International Journal of Earth, Energy and Environmental Sciences
ISSN: 2517-942X
Vol:4, No:8, 2010

Sensitivity of the SHARC Model to Variations of Manning Coefficient and Effect of "n" on the Sediment Materials Entry into the Eastern Water intake- A Case in the Dez Diversion Weir in Iran

[1]M.R.Mansoujian, [2]A.Rohani, [3]N.Hedayat , [4]M.Qamari and [5]M. Osroosh

***Abstract*—**Permanent rivers are the main sources of renewable water supply for the croplands under the irrigation and drainage schemes. They are also the major source of sediment loads transport into the storage reservoirs of the hydro-electrical dams, diversion weirs and regulating dams. Sedimentation process results from soil erosion which is related to poor watershed management and human intervention ion in the hydraulic regime of the rivers. These could change the hydraulic behavior and as such, leads to riverbed and river bank scouring, the consequences of which would be sediment load transport into the dams and therefore reducing the flow discharge in water intakes. The present paper investigate sedimentation process by varying the Manning coefficient "n" by using the SHARC software along the watercourse in the Dez River. Results indicated that the optimum "n" within that river range is 0.0315 at which quantity minimum sediment loads are transported into the Eastern intake. Comparison of the model results with those obtained by those from the SSIIM software within the same river reach showed a very close proximity between them. This suggests a relative accuracy with which the model can simulate the hydraulic flow characteristics and therefore its suitability as a powerful analytical tool for project feasibility studies and project implementation.

***Keywords*—**Sediment transport, Manning coefficient, Eastern Intake, SHARC, Dez River.

I. INTRODUCTION

SOIL erosion due to poor watershed management in the river basins of arid and semi-arid regions which have poor vegetation covers is emerging as a major challenge in the river engineering. This is because eroded soils are transported by the water flow down the slopes in the mountain skirts, move along the river stream and depend on the river characteristic either settle along the river course or settle behind the hydraulic structure downstream . One of such structures is the diversion weirs which are principally designed and constructed to divert the flow into the water intake feeding the irrigation and drainage canals which in turn operate to supply the water requirements of croplands under its command [1]. Because of the vital importance of the renewable water resource to meet the demands of various sectors in the arid regions sedimentation can not only be a major challenge not only for limiting the productive reservoir capacity but also undermine the operational sustainability of the hydraulic structures and for that matter the water supply system of the area under its command [8]-[9].

Sediment formation behind diversion weirs and the subsequent emergence of the sediment island immediately its upstream can not only challenge the operational efficiency of these hydraulic structures but can also change the established hydraulic regime of the river. This includes changing the hydraulic gradient and the river morphology which in turn causes the flow to change its direction to a particular bank [8]-[10]-[12]. Given the above considerations, this paper aims to analytically study the sensitivity of SHARC model to the variations of the Manning coefficient "n" in a specific river range and the ways in which these might affect the operation and behavior of these hydraulic structures in general, and in the Eastern water intake of the Dez Diversion Weir in particular.

II. MATERIALS AND METHODS

Dez diversion weir is situated 36 km downstream of the Dez hydro-electrical dam and 6km downstream of Regulating dam south of Dezful, a city surrounded by a gross command area of 120,000 ha cultivated by a wide-variety of cash crops and industrial sugarcane estates of Haftapeh and Karoon agro-industrial complexes. It is designed as part of the complex system of water abstraction, conveyance and distribution system to meet the competitive demands of various sectors including agriculture, industry, domestic and environment. It is designed to divert and supply annual water requirements of about 3.5 MM3 which is fed into Eastern and Western Canals that irrigate strategic areas of Karkheh flood plain and Shahvali area[1]-[10]. The diversion structure is designed to incorporate Ogee shape concrete discharge structure of 394m

1- Researcher, Islamic Azad University, Dehloran Branch, Iran, (e-mail: Rezamansoujian@Yahoo.com).
2- Associate professors, Islamic Azad University, Zahedan Branch, Iran, (e-mail: Alirohani@Yahoo.com).
3- Associate professors, Islamic Azad University, Dezful Branch, Iran. (E-mail: n.hedayat@Yahoo.com).
4-Post-graduate researcher, Islamic Azad University, Dezful Branch, Iran.
5- Post-graduate researcher, Islamic Azad University, Dezful Branch, Iran

long having 4m height from the river bed at 116.5 m altitude from the free see level. Its hydraulic features include two sludge gates, one on the western side incorporating two arc gates with a dimension of 15×4m equipped with electrically operated gates with 750 m3/sec discharge and another in the eastern side having 850m3/sec discharge incorporating 8 electrically-operated slide gates.

There are two water intakes, one constructed on western side of the weir with a capacity to feed a 157 m3/sec western canal at a 200 angle and another at the Eastern side having a 93 m3/sec canal with a 900 intake angle. This structure is design to operate at a maximum flooding discharge of 6000 m3/sec [1]-[2].

Field data were collected from along the river course stretching about 1.4 km between the Diversion Weir and the Old Dezful Bridge upstream. These were then complemented by the observation data from the Dezful Hydrometric Station. These data on hydraulic behavior and sedimentation processes were analyzed considering the two water intakes and the hydraulic features of diversion weir using the SHARC software. The crucial data requirement to model the experiment included the river discharge and diverted flow towards the eastern water intake, river cross-section, suspended sediment particles, and bed-load particles. In order to validate and ascertain the reliability of data on calibration of the model, the simulated data were then compared with observational data.

A. Data for the simulation model

This paper used two methods to estimate the Manning roughness co-efficient, Lacy and Simons and Albertson (figures 1 and 2). This was needed to find out which of these two methods would have the most appropriate choice of "n" to measure water level (115.980 m) at specified river cross-section.

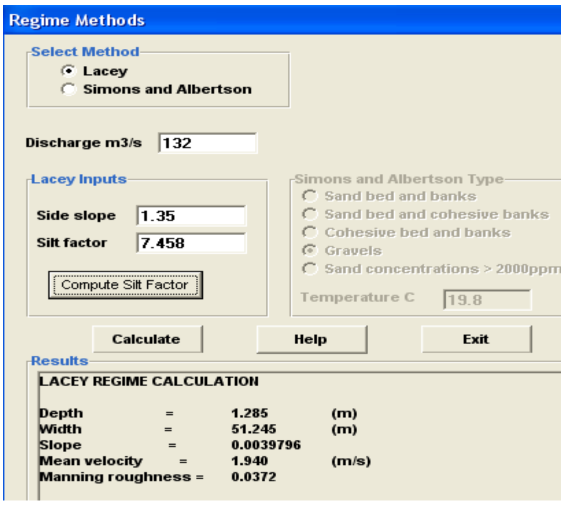

Fig. 1 Methods of estimating the Manning roughness co-efficient using Lacy method

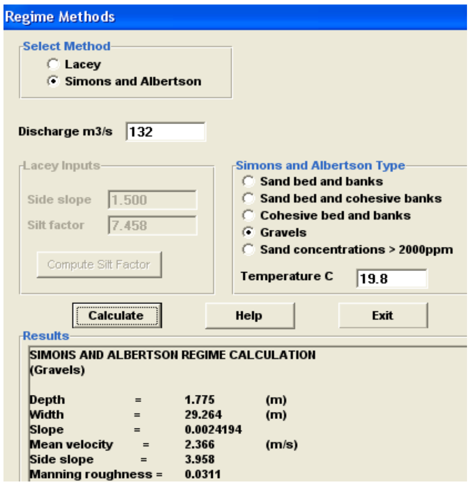

Fig. 2 Methods of estimating the Manning roughness co-efficient using Simmons and Albertsons method

B. Calibration of the manning roughness coefficient

The Manning roughness coefficient was calibrated by inputting data on the river cross-section area, flow discharge and longitudinal slope (figures 3 and 4)

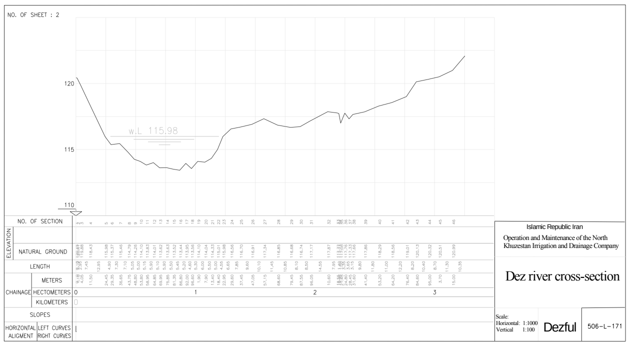

Fig. 3 The Dez River's cross-section

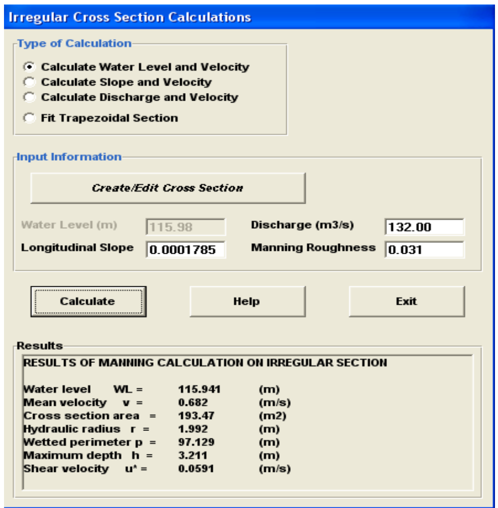

Fig. 4 Calibration of the model based on the flow velocity and water level with (n_l=0.031)

C. Calculating the hydraulic characteristics of the Dez cross-section

This was achieved by inputting the river Bed Width on Manning calculation menu, incorporating data on hydraulic characteristics such as depth, mean velocity and shear velocity (figure 5).

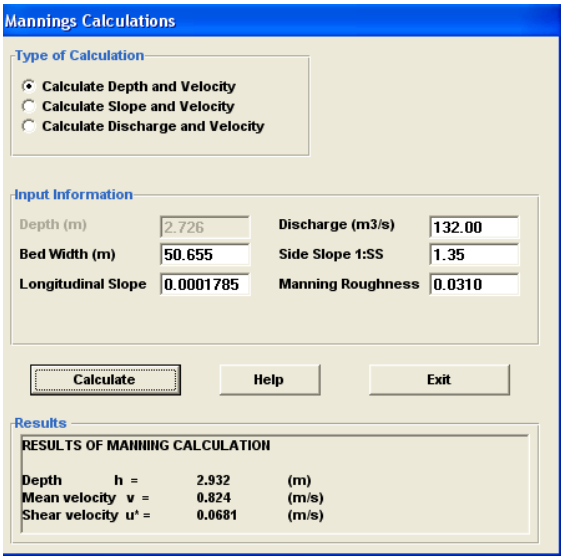

Fig. 5 method of calculating the hydraulic features of the river cross-section

D. Sand transport prediction

From the six methods that can be used by the software to predict the amount of sediment transport Yang model was selected to run the intake model [3] (figure 6).

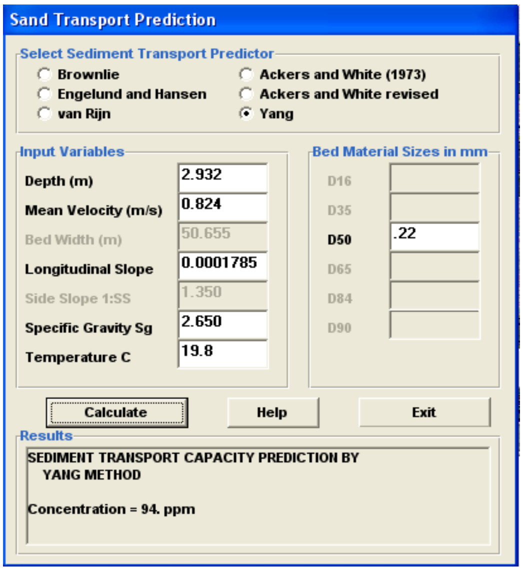

Fig. 6 Estimating sediment transport capacity prediction using Yang method

E. Determining hydraulic characteristics of the Eastern Intake

Various hydraulic parameters (i.e., river discharge, water level gradient, Manning roughness co-efficient, water temperature, sand particle specific gravity and estimated sand transported concentration) were provided by the software in order to simulate the eastern intake structure model (fig. 7).

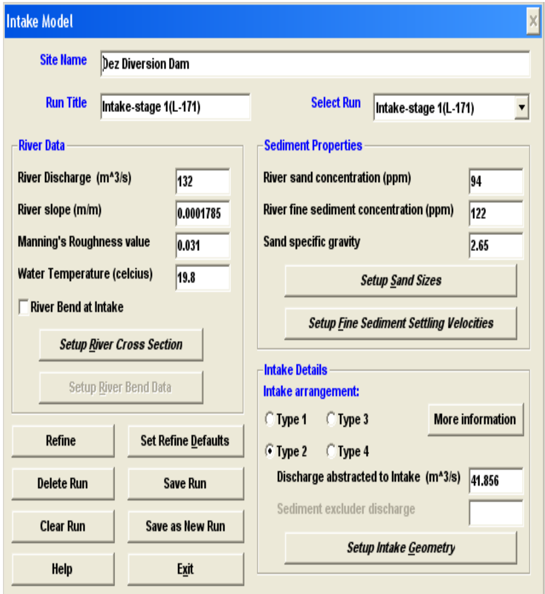

Fig. 7 Running the model

After carrying out the aforementioned stages a test was necessary to ascertain the sensitivity of the SHARC model relative to the variations in the Manning coefficients. For this purpose the latter was increased by 10 %(the "n2" obtained from the Simmons and Albertsons method for all parameters in the model was increased from 0.031 to 0.034).

F. Equations

The methodology followed by Simons and Albertson (1963) was based on available data on a databank of few North American rivers. In order to provide a systematic methodology for their theoretical model, they classified five types as follows [5]:

Type1- Sand bed and banks
Type2- Sand bed and cohesive banks
Type3- Cohesive bed and banks
Type4- Gravel
Type5- sand concentrations > 2000 ppm

Typical equations used by Simons and Albertson in their study are as follows

$$B = 0/9P \quad , \quad P = K_1 Q^{1/2}$$

$$R = K_2 Q^{0/26} \quad , \quad S_o = \frac{1}{R^2}\left(\frac{V}{K_3}\right)^{1/n}$$

$$y_n = \begin{cases} 1/21\ R \quad , \quad R < 2/1\,m \\ 0/61 + 0/93\ R \quad , \quad R > 2/1\,m \end{cases}$$

These constant values depend on the type of canals, i.e., for the type 2 canals the following constants can be used: [5]

n=0.33 K_1=4.71 K_2=0.484 K_3=10.81

Yang and Mollinos used the principle of the disturbed flow showed that the following relation between the total sediment volume and the flow strength should be established as shown bellow:

$$\log C_T = M + N \log \frac{VS}{w_x}$$

Where M and N are without dimension and depend on the flow and sediment characteristics. Yang provided a formula for rivers with sandy bed and particle sizes diameters less than 2 mm as follows:

$$\log C_T = 5.435 - 0.286 \log \frac{w_s D_s}{\gamma} - 0.4571 \log \frac{u^{\bullet}}{w_s}$$
$$+ \left(1.799 - 0.409 \log \frac{w_s D_s}{\gamma} - 0.314 \log \frac{u^{\bullet}}{w_s}\right) . \log\left(\frac{VS}{w_s} - \frac{V_c S}{w_s}\right)$$

Where Cr is total sediment transport (ppm). Yang (1984) provided another equation for rivers with sandy bed having particle size between 2-10 mm as follows [6]:

$$\log C_\tau = 6.681 - 0.633 \log \frac{w_s D_s}{V} - 4.816 \log \frac{u^{\bullet}}{w_s}$$
$$+ \left(2.784 - 0.3051 \log \frac{w_s D_s}{V} - 0.282 \log \frac{u^{\bullet}}{w_s}\right) . \log\left(\frac{V.S}{w_s} - \frac{V_c.S}{w_s}\right)$$

One of the equations that can be used to determine the flow velocity for the steady flow conditions is provided by Manning (1889) which has been applied in this study as follows:

Manning formulae in Empirical System

$$V = \frac{1.486}{n} R^{\frac{2}{3}} S^{\frac{1}{2}}$$

Manning formulae in Metric System

$$V = \frac{1}{n} R^{\frac{2}{3}} S^{\frac{1}{2}}$$

Where,
V is average flow velocity,
R is hydraulic radius,
"n" is Manning Roughness Coefficient,
S is canal slope.

The Manning formula was derived at data obtained from Bazin experiments where the "n" in all seven equations both in the Metric and Empirical systems are similar and "n" is considered as dimensionless quantity [11].

III. Results and Discussions

Results of the calibration of the SHARC model based on increasing the water level and increasing "n" in the program from 0.031 to 0.032 (fig. 8) showed that the software estimated the water level at 115.983 m. this was the case where the actual observed water level at the river cross-section was 115.98m [2]. This indicates a very close proximity between the model and the observational data. Such proximity between two sets of data along the study area where various research studies were conducted [4, 8, 9, 10] and focused on the "n" factor but applied different methodology all arrived at similar results.

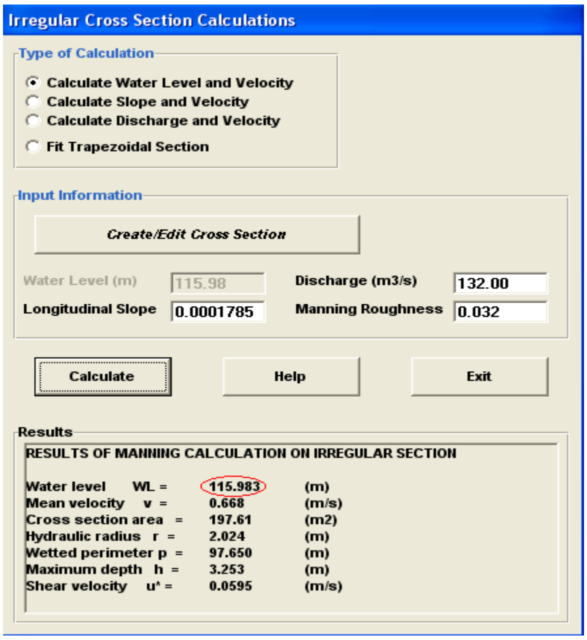

Fig. 8 validation of the model data by increasing Manning coefficient by 10%

The results further showed that by 10% increment on the Manning roughness coefficient but keeping the river discharge constant and assuming the river cross section as rectangular, the following equation was derived at:

$$\frac{n1}{n2} = \left(\frac{y_1}{y_2}\right)^{\left(\frac{5}{3}\right)}$$

Where ;
n1= the original Manning coefficient
n2=increasing the Manning coefficient by 10%
y1= original river depth
y2=secondary river depth

$$\frac{0.031}{0.034} = \left(\frac{2.932}{3.097}\right)^{\left(\frac{5}{3}\right)} \longrightarrow 0.9117 \neq 0.9127$$

Results suggest that approximately same quantities in both sides of equation which indicates that increment of the 10% Manning roughness coefficient would not make a significant statistical difference in the results of the model. Results [figs 12 and13] further indicated that increment of 10% on the Manning roughness coefficient, the median bedloads materials size in the Eastern intake head reach increases from 1.99mm to 2.00 mm. It can be interpreted that such proximity in the two quantities might be a clear sign to substantiate the results and support their validity components.

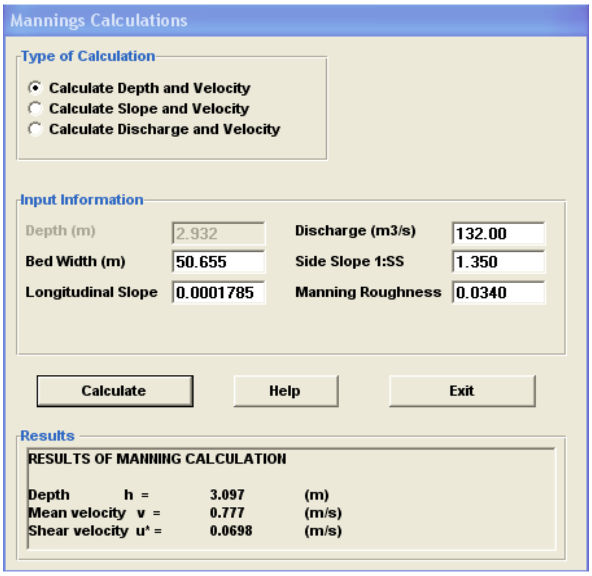

Fig. 9 estimation of the cross-sectional characteristics by 10% increment on "n".

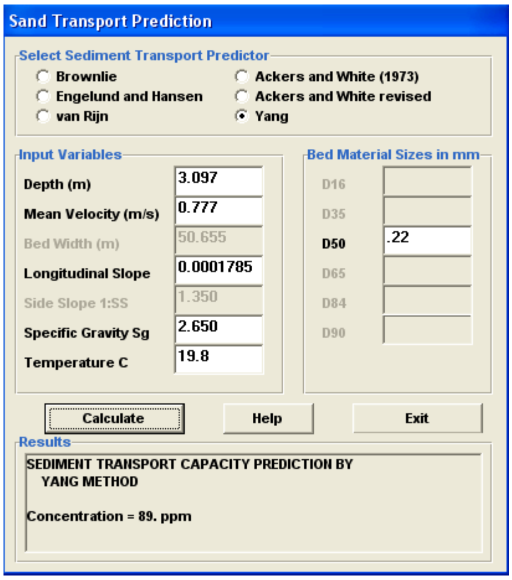

Fig. 10 transport sediment load concentration by 10% increment on the "n".

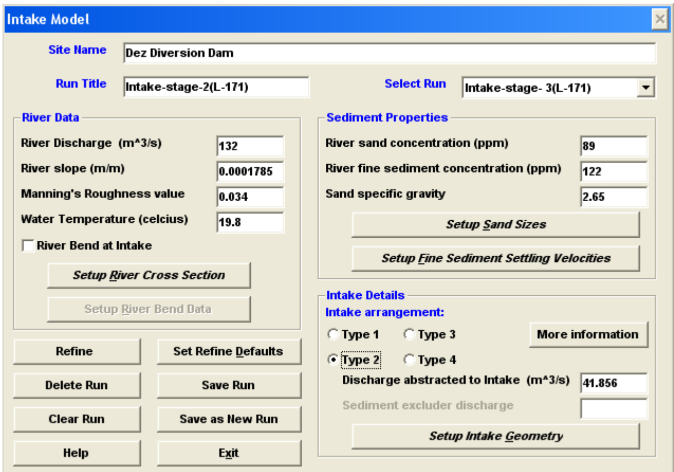

Fig.11 running the intake model after 10% increment on "n"

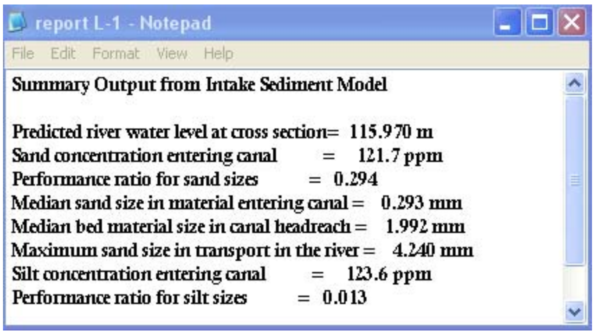

Fig .12 Results of the original simulation model for the intake with 41.856 m3/s discharge.

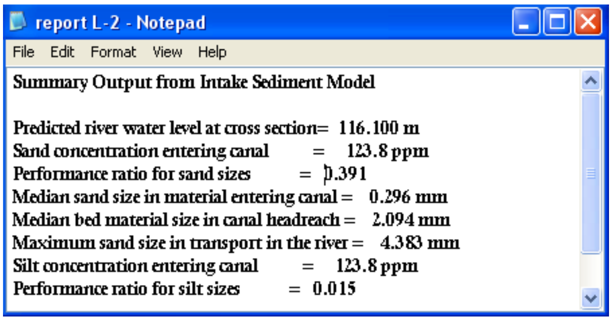

Fig .13 Results of the simulation model for the intake with 41.856 m3/s discharge by 10% increment on the "n".

Moreover, comparisons of the results (fig. 12 and13) indicated that sand concentration entering the intake structure increases from 123.6ppm to 123.8ppm. This shows that the simulation model was not very sensitive to variation of the "n" factor and its influence (effects) of 'n' on the sediment load concentration entering the Eastern water intake structure.

It can be concluded that the "n' that was introduced in the model within the study area of the river range was appropriate and by comparison it with the similar models like the SSIIM [7]-[13] within the same river range there was no significant statistical differences between the two . However, it supports the validity of the model's results and indicates no sensitivity to the variations in parameters that were introduced in the model.

The overall conclusion being that the optimum "n" in this particular river range is 0.0315. It was further shown that the SHARC model can be considered as a powerful analytical tool for the feasibility studies and the operation and maintenance of water resources projects under arid and semi-arid climatic condition like Dezful region in Iran.

References

[1] Hedayat,N. [2005]. Improving The Performance Of Water Delivery In The Dez & Moghan Irrigation Schemes In Iran, PhD Thesis , Cranfield University , UK(2005).
[2] Operation and Maintenance of the North Khuzestan Irrigation and Drainage Company (2009). KWAPA, Dezful, Iran.
[3] Department for International Development [2001]. "Sediment and Hydraulic Analysis for Rehabilitation of Canals, "Software Manual, H.R Wallingford, UK.
[4] Abshoori,A[2006]. Investigating the sedimentaatio process in settling basin in irrigation netwrok of the Imam Khomeini agro-complex, MSc Dissertation, Chamran University, Iran.
[5] Chadwick ,A[2008]. Hudraulics in civil environmental engineering ,3rd translated by Mashal, M, Tehran University Press
[6] Shafaaee Bejestan,M[1994]. Sedimntation Hydraulics, first Edition, University Of Chamran, Iran
[7] Najafi,L[2005]. Investigating the challenges of the water intake in Diversion weirs and means of overcoming them-Case study in Dez Diversion Dam In Dezful, Iran. MSc Dissertation, Khajeh Nasiradin University, Tehran, Iran.Toosi.
[8] Ashkaria, S, Kiamanesh, H, and Hedayat, N[2010]. Simulation of the flow pattern using Flow 3D software- a case study in the Dez diversion Weir in Dezful, Iran. Proceedings: National Conference in water, soil, palnt and mechanisation , Islamic Azad University, Dezful, Iran.
[9] Shirin,H, Hedayat, N, and kiamanesh ,[2010]. Analytical investigation of the sedimientaion process and their underlying cause- a case study in the Dez Diversion Weir in Dezful, Iran. Proceedings: National Conference in water, soil, palnt and mechanisation , Islamic Azad University, Dezful, Iran.
[10] Mansoujian, M.R[2008]. Crtiical iinvestigation of the sedimentation processes in the water intakes using the SHARC software- A case study of the Eastern Intake structure in Dezful. MSc dissertation, I.azad University, Dezful, Iran.
[11] Najmaee, M[1994]. Applied hydraulics, 1st edition, Elmosanat University Press, Tehran, Iran.
[12] Shirin, H[2009]. Investigating the sedimientaion process and their underlying cause- A case study in the Dez Diversion Weir in Dezful, Iran. M.Sc dessertation, Islamic Azad University, Dezful, Iran.
[13] Ahwazin, H[2007]. Numerical model of dez diversion Dam in Dezful, Iran. M.Sc dessertation, Islamic Azad University, Dezful, Iran.