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Estimating Flood Hydrograph with Different Return Periods (Case Study: Urmia Shahar Chay Basin)

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ABSTRACT: The frequency of floods during the last few decades has caused the majority of the country to be vulnerable to devastating flood and the loss of life and property is significantly increased. The increased population associated with poor land use planning, deforestation and the development of impervious surfaces has led less water penetrate the earth in the drainage basins and flow to the downstream. As a result the floods have become frequent, severe and sudden which causes more damage. In this study a part of ShaharChay River-Urmia was chosen and based on the importance of the basin and flood mapping in this area, it is chosen as the main objective of this study. In this research using GIS techniques and existing HEC-HMS hydrologic model the flooding of the ShaharChay River-Urmia was studied and the hydrographic maps were obtained for 2, 5,10,25,50,100 return periods.

Keywords: Environmental crises, Flood zoning, ShaharChay River, HEC–HMS.

INTRODUCTION

Although the human being is not capable of living without water but water can be the threatening factor of health and welfare of humans and even geographical areas as well. Near the great rivers there is always enough water for municipal, industrial and irrigation. Hence, a high proportion of advances in the developed urban centers, agriculture and industry are located along the rivers. Against the aforementioned benefits, massive flooding in the river is considered a threat to the facility located in its neighborhood (Hassanpour and Kashani, 2006). One of the main issues raised during the watershed operation is to prioritize erosion control and reduce flooding measures in the sub-basins of a basin (Alizadeh, 2010).

Shushtari *et al.,* (2002) simulated the flow in Kor and the Seyvan Rivers in using HEC - HMS the model. In this model methods were predicted to calculate the precipitation losses, runoff and basic discharge and flood routing. Jalalirad *et al.,* (2003), flood mapping using HEC – RAS software and Geographic System Information in watershed basin in Darabad city of Fars province. Abghari *et al.,* (2006) provided the application of hydraulic and GIS model in the optimal management of the flood plain. In this study they mapped the flood risk using various return periods. Randel *et al.,* (2000) in the United States Bureau of Land Development used the HEC - RAS mathematical model to simulate the hydraulic parameters such as water height, average flow rate and the water fluctuation in the Teton River in the Teton Dam upstream in the Idaho for four various intervals. Neshat and Sedghi (2006) estimated the runoff using the SCS method and HEC – HMS model in the Gulalai drainage basin. In this study the results of estimating the rainfall conversion to the surplus rainfall under the title of CN as analyzed using two different methods. Radmanesh *et al.,* 2006) analyzed the calibration and the evaluation of model HEC – HMS in the Dez River watershed basin. The results indicate a good fit of the observed hydrograph peak and simulated hydrographs. Time difference in reaching the peak of the hydrograph in all cases, was equal or less than an hour. Mohammadi *et al.,* (2006) in his study titled "Estimating average weekly Kor River discharge using the artificial neural network and HEC - HMS model" predicted the average discharge rate in Kor River- Fars Province. The results of this study determine the higher performance and facility of the artificial networks compared to the HEC – HMS model in predicting the weekly Kor River flood. Ashouri *et al.,* (2007) evaluated the effects of the urban development on the increased runoff in the watershed basin of Darabad using the HEC - HMS model. Then the rainfall-runoff events in the watershed before and after the urban development was simulated using the HEC – GEOHMS and HEC - HMS model and the flood peak discharge values obtained in different return periods.

Kathol *et al.*, (2003) used the HEC - HMS model to determine the highest discharge in runoff volume in two agriculture basins in the South East State Dakota South. In order to estimate the losses in these basins they used SCS method and in order to determine the hydrograph they used the SCS Unit Hydrograph.

MATERIALS AND THE METHODS

ShaharChay River is one of the major independent rivers of the Urmia plain located in the south and south west of the city of Urmia. The River is known as the Barde Sur in the upstream and the Kakre, Kouse Lou and Mirabad rivers pour into it and it is fed by the precipitations received from the West to the East. ShaharChay River is located in the category of medium-sized rivers with the catchment area located in the central part of central Silvana which is also known as the Urmia River. The area under study is 575.59 square-kilometers located in the city of Urmia. It is in 470,000 to 520,000 E and 4,128,000 to 4,160,000N. The residential areas under study include Urmia, Noushinshahr, Silvane and Serve.

The Lowest height of the area is 1267 m and the maximum catchment area is 3507 m above sea level. The study area circumference is equal to 47/156 km. The geographical map of the catchments under study is presented below. The range is located outside Urmia city and within the Urmia plain before reaching Lake Urmia. This range is about 100m below the Keshtiban Dam in coordinates 518, 274 and 4,156,881 and has a length of 1200 meters. Within this range the river passes through the Haspestan, Poshtgol and Darghalu villages. In this paper first we obtained the topographic map of the area with 1: 50000 scales from the mapping organization of the country and then using the map the contour lines were drowned and the required revisions were made visually. Also the waterways and network of streams of the basins were formed and the GIS model was completed. The software can conduct physical calculations of the basin and the required parameters after the completion of the basin model. This is easily done on GIS. The following figure presents the basin model in the GIS software.

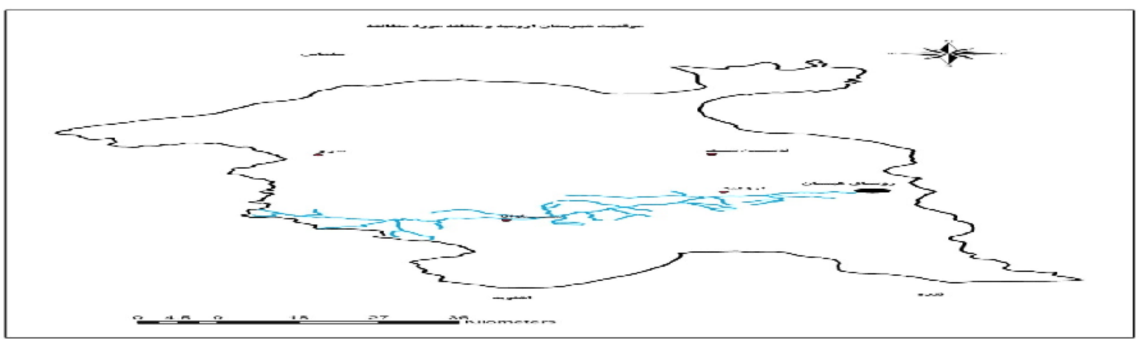

Fig. 1. Location of the city of Urmia and study area.

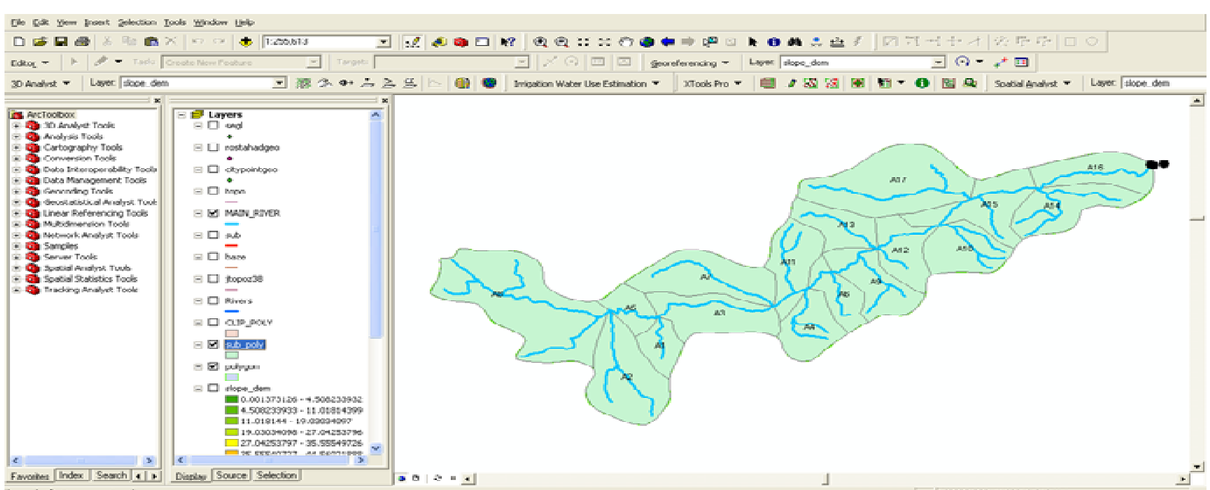

Fig. 2. Formation of the basin and sub-basin operations in ARC GIS software.

Table 1. Physical characteristics of the studied basins in the study area ShaharChay.

Row	Basin No	Area (Km)	Circumference (Km)	Main Channel length (Km)	Average slope (%)	Maximum Height (M)	Minimum Height (M)	Medium height (M)	Coefficient Compactness	Equivalent circle diameter (Km)	Time of concentration (H)	Equivalent rectangle Length (Km)	Equivalent rectangle width (Km)	Shape factor	x	Y
1	A1	12.86	15:06	4.59	40.8	3119	1801	2556	1.2	4.0	1.0	4.9	2.6	0.5	480644	4139022
2	A2	44.27	28.12	11:54	27.3	3126	1872	2543	1.2	7.5	2.5	9.3	4.8	0.5	478196	4136158
3	A3	32.62	27.33	10:11	26.8	2836	1575	1902	1.3	6.4	2.2	10.6	3.1	0.3	484669	4142230
4	A4	23:01	19:40	7.14	9.5	1855	1573	1669	1.1	5.4	2.0	5.6	4.1	0.7	492364	4141105
5	A5	12.81	14:52	5.21	40.4	2800	1774	2129	1.1	4.0	1.2	4.2	3.0	0.7	478165	4142937
6	A6	16.72	19.85	5.32	17.2	2202	1473	1800	1.4	4.6	1.4	7.8	2.2	0.3	494304	4143604
7	A7	39.23	28.82	11.65	13.5	2767	1577	1846	1.3	7.1	2.9	10.8	3.6	0.3	483660	4146219
8	A8	83.85	43.23	14.69	31.7	3507	1870	2632	1.3	10.3	2.9	16.5	5.1	0.3	469872	4138048
9	A9	27.57	24.75	8.78	17.6	2224	1453	1835	1.3	5.9	2.1	9.5	2.9	0.3	497039	4145132
10	A10	26.62	20.70	6.66	10.8	2129	1400	1578	1.1	5.8	1.8	5.6	4.8	0.9	504331	4148742
11	A11	26.51	24.52	8.30	12.2	2206	1570	1791	1.3	5.8	2.2	9.5	2.8	0.3	490935	4147113
12	A12	23:52	22:31	8.49	19.2	2208	1383	1700	1.3	5.5	2.1	8.3	2.8	0.3	499607	4148066
13	A13	20.60	20.95	7.48	15.5	2213	1450	1825	1.3	5.1	1.9	7.9	2.6	0.3	493964	4150552
14	A14	30.45	26.18	7.05	4.0	1675	1269	1362	1.3	6.2	2.3	10.1	3.0	0.3	512729	4153191
15	A15	32.89	31.84	9.35	4.5	1713	1332	1418	1.6	6.5	3.0	13.5	2.4	0.2	504224	4152347
16	A16	26.52	23.90	9.48	1.0	1360	1267	1307	1.3	5.8	4.2	9.0	2.9	0.3	513714	4156508
17	A17	63.20	33.37	13:37	8.8	2109	1352	1604	1.2	9.0	3.5	10.9	5.8	0.5	497981	4155190

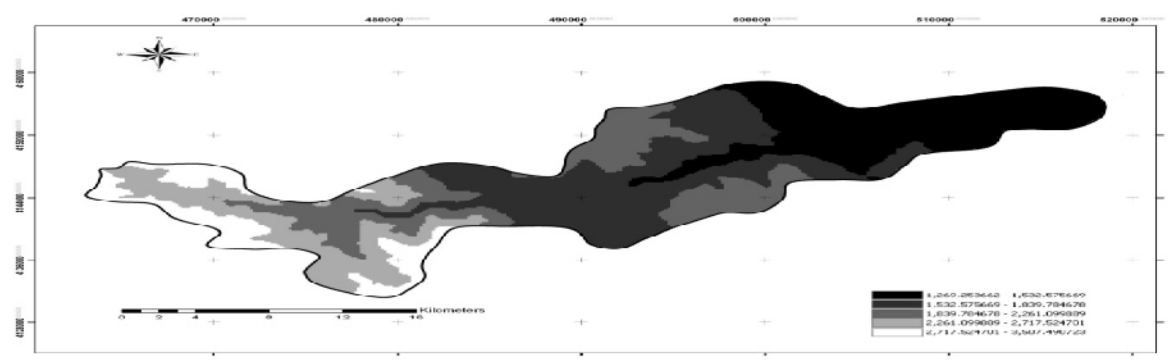

Fig. 3. Elevation map of the studied area.

In this paper the elevation of the studied area was performed using the topographic map of the area with 1: 50000 scale and Arc GIS software.

As it can be seen the largest catchment area of ShaharChay is within 1269-1533 and 1533-1839 range.

To obtain every single slope of the waterways the drainage basin slope maps of the area produced by Arc GIS software are used. The upstream waterway have higher slope than the rest of areas indicating the mountainous basins in the area. From the maps of the slope it can be inferred that that the highest area is within the class of 0.02-8% slope.

In this study to estimate the intensity curve - time - frequency curves the prepared for the Western Azerbaijan province is used. This equation is calibrated based on the one-hour rainfall with 10 year return period that has 10-19 variables. This value varies 10.75-19 in Western Azerbaijan province. The Hesari-MovahedDanesh equation for the acceptable ranges is as follows:

$$P_T^t=[0.4548 + 0.2387 * Ln(T - 0.19)][-0.7685 + 0.847t^{0.1805}]P_{10}^{60} \quad (1)$$

$$2 \leq T \leq 100yr \ , \quad 15 \leq t \leq 120min$$

$$P_T^t=[0.5806 + 0.1888 * Ln(T - 0.79)][0.3594 + 0.0934t^{0.4757}]P_{10}^{60} \quad (2)$$

$$2\leq T\leq 100yr \ , \quad 15\leq t\leq 120min$$

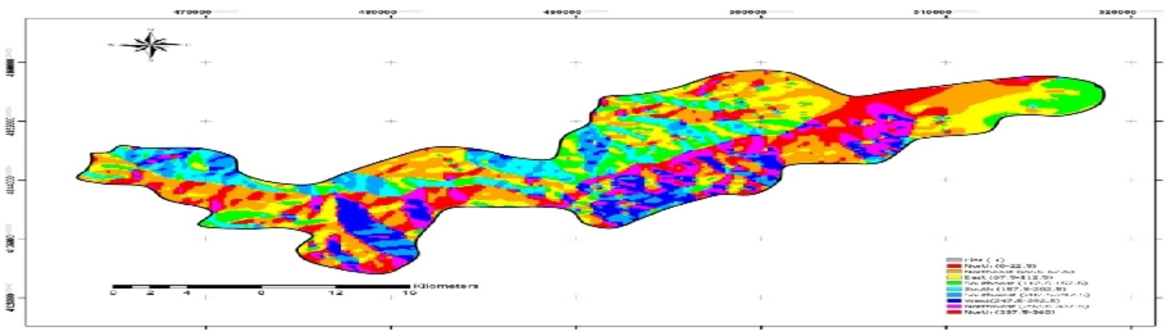

Fig. 4. Map of the slope in the study area.

RESULTS AND DISCUSSION

To estimate the discharge with return periods of 2, 5, 10, 25, 50 and 100 of the HEC – HMS software is used. Since the maximum discharge for the mentioned basin is estimated using HEC - HMS software, therefore having the unit hydrograph it is possible to obtain the flood hydrograph for various frequencies. For this purpose, it is necessary to multiple the dimensions of the unit hydrograph peak discharge rate in maximum hydrograph discharge.

Table 2: Estimated maximum instantaneous discharge in ShaharChay basin.

The maximum instantaneous discharge (CMS)	Return period (T)
59.2	2
113.5	5
175	10
225.6	25
277.8	50
331.5	100

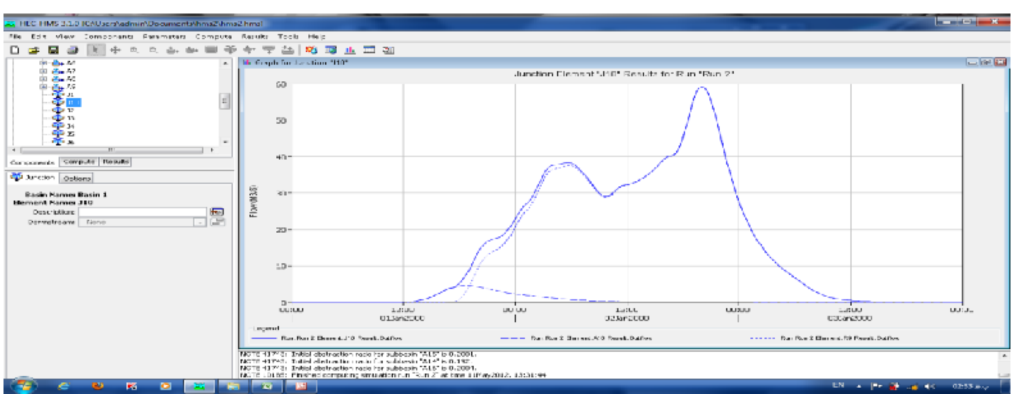

Fig. 5. 2-year returns period flood hydrograph obtained by HEC -HMS software.

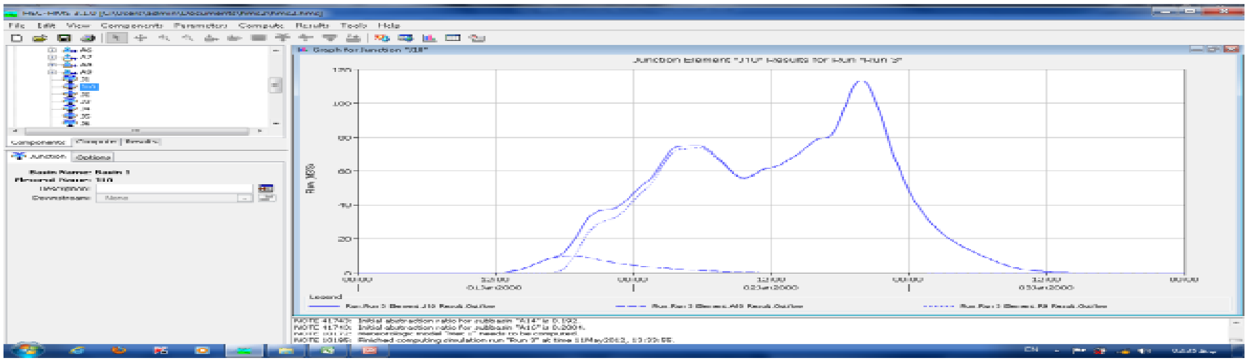

Fig. 6. Flood hydrograph for a 5year return period obtained by the HEC- HMS software.

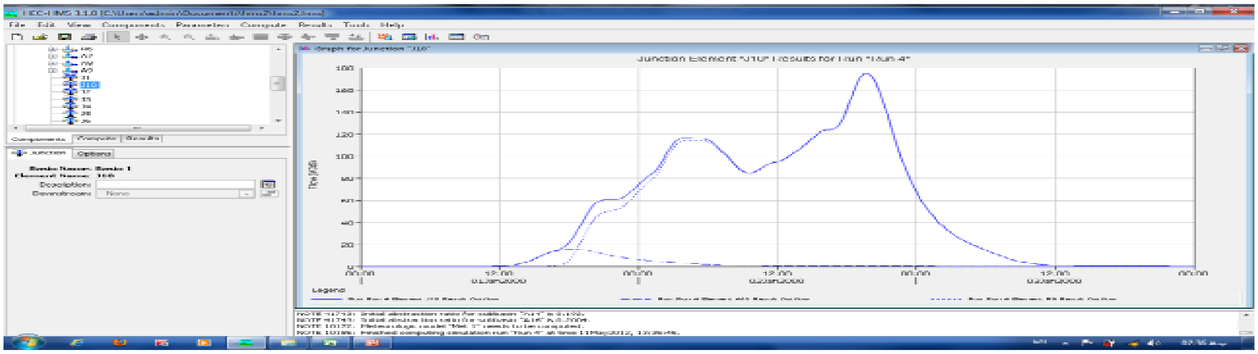

Fig. 7. Flood hydrograph for a 10year return period obtained by the HEC- HMS software.

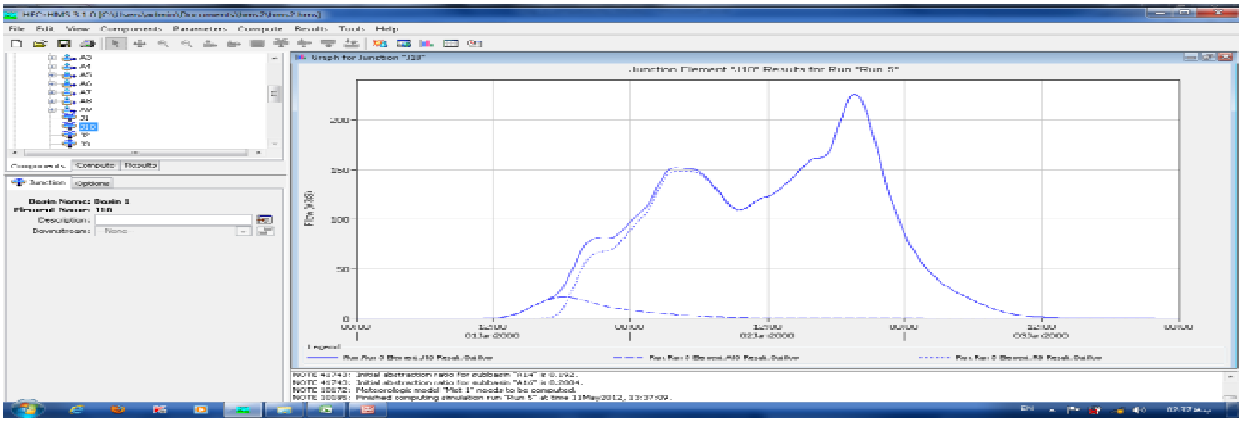

Fig. 8. Flood hydrograph for a 25year return period obtained by the HEC- HMS software.

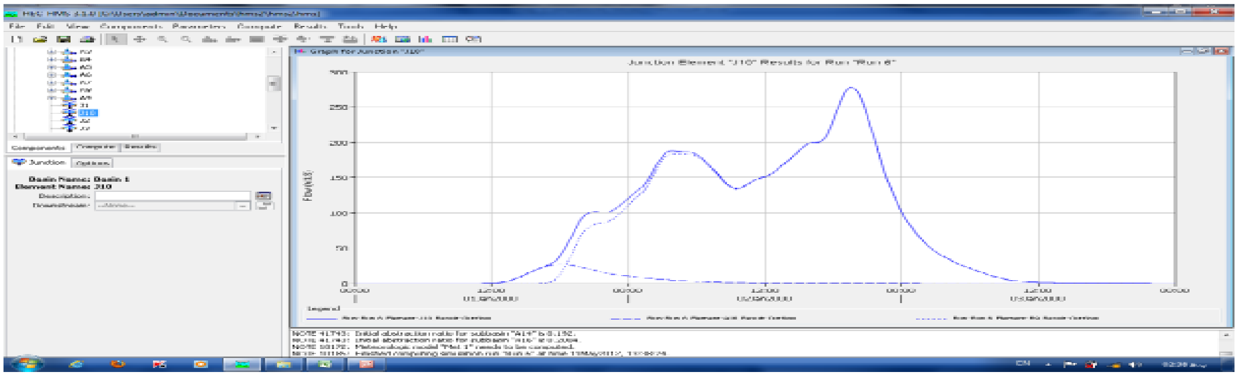

Fig. 9. Flood hydrograph for a 50year return period obtained by the HEC- HMS software.

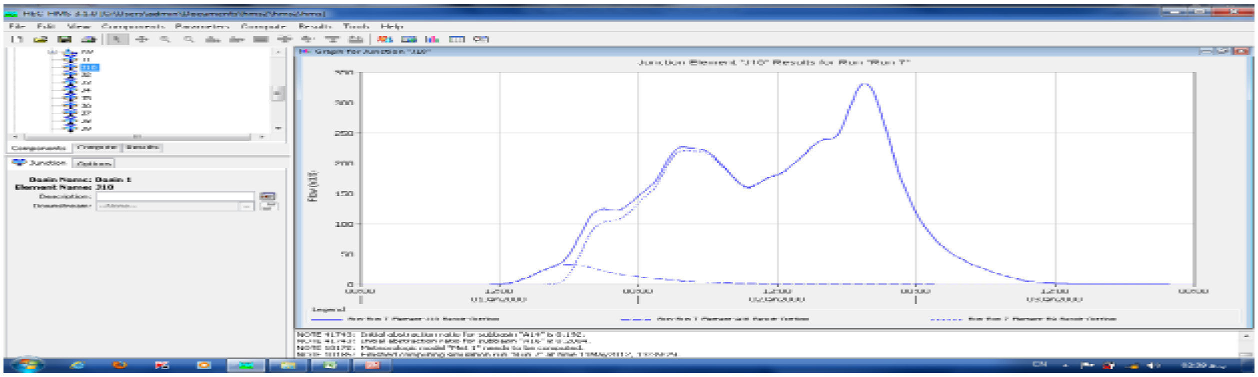

Fig. 10. Flood hydrograph for a 100 year return period obtained by the HEC- HMS software.

SUMMARY OF THE RESULTS

In this study the ARC GIS software was used to investigate the Sub-basin of ShahrchayRiver overlooking the studied period. This software is able to calculate the physical characteristics of the catchment basins and the parameters used in the application HEC – HMS. Study area was divided into 17 sub-basins by the software. To estimate the flood discharge with different return periods the HEC - HMS software and SEC method were used. This model was used to estimate the CN through the physical characteristics of the basin and combining the land use maps and the soil hydrologic groups in ARC GIS Software.

SUGGESTIONS FOR FUTURE STUDIES

(i) It is suggested to specialist organizations to use the methods of this study in their projects.
(ii) The statistics of the instantaneous discharge can be used to estimate the flood discharge with various return periods.
(iii) The WMS software can be used to estimate the physical parameters of the studied area.
(iv) Using the same set but devising various DEMs with different precision similar analysis can be performed and the results can be compared by the results of this study.

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