluate the Flood Peak for various return period i.e. 10, 25, 50, 100, 200, 500, 1000 years along with their 95% significance confidence limits for each distribution for all the three barrages. It also explained the prediction of discharge by using the graphical approach of each distribution for all the three barrages on River Yamuna in Delhi. It also used the goodness of fit test i.e. D-Index test through which it easily compare all the distribution that is which distribution is best fitted distribution to evaluate the discharge with their corresponding return period for all the three barrages.

CONCLUSION CHAPTER 5

It has discussed about the results of annual flood series data of River Yamuna at the Wazirabad, Indraprastha and Okhla Station choosen from Delhi region taken for study purpose initially screened for randomness & Goodness of fit. Flood frequency formulae using different distribution have been calculated.

Wazirabad Station

- It observed that the parameters for statistical point of view for Original Series of Yamuna river at Wazirabad station are coefficient of variance 0.9047, mean 3208.728 m^3/s, standard deviation 2902.975, kurtosis coefficient 11.519 and coefficient of skewness 2.748.
- It observed that the parameters for statistical point of view for log transformed Series of Yamuna river at Wazirabad station are coefficient of variance 0.1365, mean 7.3665m^3/s, standard deviation 1.0057, kurtosis coefficient 5.4318 and coefficient of skewness - 0.0549

Indraprastha Station

- It observed that the parameters for statistical point of view of Yamuna river at Indraprastha station are coefficient of variance 1.18325, mean 2703.054m^3/s, standard deviation 3198.405, kurtosis coefficient 3.0146 and coefficient of skewness 1.6
- It observed that the parameters for statistical point of view for log transformed Series of Yamuna river at Indraprastha station are variance coefficent 0.1365, mean 7.3393m^3/s, standard .deviation 0.839, kurtosis coefficient 5.26935 and coefficient of skewness -0.1739

Okhla Station

- It observed that the parameters for statistical point of view for Original Series of Yamuna river at Okhla station are coefficient of variance 0.8376, mean 2654.919m^3/s, standard deviation 2223.948, kurtosis coefficient 6.87 and coefficient of skewness 2.018.

- It observed that the parameters for statistical point of view for log transformed Series of Yamuna river at Okhla station are coefficient of variance 0.1143, mean 7.057m^3/s, standard deviation 0.949, kurtosis coefficient 3.195 and coefficient of skewness 1.58

1. Preliminary analysis of Hydrological data i.e. Discharge at the three station namely; Wazirabad, Indraprastha, and Okhla barrage & check for their independency, it found out that our discharge at all three station is Random by using Anderson's correlogram test.
2. frequency analysis of flood suggested that, any return þeriod discharge carried out along with 95% Significance limits.
3. Statistical approach is used to find out the prediction of flood for various return period.
4. Prediction of discharge data of an éxtreme event which approximately 10, 25, 50, 100, 200, 500, and 1000 years respectively for analysis of flood frequency.
5. From above Results, it's clearly shows that the distribution results by using various methods of distribution. It also observe that the flood peak with their corresponding return period and their true value which lies between the lower & upper value of confidence limits with 95% significance level.

Comparision among various Distributions Methods By using D-index Method:

From the values of D-index for each Distribution, from the various methods the Logarthmic Normal Distribution well suited distribution for Wazirabad station of River Yamuna. Similarly, Logarthmic Normal Distribution well suited distribution for Indraprastha station of River Yamuna and the last not the least Logarthmic Gumbel Distribution well suited distribution for Okhla station of River Yamuna for predicting the discharge flow in River Yamuna at all these three barrages with their corresponding return period.

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