The study of effect of dredging and dike construction on the flow hydraulic and reduction of flood in downstream of the river
(Case study: Karun River downstream between Ahvaz and Farsyat)

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Abstract

The aim of this study is to simulate a numerical model for flood spreading and to control it in Karoun River in the downstream of Ahvaz to Farsyat which is affected by dredging and the construction of dike. Using the HEC-RAS 4.1 software, one-dimensional flow model in this field was simulated. After entering the data to the model and calibration, the model was run based on selected design flow rates, and water levels were calculated and areas of flood spreading were defined. Then, the mathematical model was run based on the dredging and dike construction. Due to lack of efficiency of dredging operations for flood control and the lack of a suitable location for deflecting flow, the only practical and cost-effective method for controlling the flood of the Karoun River in the studied interval is to construct a dike with designed height.

Keywords: Karoun River, flood, HEC-RAS model, dike, dredging.

1- Introduction

Karoun River (including Karoun, Bahmanshir and Dez rivers) with the length of more than1000 km is the largest and most watery river of Iran. In recent years, due to various developmental projects in industrial, agricultural and drinking fields, the quantity and especially the quality of the river has undergone many changes and faced by severe environmental problems and social consequences, particularly in downstream areas. The hydraulic conductivity level of the river, especially in urban and rural areas has greatly reduced and this caused problems of inundation of lands, cities and farmlands (Shahinejad, 2009). Dredging of Karoun River in Ahvaz City and downstream of the river will increase the hydraulic conductivity of the by approximately 5,000 cubic meters per second. However, for the risk of flood does not threaten the security of the city, this capacity must be increased to more than 6,000 cubic meters per second. To reliably control floods in areas of downstream and Ahvaz city, in addition to dredging the river, it is required to take some complementary measures such as deflecting the flood to natural ravines and construction of dikes (Abrishami and Hosseini, 2008).

2. Background Studies

Afshin Jahanshahi et al (2002) attempted to flood zoning using HEC-RAS model in Halil River. To do this, they first calculated the hydrograph of output flood at upstream of the basin and sub- basins available in the route using the hydrograph method of Snyder unit in HEC-HMS software, as well as the maximum digits and the water level profiles in 20 specific cross sections along the route by MIKE 11 and HEC-RAS model. Then using digital earth model in a triangular irregular network (TIN) generated from basin and border of the river by GIS software, the risk zone of flood was estimated for return periods of 2, 5, 10, 25, 50 and 100 years. The area of agricultural lands and residential areas which would be at risk in case of flood was defined for floods with abovementioned return periods. Results indicate that MIKE 11 model is more capable for zoning and damage assessment than the HEC-RAS model (Jahanshahi et al, 2002 and Hekmatifar et al, 2009). Peiro et al. (2012) study part of Bashar River with length of 25km located in Kohkiluye Boyer Ahmad Province. To do this, samples were collected at different sections of the river. To analyze and evaluate suitable locations for taking material, the hydrographs for return periods of 2-year and 25-years were used. In order to simulate, after providing basic information including information about the geometry of the river and roughness coefficients of different sections, information about sediments and grain size of suspended and basin sediments, information about river hydrology and hydraulic boundary conditions at downstream system, the river sediment along the route was estimated using HEC-RAS model. The results showed that if the bed river is resistance to erosion, the body of the river will begin to slide and causes river widening (Peiro et al, 2002; Gharib et al, 2007). The aim of this study is to simulate a numerical model for flood spreading and its control in Karoun River in the downstream of Ahvaz to Farsyat which is affected by dredging and the construction of dike.

3. Materials and Methods:

3.1. Situation of case study:

The studied area is part of Karoun River downstream of Ahvaz which begins from Chanibiye village and is continued to Farsyat village and is located in coordinate interval of x: 272503 and y: 3461850 to x: 253424 and y: 3446780. It should be noted that the average longitudinal slope of the river bed in abovementioned area is calculated about 0.000052. Length of studied area is approximately 50 km. However, considering that the flow is subcritical in this area and that subcritical flow control section is in downstream, the mathematical model of the river has been developed by upstream of Khorramshahr, on the approximate length of 180 km. In Figure 1, images of flood spreading in the studied area can be observed.

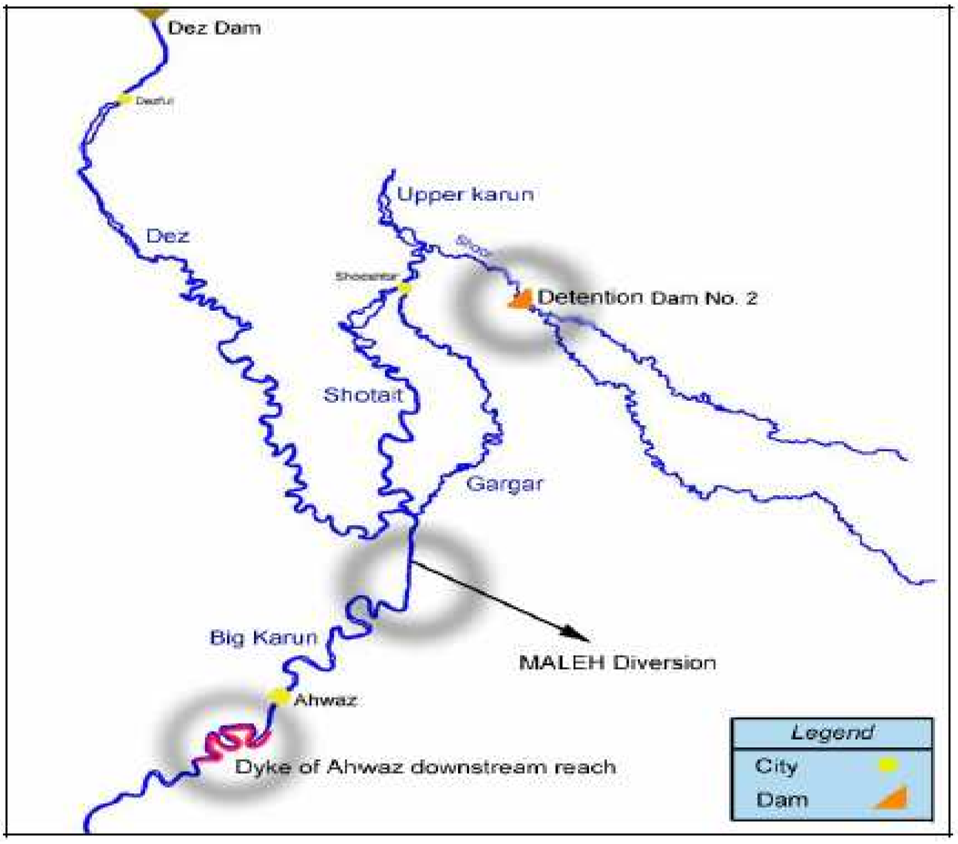


Figure 1: Part of flood spreading in bank of Karoun River at downstream of Ahvaz

3.2. Mathematical models: HEC-RAS

In this study, the 1-D HEC-RAS software was used. HEC-RAS is the complete version of HEC-2 which is run under the windows operating system. The software is capable of computing one-dimensional flow in steady and unsteady forms. The model is able to consider a full network of channels, a branch system or a unit part of river. Loss of energy includes loss of friction (Manning's equation) and loss of expansion and contraction which is applied in the form of a coefficient in load changes (Ghaffari and Amini, 2010). The momentum equation is used in situations where the water level profile is rapidly changing. Another model capability is determination of water level profiles and consequently the organization of the river along the route (HEC-RAS4.0 manual, 2013).

The steps for simulation of river flow with the software are as follows:

-Preparation of river network plan including main and secondary branches,

-Data collection of plans and cross sections of the river,

-Data collection of measurements of flow and water level elevation at start and destination stations

-Data collection of palm sized river in different stations,

-Information of the data measured in river sediments

-Making input file of data and information

-Running the program and interpretation of results

3.3. Required data:

3.3.1 Route plan and waterway length:

To access the information needed for plan the route of the river, the river survey conducted by the Water and Power Authority was used as the river route and for distances determination.

3.3.2 Cross-sections:

In Plan Area (studied area), 137 sections in intervals with different lengths were used which were provided by Water and Power Authority. To improve the accuracy of the model, some sections with 50 m intervals were generated by software between the surveyed sections.

3.3.3 Roughness coefficient:

According to the specifications of surveyed sections and based on mentioned methods, the mathematical model of Karoun River within the studied area has been calibrated and the Manning coefficient is determined for each section. So, in recent studies the factor of 0.022 has been used as calibration factor.

3.3.4 Upstream boundary condition:

According to hydrological studies results and considering standards required to determine the flow rate in hydrograph design, the downstream flood of Bahre Creek with return periods of 25 and 50-year were used as upstream boundary condition in the studied area.

3.3.5 Downstream boundary condition:

Maximum scale values of return periods of 25 and 50-year for Abfar station in Khorramshahr were estimated and applied to the model as downstream boundary condition in flood.

4. Summary and Conclusions:

4.1 Calibration of mathematical models:

To calibrate the mathematical model, the measured data of Farsyat and Ahwaz stations were used. The scale flow rates of Farsyat station were extracted from measurements for different scales of Ahvaz station during watery years. The curve and the equation fitted to curve of flow rate scale in Farsyat station were obtained. Then flow rates of the Ahvaz station were introduced to model and scale flow curve of Farsyat station was obtained from mathematical model. In Figure 2, observed scale flow curve or Farsyat stations is presented.

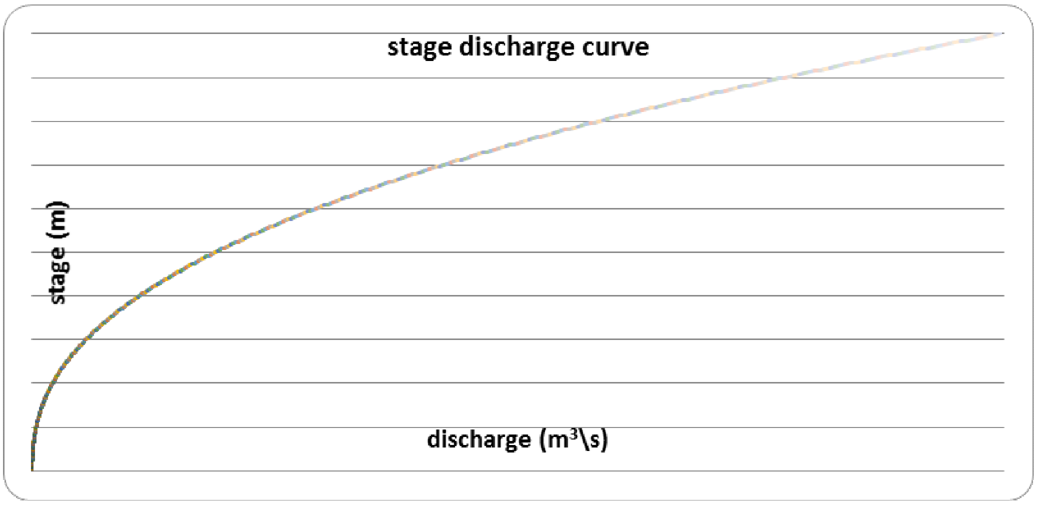


Figure 2: Scale flow curve or Farsyat stations

4.2 Hydraulic results of model implementation:

First, full capacity of the river was calculated by mathematical models for different sections of the studied area. According to simulations, the river has the flood passing capacity of 2500 to 4500 cubic meters in studied area. The maximum flow rate with a return period of 50 year is 4871 cubic meters per second in downstream of Bahre creek, and with respect to full capacity of the river, for this flow rate, flood spreading will happen.

4.3 Running the model in current and dredging scenarios:

Water surface elevation in both cases of dredging and non-dredging indicates that the dredging has no significant effect on the reduction of water surface elevation in flow rates with longer return periods. And the maximum water level difference between the two mentioned cases is 19 cm. Table 1shows the water surface elevation for before and after dredging and their difference for sections No.126 - 138.

Table 1: Changes in water level within downstream of Bahre creek to Farsyat station for dredging and non-dredging cases.

Section No.	Flow rate	Water surface elevation (non-dredging)	Water surface elevation (dredging)	Water surface elevation difference for non-dredging and dredging cases
	(m3/s)	(m)	(m)	(m)
138	4861.95	13.77	13.59	0.18
137	4859.95	13.68	13.49	0.19
136	4855.87	13.46	13.26	0.2
135	4852.2	13.33	13.16	0.17
134	4851.52	13.29	13.11	0.18
133	4851.45	13.27	13.09	0.18
132	4848.31	13.07	12.96	0.11
131	4847.18	12.99	12.92	0.07
130	4846.09	12.96	12.88	0.08
129	4843.32	12.81	12.74	0.07
128	4836.06	12.62	12.52	0.1
127	4827.82	12.44	12.33	0.11
126	4824.9	12.4	12.28	0.12

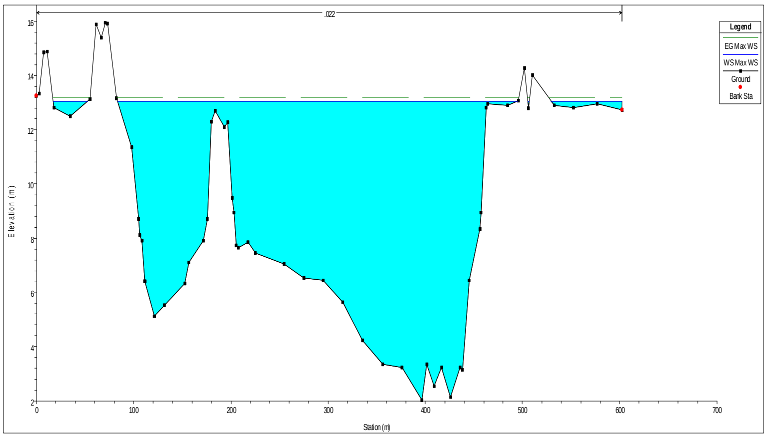
In the studied area, the volume of sediment removed by dredging (corrected section) is about 3060000 cubic meters and according to today rates, cost of dredging operations in downstream of Ahvaz to Farsyat is about 10000000 USD. Despite the slight difference in water levels in the two cases mentioned, the results indicate an increase in flow rate in case of dredging, and this result in movement of sediments and reduction of sedimentation in the river bed and border.

Table 2 shows flow rate for 126 to 138 cross sections in both dredging and non-dredging cases.

Table 2: Flow rates for dredging and non-dredging cases in downstream part.

Section No.	Flow rate	Flow rate (non-dredging)	Flow rate (dredging)	Flow rate difference for non-dredging and dredging cases
	(m3/s)	(m)	(m)	(m)
138	4861.95	0.45	0.57	0.12
137	4859.95	1.5	1.65	0.15
136	4855.87	2.25	2.26	0.01
135	4852.2	0.75	0.96	0.21
134	4851.52	1.06	1.19	0.13
133	4851.45	0.23	0.26	0.03
132	4848.31	1.7	1.51	-0.19
131	4847.18	1.04	1.1	0.06
130	4846.09	1.26	1.47	0.21
129	4843.32	1.66	1.56	-0.1
128	4836.06	2.01	2.23	0.22
127	4827.82	0.47	0.56	0.09
126	4824.9	1.11	1.21	0.1

It is noteworthy that the dredging (corrected section) will cause the deepening of flow and barriers removal and facilitate traffic of boats, barges and vessels. Figure 3 show sections of river before and after dredging which indicate the amount of correction (dredging) in sections of studied area.



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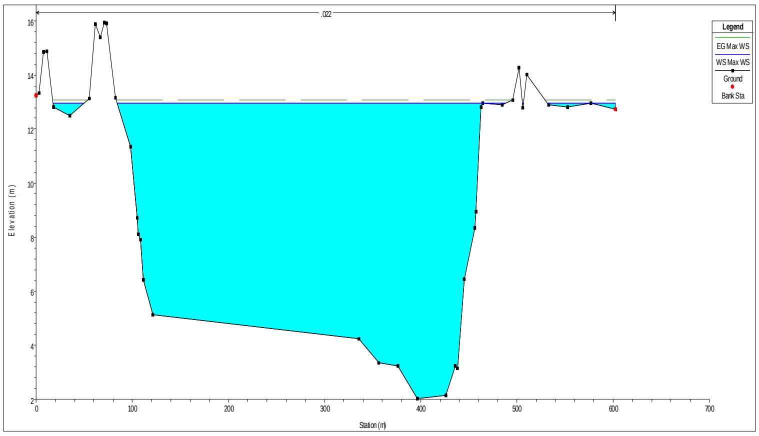

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Figure 3: An example of the cross section (section No. 132): (A) before dredging, (B) after dredging

4.4 Dike Construction in the stream- bank

Due to lack of efficiency of dredging operations for Karun River flood control in studied area (Due to slight decrease in water surface elevation, there is a flood spreading in more than 90% of the sections), Using other methods of flood control including dike construction and flood deflection along with dredging operations is inevitable. Since there is no suitable site for flood deflection, the model was implemented in dredging and dike construction cases. After much trial and error in the height of dikes at left and right banks, in order to prevent flood spreading and to achieve a minimum height of dike (to reduce costs of dike construction), the appropriate level of dikes in the two banks were obtained and these levels plus water surface elevation in dredging and dike construction are presented for sections No.126 to 138 (Table 3).

Table 3: The water surface elevation and the elevation of dikes designed in two banks when dredging and dike construction has been done in downstream of Bahre creek to Farsyat station.

Section No.	Flow rate	Water surface elevation (dredging and dike construction)	Dikes level (Left Bank)	Dikes level (Right Bank)
	(m3/s)	(m)	(m)	(m)
138	4817.21	15.44	15.62	15.64
137	4815.59	15.36	15.68	15.69
136	4811.77	15.23	15.44	15.45
135	4808.87	15.19	15.35	15.36
134	4808.31	15.13	15.32	15.31
133	4807.79	15.05	15.89	19.53
132	4805.36	14.98	15.93	15.17
131	4804.07	14.93	15.13	15.12
130	4803.65	14.81	15.08	15.07
129	4801.14	14.81	15	14.99
128	4795.01	14.5	15.02	15.62
127	4788.37	14.38	14.52	14.5
126	4786.89	14.35	14.59	14.58

In this study, we have attempted to construct dikes in the right place to avoid intrusion to agricultural lands. And dikes were constructed at locations where dikes have already existed, and just if needed, their heights were increased.

In Figure 4 the longitudinal profile of the bed and the water surface is shown in case of dredging and dike construction.

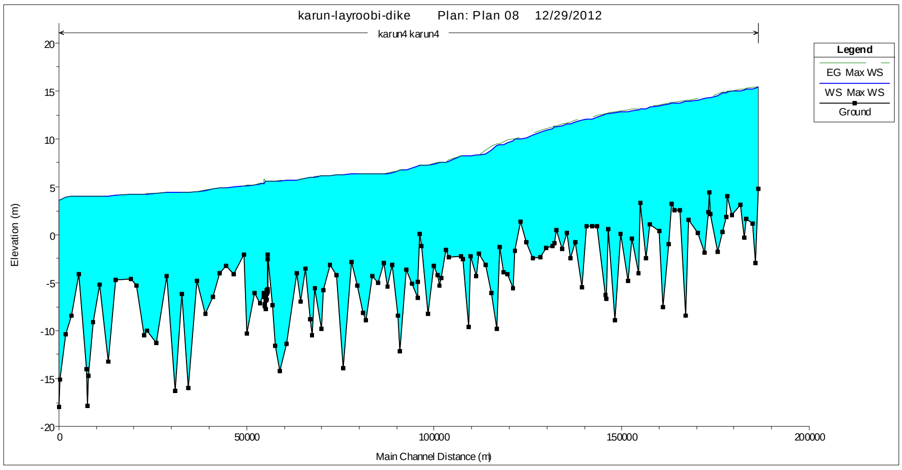

Figure 4: Water surface profile with a return period of 50 years in the case of dredging and dike (dike).

5. Conclusions and Discussions:

Water surface elevation in both cases of dredging and non-dredging indicates that the dredging has no significant effect on the reduction of water surface elevation in floods with longer return period, and the Maximum water level difference between these two cases is 19 cm. The volume of removed due to sits due to dredging is 3060000 cubic meters in studied area and the cost of this operation in this area is 10000000 USD. The comparison of results of flow rate for dredging and non-dredging conditions indicates that with dredging the flow rate is higher and consequently sediments move faster and sedimentation decrease in bed and bank of the river. Dredging will cause the deepening of flow and barriers removal and facilitate traffic of boats, barges and vessels. Due to lack of efficiency of dredging operations, using other methods of flood control including dike construction and flood deflection along with dredging operations is inevitable. Due to the lack of suitable sites for flood deflection, in this study the construction of dike in dredged river was applied, and the studies showed that the only practical and cost -

effective method to control the Karun river flood in the studied area is to build a dike with height designed in this study.

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