2007 UCOWR/NIWR
Annual Conference
Hazards in Water Resources
Boise, Idaho | July 24 – 26, 2007

Determination of precipitation and return periods to assess flood risks in the City of Juarez, Mexico

HECTOR A. QUEVEDO (Ph.D.), Jorge A. Salas Plata M. (Ph.D.) and Humberto García (Ph.D.)

July 24, 2007

INTRODUCTION

In hydrological studies, the period of return is one of the most significant parameters that must be considered in the projection of hydraulic works or in the implementation of flood prevention measures.

http://cuentame.inegi.gob.mx/monografias/informacion/chih/imagenes/lago.jpg

STATING THE PROBLEM

Only a few studies about return periods have been done in the city of Juarez, Mexico. Moreover, no studies have defined the extreme return periods that occasioned the flooding and loss of property and human lives of July 2006.

BACKGROUND INFORMATION

Normaly, the accepted return periods used in the designing of hydraulic works are of about 20 to 50 years. For important bridges and dams the return periods are of 100 years. These return periods are corroborated by the method of Maximum Probable Precipitation (Bedient y Huber, 1948).

Cont..

Similarly, Chow (1964), discusses a graphical method to estimate the mathematical relationship among the intervals of the series of annual maximum recurrence (in years) and the recurrence intervals of annual excedences.

http://www.mccullagh.org/db9/d30-25/rio-grande-2.jpg

Cont..

Furthermore, Linsley (1958), discusses the corresponding return periods for partial and annual series. Likewise, Gupta (1989), discusses the application of Bernoulli processes, that is, the binomial discrete function.

Cont…

Regarding the application of discrete distributions, the binomial functions assign probabilities to the number of occurrences to an event, while the continuous distributions (like the normal distribution) determine the probability of the magnitud of an event (Bedient y Huber, 1948).

Cont…

Further, these investigators applied the binomial distribution to studies of risk and reliability, in which risk is defined as the probability of occurrence in *n* events. Accordinlgy, the risk is the sum of the probabilities of 1 flood, 2 floods, 3 floods,… of *n* floods that occur during *n* periods of years. To calculate the risk, the function below is used:

$$Risk = 1 – (1 – 1/T)^n$$

Where n is the number of events and T is the return period.

Similarly, to estimate the reliability the function used is:

$$Reliability = (1 – 1/T)^n$$

For example, in the study of a flooding critical design, the hydraulic engineer can calculate the probability that, at least one 50-year flooding would occur during the lifetime of a 30 year project. This is simply the failure of risk discussed using equation (2). So, with 1/T = 50 = 0.02 and with n = 30 years, the risk for this particular instance is:

$Risk = 1 – (1 – 0.02)^{30} = 0.455$.

Cont…

However, under these conditions this risk is too big and the engineer would have to design the flood control system to an event of 100 years, in whose case this would give: Risk = 1 – (1 – 1/100)^{30} = 0.26.

Then, under these circumstances, the reliability is estimated using equation (3), that is: Reliability = (1 – 0.01)^{30} = 0.74

Cont…

The concept of reliability is very important in designing hydrological projects and can be used to determine the period of return required for the life of a hydrological project and its level of risk.

OBJECTIVE

The main objective of this study is to determine return periods, probabilities of occurrence and annual precipitation, through the application of the Hazen methodology. The study used the annual precipitation data of the Comisión Nacional del Agua (CNA), for the historical statistical period of 1957-2006 corresponding to the city of Juarez, México.

http://www.sagarpa.gob.mx/dlg/chihuahua/nuestro_edo/imagenes/arco.jpg

METHODOLOGY

- **The methodology of this study consisted, first, in performing a test for the normality of the data, through descriptive statistics by estimating the arithmetic mean, the mode, standard deviation, tests of Anderson-Darling, etcetera.**
- **Next, the study applied the Hazen graphical position method.**
- **Afterwards, the data was assembled as shown in the following table:**

Table 1.0. Original precipitation data of the City of Juárez, Chihuahua, México (Period 1957-2006).

Year	Mm	Yr	Mm	Yr	Mm	Yr	Mm	Yr	Mm
1957	162	1967	172.5	1977	171.5	1987	216	1997	284.8
1958	349.5	1968	323	1978	284	1988	239.5	1998	187.5
1959	125.5	1969	195	1979	190	1989	183	1999	186
1960	209.5	1970	298	1980	259	1990	376.3	2000	294
1961	174	1971	119	1981	392	1991	430.5	2001	177
1962	189.7	1972	343.5	1982	249	1992	390.7	2002	303.5
1963	193	1973	293	1983	245	1993	244.4	2003	104.5
1964	117	1974	449.5	1984	435.5	1994	165.5	2004	300
1965	161.5	1975	208.8	1985	243	1995	275.8	2005	335.5
1966	283	1976	246	1986	323	1996	202	2006	469.5

Cont..

Next, using the data of Tabla 1, the study processed the precipitation data through the use of the following equation:

Probability (F_a) = [100(2n-1) / 2y] = 100/period of return

Cont..

Where:

F_a .- Probability of ocurrence (%)

***n*.- Rank of each event**

***y*.- Total number of events**

RESULTS

The results of the descriptive statistics and normality test for the precipitation data were:

- **Arithmetic mean = 25.54 cm/year**
- **Median = 24.47 cm/year**
- **Mode = 32.3 cm/year**
- **Standard deviation = 9.17 cm**
- **Skewness = 0.56**
- **Confidence interval 24.3, 26.8; level of significance of 95%**

RESULTS

The population distribution of precipitation is approximately normal. Insofar as the results obtained using Figure 1, for example, if one desires to use a return period of 20 years for a given project, then the expected precipitation is about 44 cm with a probability of 0.05 (5%). Similarly, if one is interested in estimating a period of return of 80 years, then the precipitation is about 50 cm of rain, with a probabililty of occurrence of about 2%, and so on.

Rank	Precipitation (mm)	Probability (%)	Period of Return (years)	Rank	Precipitation (mm)	Rank	Period of Return (years)
1	469.5	1	100	26	244.4	51	1.96
2	449.5	3	33.33	27	243	53	1.87
3	435.5	5	20	28	239.5	55	1.82
4	430.5	7	14.28	29	216	57	1.75
5	392	9	11.11	30	209.5	59	1.69
6	390.7	11	9.09	31	208.8	61	1.64
7	376.3	13	7.69	32	202	63	1.59
8	349.5	15	6.66	33	195	65	1.54
9	343.5	17	5.88	34	193	67	1.49
10	335.5	19	5.26	35	190	69	1.45
11	323	21	4.76	36	189.7	71	1.41
12	323	23	4.35	37	187.5	73	1.37

Cont..

Rank	Precipita-tion (mm)	Probabili-ty (%)	Period of Return (years)	Rank	Precipita-tion (mm)	Rank	Period of Return (years)
13	303.5	25	4	38	186	75	1.33
14	300	27	3.7	39	183	77	1.3
15	298	29	3.45	40	177	79	1.27
16	294	31	3.23	41	174	81	1.23
17	293	33	3.03	42	172.5	83	1.2
18	284.4	35	2.86	43	171.5	85	1.18
19	284	37	2.7	44	165.5	87	1.15
20	283	39	2.56	45	162	89	1.12
21	275.8	41	2.44	46	161.5	91	1.09
22	259	43	2.33	47	125.5	93	1.07
23	249	45	2.22	48	119	95	1.05
24	246	47	2.13	49	117	97	1.03
25	249	49	2.04	50	104.5	99	1.01

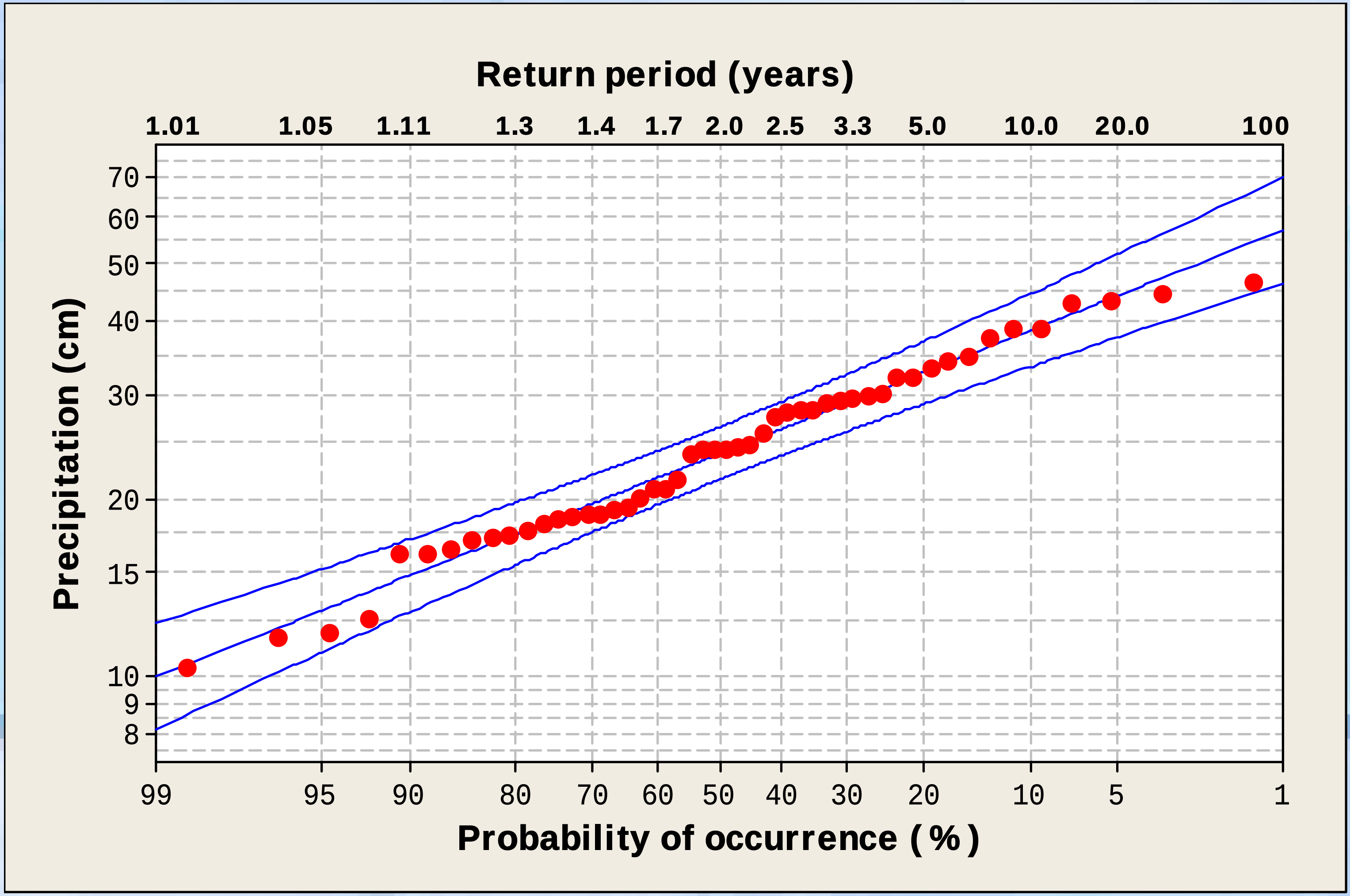


Figure 1.0. Graphical representation of precipitation on logaríthmic scale (cm), periods of return (years) and probabilities of occurrence (%) respectively, with a regression line and confidence bands.

CONCLUSIONS

- **According to the logarithmic and probability graph and the adjusted line of regression depicted in Figure 1, the graphical method selected was that of Hazen, because of its traditionality and simplicity.**
- **According to the results of Table 2 and Figure 1, if the return period calculated for the construction of a dam is of 20 years, this means that, on the average, every 20 years there will be a flooding.**

Cont..

- The period of return of the pluvial precipitations that occasioned severe flooding in Ciudad Juárez, according to the results of Figure 1, for this region and for this period of information (1956-2006) was of about 100 years.

Cont…

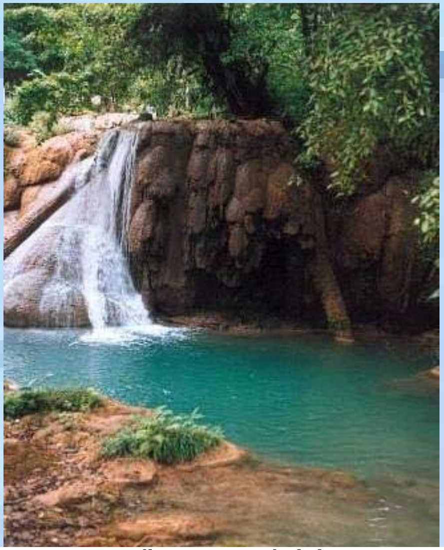
It is concluded that, the challenge the hydraulic engineer will have, is how to confront upcoming future extreme hydrological events, by designing hydraulic projects more adequate, safely and less costly to avoid risks of flooding and loss of property and lives.

RECOMMENDATIONS

Of all the existing graphical positions cited in the literature as those of Weibull, Cunnane, Gringorten, Hazen, etc., to estimate precipitations, probabilities and periods of return, this study recommends the graphical position of Hazen. This is because of its traditionality and simplicity.

Cont…

Insofar as the frequency analysis, to define the distribution of a hydraulic variable, it is recommeded to use continuous and discrete distributions as the normal and binomial distribution, respectively.



http://www.fotomaya.com/images/chi_agua_azul.jpg

Cont…

Moreover, it is recommended to perform descriptive statistical studies and tests of normality before one intends to process the precipitation data, especially in this type of study.

DISCUSION

This study contends that the underway global warming is provoking climatic changes due to the emissions and effects of vehicular and industrial greenhouse gases as CO_2, CH_4, water vapor, etc. It is believed that extreme pluvial events are going to be even more common,| as the global temperatures increase.

- **The pluvial precipitations of 2006 in Juarez, Mexico were atypical. The changing global climatic conditions, imply that the upcoming extreme temperatures and meterological condions will bring more extreme events that can repeat the meterological conditions that caused the flooding of july and august of 2006.**


Zona Centro
Av. Vicente Guerrero


diario.com.mx


"CADENA"
Coca-Cola
diario.com.mx


diario.com.mx


diario.com.mx

THANK YOU… GOD BLESS

QUESTIONS OR COMMENTS