APPLICATION OF NON-LINEAR STORAGE FUNCTION MODEL TO SELECTED WATERSHEDS OF PAKISTAN

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FOR THE DEGREE OF

MASTER OF PHILOSOPHY
IN
HYDROLOGY

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LAHORE, PAKISTAN

JULY, 1987

SUMMARY

This study primarily aims at determining the applicability of the non-linear storage function model to watersheds of Pakistan. The model $S=k_1 Q^{p_1} + k_2 \, d/dt \, (Q)^{p_2}$, having four lumped parameters - k_1, p_1, k_2 and p_2 was developed by Dr. Kiyoshi Hoshi of Japan in 1982. He related the storage function (lumped) parameters to the kinematic wave (distributed) parameters. These relations indicate that k_1 is a function of basin characteristics, viz. flow plane i, Manning's roughness n, kinematic wave parameter m, area of the basin and, inter-alia, the geomorphic parameters of Hack's Law; p_1 is a function of kinematic wave parameter m; k_2 depends upon k_1 and the average rainfall intensity; and p_2 is related to kinematic wave parameter m, total duration of rainfall, and the time to peak rainfall intensity.

The rainfall data used in this study has been taken from Surface Water Hydrology Project of Pakistan WAPDA.

Parameter optimisation has been undertaken for ten storms of four basins. The prominent features of the optimised hydrographs - peak discharge, time to peak, the rising and the recession limbs, and the base width-significantly coincide with those of the observed ones.

Sensitivity response of the optimised parameters has been determined by varying each, in turn, within ± 100 per cent range. A positive error in the value of parameters k_1, k_2 and p_1 reducesthe peak flow ordinate and vice-a-versa. An error in parameter p_2, in any direction, results in the under estimation of peak discharge. Parameters k_2 and p_2 effect the time to peak; a positive error in these parameters induces a positive shift in time to peak. However, the effect of p_2 is not as pronounced as that of k_2.

Synthesis of flood hydrographs for ungauged watershed has been achieved by estimating the model parameters using the storm as well as watershed characteristics. The application of this technique has been undertaken for four different storms of a system. The percent variation in peaks of the simulated and observed hydrographs ranges from -4.369 to +7.45, with a zero error in the time to peak. The observed and generated system outputs are almost coincident.

The US SCS procedure of estimating direct runoff alongwith the parameter estimation technique has been applied to simulate flood hydrographs from two storms of an ungauged watershed. The synthesised and observed hydrographs of the two storms show an RMSEQ[1/] of 0.092565 and 0.198695, a + 0.08 and + 7.96 per cent error in peak, and a negligible difference in time to peak.

The procedure of synthesising ungauged flood hydrographs, using the optimised parameters, has been outlined. For three different watersheds, the optimised parameters of a storm have been used to synthesise a flood hydrograph resulting from another storm of the same basin, by incorporating the new storm characteristics into the optimised parameters. The resulting generated hydrographs are significantly comparable to the observed ones. The accuracy of the results of this technique largely depend upon the quality of the pertinent information.

The frequent application of the model to predict outflow sequences from watersheds of Pakistan requires the values of friction factor $(n/\sqrt{\bar{i}})^{0.6}$ *for physiographically different catchments. The application of the model for flood forecasts in the ares of hill torrents may be useful.*

As essential pre-requisite for its application to an actual system is the quantification of effective precipitation as an input to the model.

1/ *Root Mean Square Error in Discharge.*