FLOOD FORCASTING USING HEC-HMS (CASE STUDY: MAROON CATCHMENT-UPSTREAM OF BEHBAHAN)

PREVISION D'INONDATION UTILISANT HEC-HMS (ETUDE DE CAS : BASSIN VERSANT DE MAROON EN AMONT DE BEHBAHAN)

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ABSTRACT

The Maroon River, one of the Jarahi River head waters, is located in Maroon Catchment and at the upstream of Behbahan City. Maroon Dam with maximum volume of 1193 MCM was built on this river by Khuzestan Water & Power Authority (Dams Identity). The dam prevents from seasonal high flood damages and saves large amounts of water for agricultural consumptions. The river has flash floods with high peaks, so it seems that flood control and management are cases of high importance in this catchment and it is necessary to have information about flood volume for flood management, downstream programming and consumption estimation in a water year. Therefore, runoff data were calibrated based on the real precipitation data, using HEC-HMS Rainfall-Runoff Model and Schneider Method. Considering several sample observed floods in the past years, observed and calculated runoff values were compared and the best parameters were calculated for initial & final soil infiltration and time of concentration.

Key words: *Rainfall, run off, Maroon, HEC-HMS, parameter.*

RESUME

La Rivière Maroon, l'une des sources d'eau de Jarahi, s'écoule dans le bassin versant de Maroon et dans la partie supérieure de la Ville Behbahan. Le barrage Maroon avec le volume maximal de 1193 MCM fut construit par l'Autority de l'eau et de l'énergie de Khuzestan (Identité de Barrage). Le barrage protège contre les grands dégâts causés par l'inondation saisonnière et conserve une grande quantité d'eau pour usage agricole. La rivière a des crues éclaires avec une pointe de débit relativement élevée, donc la maîtrise et la gestion des crues portent

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une grande importance. Il est nécessaire d'avoir des informations sur le volume d'inondation pour sa gestion, la programmation en aval et l'évaluation de la consommation dans une année d'eau. Donc, les données d'écoulement ont été calibrées compte tenu des données de précipitation réelles, utilisant le Modèle de précipitation-de ruissellement HEC-HMS et la Méthode Schneider. Compte tenu des divers échantillons étudiés depuis des années, les valeurs calculées de ruissellement sont comparées et les meilleurs paramètres sont obtenus pour l'infiltration du sol initiale et finale et le temps de concentration.

Mots clés : *Précipitation, ruissellement, Maroon, HEC-HMS, paramètre.*

1. INTRODUCTION

Maroon River length is 422 km and the catchment area is about 3634 km^2. The average yearly discharge of the river is 1572 MCM. The maximum discharge of the river is reported 5360 m^3/s in Idanak hydrometric station (upstream of Maroon Dam). The average of annual discharge of the river is 49 m^3/s. Maroon Dam on the river was ready for impoundment in 1997, but it was delayed till 2000 due to technical reasons. The dam capacity is 1200 MCM and its location is 19 km from Behbahan City. Khuzestan Water and Power Authority assumes the responsibility for the dam. Inflow to Maroon River in dry season is very low. It is up to 9 m^3/s in normal years and falls to 3 m^3/s in dry years as a result of low snow interception capacity of the basin, compared to Karoon and Dez watersheds. However there are dangerous and disastrous floods in this river during wet seasons like autumn, winter and early in spring. The peak flood is sometimes over 5000 m^3/s. During heavy rain, the inflow to the reservoir increases suddenly and this process continues at every moment until it reaches to peak level. When there is a flood, the water level in the reservoir rises rapidly and it becomes necessary to use spillways to discharge the excess water from the reservoir to the downstream. Calculation, estimation and forecasting of the inflow flood to the dam reservoir, based on the rainfall, help us in programming, management and reservoir control. As it is possible to estimate peak flow, total runoff volume to the reservoir and its arrival time by using predicted rainfall from internet and the data from online meteorological stations in upstream and also to control floods. This study made it possible to plot inflow prediction hydrograph to the reservoir of Maroon Dam, with 90% accuracy.

At first, the hourly rainfall-runoff data of Idanak station in upstream of Maroon Dam were gathered, corrected and completed. Then HEC-HMS was calibrated using the observed floods and catchment coefficients were determined so that forecasting future floods by using rainfall data is feasible.

2. IDANAK HYDROMETRIC STATION

The station is located on the Maroon River and beside the Idanak Village. It is in the upstream of the Maroon Reservoir Dam and is used to check the input discharge to the reservoir.

3. HEC-HMS HYDROLOGIC MODELLING SYSTEM

The HEC-HMS hydrologic modelling system is developed by U.S. Army Corps of Engineers (USACE) and is used for rainfall- runoff modelling, instead of HEC-1. HEC-HMS, in addition to HEC-1, is a great achievement in computer sciences and engineering hydrology and is a product of The Hydrologic Engineering Center (HEC), an organization within the Institute for Water Resources, is the designated Center of Expertise for the US Army Corps of Engineers. HEC-HMS has more capabilities than HEC-1 in simulation and flood routing. Adding other options like snow melting simulation, floods return period analysis, reservoir outflow structure and dam break is under investigation, but not yet established. However, analyzing the damages caused by floods can be done either by HEC-1 or HEC-MDA. There are several new and useful capabilities which does not exist in HEC-1 including: simulation of flood continues hydrograph over long period and calculation of spreaded flow by plotting catchment simulated cellular network (Rezaeianzade and Diani, 1383[4]).

4. RAINFALL - RUNOFF SIMULATION

The necessary time for rainfall-runoff simulation is determined based on the project characteristics control, which includes day and time of the start and end of the project and the required time for calculations. Calculations for each case are done by a combination of catchment and meteorological models and characteristics control. The model executive options are rainfall or flow ratio which it's possible to save all the catchment conditions at a point and start simulation using the saved conditions.

The results of the calculations can be seen a schematic model of the basin. Data tables flood peak and total flood volume exist in the software. Historical data tables and graphs are available for different simulation elements and can be printed by a variety of printers.

5. PARAMETERS ESTIMATION

Most of the parameters are estimated by user to optimize the target function in different simulation methods for sub-catchments and flood factors. Observed floods should be available to optimize simulation. Parameters can be estimated for each upstream observed flood. There are four main and basic methods to converge observed and simulated floods (Baghal Nejad, 1385). The Schneider Unit Hydrograph Method is used in this study.

6. MAROON CHATCHMENT ANALYSIS USING HEC- HMS

Rainfall- runoff calculations was done using Schneider method.

7. SCHNEIDER UNIT HYDROGRAPH

This method was presented by Schneider based on his studies in Appalachia mountainous area in 1938, and is applicable for catchments with area of 10 to 10000 mile^2 (30 to 300000 km^2).

8. SCHNEIDER UNIT HYDROGRAPH PARAMETERS

a. Standard Unit Hydrograph t1=5.5tr

4 Iran calendar year. To get English calendar year add 621.

b. Desired Unit Hydrograph t1R#5.5tR.

Korpof Inch presented some other relationships in 1959 which are corrected as below:

For unit excess rainfall, 5 parameters can be calculated:

1. t1R: delay time (interval of hydrograph peak and excess rainfall center of gravity)
2. qpr: hydrograph peak discharge for catchment area unit
3. tb: hydrograph base time
4. tp: hydrograph peak time
5. unit hydrograph width in 50% and 75% of hydrograph peak discharge: W50 and W75

-Delay time: t1

Schneider suggested a standard unit hydrograph which its delay time can be calculated from the below equation:

$$t1 = 5.5tr$$

tr = excess rainfall duration in standard unit hydrograph in hour

t1= basin delay time in Schneider Standard Unit Hydrograph in hour

Delay time in Schneider Standard Unit Hydrograph can be calculated based on the basin characteristics from the below equation:

$$t1 = C1Ct(L * Lc)\ 0.3$$

L = main channel length in mile (km in Metric System)

Lc = basin outlet distance from gravity center along main channel in mile (km in Metric System)

Ct = is derived from calibrated basins with data

Ct coefficient for study area which Schneider was working on varied from 1.8 to 2.2. Although in Appalachia area, Ct changes were not noticeable, but it was increasing with decrease in slope and the upper limit is about 8 in Mexico Golf. When the maximum discharge is influenced by the snow masses, Ct varies between1.3 to 1.5.

- Unit hydrograph peak discharge for basin area unit (Qp)

Peak discharge of Standard Unit Hydrograph for basin area unit is calculated from:

$$qp = C2Cp/t1$$

qp = peak discharge of Schneider Standard Unit Hydrograph in $ft^3/s/mile^2$ for excess rainfall of 1 Inch ($m^3/s/km^2$ in Metric System for excess rainfall of 1 Cm)

t1 = basin delay time in hour

C1 = 640 in English System and 2.75 in Metric System

C2 = 0.275 in Metric System for excess rainfall of 1 mm

Cp = is derived from calibrated basins with measured data

The above equation can be written as :

$$qp = Cp/t1$$

Cp has a range of 360 to 440 in English System. The maximum value of Ct accompanies with the minimum value of Cp and vice versa. In Metric System, Cp value changes 1 mm for excess rainfall.

The procedure of calculating Ct and Cp in catchments with measured data of discharge is as follow [4]:

The above parameters were calculated using the Schneider Method in HEC- HMS, hourly flood existed samples and also intensity-duration of rainfall which is measured each 15 minutes when it's raining.

9. CONCLUSIONS

After comparing calculated data with observed data, some of the cases were acceptable and others were not (see Table 1). It's noticeable that discharge and rainfall data of Idanak hydrometric station were measured in upstream of Maroon Dam. The travel time of peak flood from Idanak Station to the reservoir dam is 3 to 4 hours (data of Khuzestan Water and Power Authority Control Center and Basic Researches and Water Resources Plans Division).

Table1. date of studied Maroon Basin floods

Date	Result	Date	Result
5 Jan 2002	1 Feb 1995	1 Feb 1995	accepted
18 Dec 2001	6 Feb 1993	6 Feb 1993	accepted
9 Dec 2001	8 Dec 1991	8 Dec 1991	average
28 Jan 2000	7 Jan 2000	7 Jan 2000	accepted
15 Apr 1996	5 Mar 1991	5 Mar 1991	accepted
10 Mar 1996	2 Dec 1989	2 Dec 1989	accepted
5 Feb 1995	average		

The results for each of the floods are shown in Table 2:

Table 2. Calculated parameters in Schneider Method for Maroon floods

Date	tp	Constant rate	Initial loss	cp
5 Jan 2002	10	2	5	0.6
18 Dec 2001	10	3	5	0.6
28 Jan 2000	10	3	5	0.6
15 Apr 1996	10	3	5	0.6
10 Mar 1996	10	2.5	5	0.6
5 Feb 1995	10	2.5	5	0.6
1 Feb 1995	10	2.5	5	0.6
6 Feb 1993	10	2	5	0.6
8 Dec 1991	10	1	5	0.6
7 Jan 2000	10	3	5	0.6
5 Mar 1991	10	4	5	0.6
2 Dec 1989	10	2	5	0.6

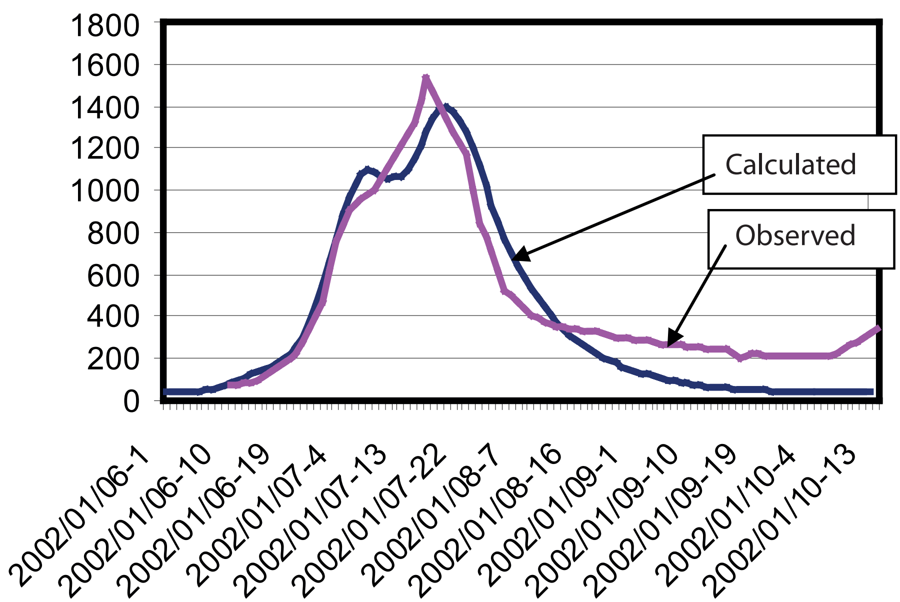

Fig1. comparison of observed and calculated floods of Idanak station (6 Jan '02)

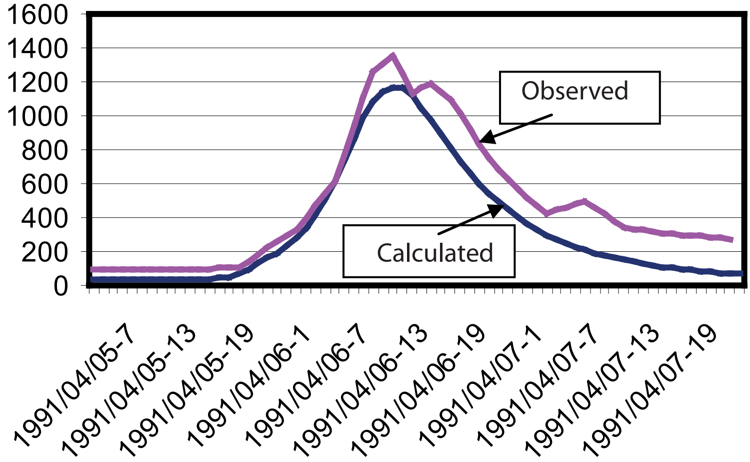

Fig 2. Comparison of observed and calculated floods of Maroon station (4 May '91)

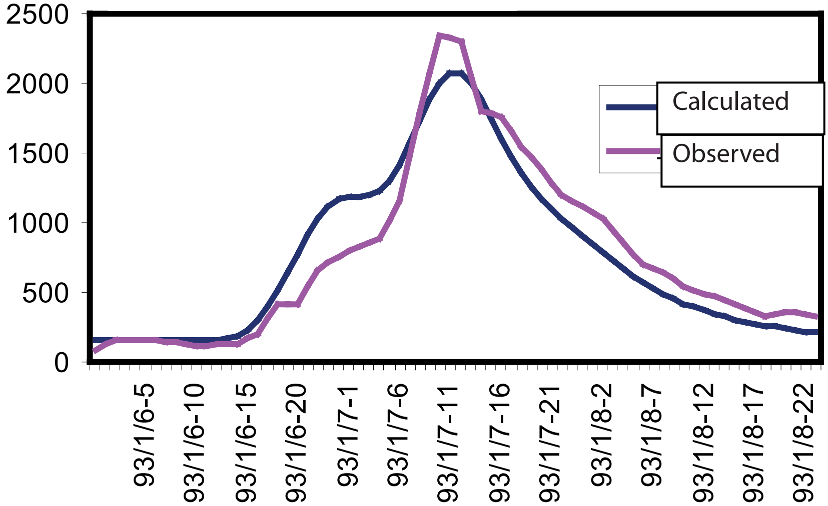

Fig 3. Comparison of observed and calculated floods of Maroon station (6 Jan '93)

Based on the results, the hydrograph peak time (tp) is 10 hours for the catchment. Also, average Cp coefficient is 0.6. Constant Rate coefficient is about 2.5. But the initial drawdown is 5 mm. 3 samples of reviewed statistics and their results are shown in Figures 1 to 3.

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