QUANTITATIVE STUDY OF LYARI WATERWAYS

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ABSTRACT Metropolitan city Karachi is the biggest and the most industrialized city of Pakistan which located at extreme west end of the Indus delta within the geographical coordinate between latitude $24^{0}51^{/}\mathrm{N}$ and longitude $67^{0}04^{/}\mathrm{E}$. The Lyari river is one of the three rivers, along with the Malir and Hub rivers, which flows through the greater metropolitan area of the city. It is one of the major flood water-carrying river which passes through the main city area of Karachi. Its main tributaries are Gujar and Orangi nullahs. The entire untreated industrial and domestic sewerage water joins the river directly or through these nullahs. This river and adjacent developed area have been subjected to severe flooding on regular basis in the past. This flood causes loss of property and men adjoining to the river which is an enormous affair for legislative association. A large scale reconnaissance survey of the under study river has been conducted for compilation of data. The long term hydraulic characteristics of the river have been gauged for collecting sufficient data to determine frequent change. The L-Section and Cross-Section assessment of the river beds and its main tributaries has also been measured. The historic discharge from river catchments area has been collected from the time to time carried hydrologic studies. In this study field survey data has been utilized for quantification of the river. The model has been constructed for designing the open channel Lyari by using its existing position and measuring the peak discharge required. This model will enable to chanalize the storm river flow smoothly in future.

Keywords: Lyari River, Strom Flow, Hydraulic Characteristics, L-Section and Cross-Section Survey, Channel Designing.

1. INTRODUCTION

Lyari river is natural stream having extensive catchments area that may be starting from as back as Keerthar and Badra ranges 100 kilometer from city. The two aspects of river hydrology are significant. First, the natural river flow and second is the phenomenon of sewage discharge from urban development along the river corridor. Moreover, average annual rainfall is relatively low (i.e. 215 mm), however high intensity rainfall becomes the cause of severe flash floods, which occurred at an average of every three years over the past fifteen years. The two-third of the runoff within Karachi occurs from the northwest is through two smaller rivers that is Orangi and Gujar nullah which empties into Lyari river .

A large scale topographic survey of the entire river is carried out and X-section of the river observed for collection of data. The L-section of the river indicates the river bed has two distinct bed slopes. The general slope of the upper reach is .0020853 where as that of the lower reach is one feet drop in 1493 feet. As river Lyari becomes a drainage system for the adjoining industries and localities when enters to the city. It has been noticed that discharged by the river remains stagnant during low tide which keeps on polluting the south-eastern creeks. Further more, since the currents move clockwise, the outgoing channel water contaminates the outer region. [ACE 1983, ACE 1993, Balfours 1988, Haq 1971, Mansoor 2007, KDA 1990, KPT 1996, Delcan Int. 1992]

In this communication large scale reconnaissance survey collected data has been utilized for designing the open channel Lyari. This constructed model will enable to chanalize the tempest river flow smoothly

2. METHODOLOGY

The historic discharge of the river for 50 years frequency is obtained from the previously hydrologic studies. The topographic maps and observed X-section of the river during survey has been utilized for design verification parameters of the river. For planning of drainage structure peak discharges has been calculated by means of under mentioned techniques.

2.1 Design Discharge Technique

a. ***Rational formula has been applied for small catchment area.***

b. ***Unit Hydrograph (triangular) method has been utilized for large catchment area.***

c. **Manning Formula *(*Chow 1959, Sharma 1990, Migual 1994*)***

3. DESIGN DISCHARGE COMPUTATION

The peak discharge for small and large catchment areas has been calculated separately. The particular of the catchment measured areas are shape, size, slope, permeability and rainfall intensity.

3.1 Rational Formula

The peak discharge for small catchment area which less than ten square miles is calculated by using the equation (1) which is

$$\rho_d = 640\eta_c R_{inst} \mathrm{A} \quad (1)$$

where

ρ_d = Peak discharge in cusecs

η_c = Runoff coefficients

R_{inst} = Critical Rainfall intensity

A = Catchment area in square miles.

The critical rain fall intensity i.e. R_{inst} is estimated by utilizing (2)

$$R_{inst} = 5338.4615\alpha \frac{S^{0.148}}{L^{0.77}(S^{0.385} + .00013L^{0.77})} \qquad (2)$$

in which

α = Twenty four hour probable rainfall in inches

L = Distance between critical point to the bridge side.

S = *Slope*

The values of the runoff coefficients are given in the Table 1 beneath.

Table 1. Runoff coefficients for different type areas

Type of the area	*Runoff Coefficients*
Steep bare rock	*0.9*
Rock, steep but wooded	*0.8*
Plateaus, lightly covered	*0.7*
Clayey soil, stiff and bare	*0.6*
Clayey soils lightly covered	*0.5*
Loan lightly cultivated	*0.4*
Loam largely cultivated	*0.3*
Sandy soil of light growth	*0.2*
Sandy soil covered heavy brush	*0.1*

Source: Irrigation Engineering and hydraulic structure.

The peak discharge for small catchment area is calculated by using the equation (3) which is

$$\rho_d = 640\eta_c R_{inst} \mathrm{A} \qquad (3)$$

where

ρ_d = Peak discharge in cusecs

η_c = Runoff coefficients

R_{inst} = Critical Rainfall intensity

A = Catchment area in square miles.

The critical rain fall intensity i.e. R_{inst} is estimated by utilizing (4)

$$R_{inst} = 5338.4615\alpha \frac{S^{0.148}}{L^{0.77}(S^{0.385} + .00013L^{0.77})} \quad (4)$$

in which

α	=	Twenty four hour probable rainfall in inches
L	=	Distance between critical point to the bridge side.
S	=	*Slope*

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Where as the peak discharges upto 10 square mile is computed by utilizing the expression (5)

$$F_{\max} = P_i A\beta \quad (5)$$

where

$F_{\max}$	=	Maximum flood discharge in m^3/sec
P_i	=	Peak intensity of rain fall in mm/hour
β	=	Catchment characteristics function

The catchments characteristic function β yields

$$\beta = \frac{0.56 f\rho \mathrm{H}^{0.385}}{(0.88L^3)^{0.385} + \mathrm{H}^{0.385}} \quad (6)$$

In equation (4) f , ρ and H are representing factor to correct variation, percent coefficient of run off and difference between critical point in meters respectively, Table 2 gives the factor to correct the variation of rainfall.

Table 2. Correction factor of rainfall

Area of catchment (Km$^{2)}$	*Correction factor*
0	*1.000*
20	*0.900*
40	*0845*
60	*0.800*
80	*0.760*
100	*0.730*
150	*0.675*
200	*0.645*
400	*0.620*
2000	*0.600*

3.2 Unit Hydrograph (Triangular) Method

This method is adopted for measuring peak discharge of the catchment area greater than ten square miles. The expression of unit hydrograph method is as follows:

$$P_d = 3.09 P_{24} f P_r \mathrm{A}(T_c)^{0.8} \quad (7)$$

where

P_d = Peak discharge

P_{24} = Twenty four hours aerial rainfall

P_r = Percentage runoff

The percentage runoff (P_r) values computed by using triangular formula are depicted in Table 3.

Table 3.Percentage Runoff.

Description	*Return Period (Year)*						
	2	*5*	*10*	*30*	*50*	*100*	*200*
Fractured Stone	*50*	*53*	*55*	*60*	*62*	*65*	*67*
Fractured Limestone	*55*	*58*	*60*	*67*	*70*	*72*	*75*
Non-fractured rock	*65*	*58*	*70*	*75*	*77*	*80*	*82*
Alluvial Fan	*25*	*28*	*30*	*35*	*37*	*40*	*42*
Low land/valley	*0*	*0*	*0*	*0*	*5*	*10*	*12*
Dense vegetation	*-5 for each return period*						

Source: BMIADP flood estimate manual 1986.

3.3 Design Water Level

The water level is design for uniform flow by using Manning formula which yields

$$Q_{maning} = \frac{1}{n} R_h^{2/3} S^{1/2} A \quad (8)$$

where

n	=	Manning roughness coefficients
R_h	=	Hydraulic radius
S	=	Slope of the channel
A	=	Waterway Area in meter^2

3.3 Critical Rainfall Calculation

The historic rainfall data is collected from Meteorological Department and Foster Type III curve method is utilized for estimation of rainfall for fifty and hundreds years respectively. The annual twenty four hours rainfall frequency calculation are estimated by using the underneath formula.

$$Rain_{24} = \gamma + \delta\lambda \quad (9)$$

where

$Rain_{24}$	=	The maximum twenty four hour rainfall in mm
γ	=	Average rainfall
δ	=	Standard Deviation
λ	=	Skew curve coefficients

4. DESINING OF THE CHANNEL

The parameters of the channel are designed on the basis of the calculation made in previous section. The design parameter of each location is summarized in Table 4. These design parameters will define opening all along the river route for the passage of fifty years storm flow.

Table 4: Design Parameter of the river

Bridges	*Designed Bed width (m)*	*Designed depth (m)*	*Bed slop*	*Side slope*	*Capacity Cusecs*	*Discharge from catchment area (Cusec)*
Sohrab Goth	*70*	*4.78*	*.0024*	*2:1*	*56,791*	*28,100*
Yaseenabad	*80*	*3.5*	*.00024*	*2:1*	*38,037*	*33,400*
Sindhi Hotel	*80*	*5.2*	*0.0024*	*2:1*	*67,865*	*35,700*
Lasbella	*100*	*4.56*	*.0018*	*2:1*	*61,425*	*56,650*
Meva Shah	*170*	*3.5*	*.0018*	*2:1*	*61,523*	*56,650*
Mauripur	*190*	*3.6*	*.0011*	*2:1*	*63,301*	*58,950*

5. CONCLUSION

In this study a large scale topographic surveys, L-section and cross-section of the river beds of Lyari and its major tributaries has been carried. Data has been collected during survey as well as the pervious carried study of the river. The river peak discharge has been estimated and calculation for the smooth flow of the river has also been computed. By the use of the river existing position, collected data, peak discharges and smooth flow calculation of the river design parameters of the river is defined. The purpose for designing the river is the smooth passage of fifty year storm flow.

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