Roughness Characteristics of Kut-Hay Reach of the Gharraf River and Its Impact On the Hay Regulator

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Abstract:-

Represent the study of this research is the problems of water levels fluctuation for different discharges in downstream Gharraf regulator for Gharraf river of the reach kut-Hay along 58.3 km . Compute Manning roughness coefficients which has not been determined before and investigate rating curve by back water curve during study period to be used simulation of HEC-RAS model. the roughness coefficient is one factors which effect on flow depth in the rivers. Many researchers have made to estimate the river roughness coefficients, Because of its importance. Among them. Absolutely, the above methods cannot be applied for each river reach due to differences in the factors affecting the roughness coefficient as (backwater curve , flood plain ,sediment ,routing etc.) . These study are important due to the diversity and irregularity of natural rivers. Field measurements were carried out during period(2016-2017) along reach included 22 across section surveys and hydrological measurements. It is found that the value n for Gharraf river which shows good agreement between observed and computed hydrographs is(0.026). The results show that effect of Al-Hay regulator on upstream reach because of backwater curve .When was gate opening less than (0.5)m for all available discharges, gate opening, (0.65 - 0.9)m for discharge more than(175 m3/sec), gate opening (0.9 - 4)m for discharge more than (210 m3/sec), and gate opening(4 - 5.8)m for discharge more than(350 m3/sec) at upstream reach.

Keywords:- Gharraf river , Roughness, Manning's n, HE-RAS software

Introduction:

All hydraulic computations involving flow in open channels require an evaluation of the roughness characteristics of the channel and also it is one of the keys to successfully predicting water flow in channel networks. At the present state of knowledge, the selection of roughness coefficients for natural channels remains chiefly an art. Since, a direct determination of the roughness coefficient is almost impossible in studying natural river flows, including unsteady and steady channel network flows. Consequently , the ability to evaluate roughness coefficients for natural channels representing a wide range of conditions must be developed through experience. Various factors

affecting the values of roughness coefficients (1). Accordingly, roughness estimation has attracted attention of many investigators . Because an estimation accuracy of roughness coefficients is of vital importance in any open channel flow study, among them (11), (7) and (6) ; have calibrated channel roughness for different rivers for the development of hydraulic model for simulate open channel flows. (9) calibrated channel roughness for Lower Tapi River, India using HECRAS model. (8) in his study has attempted calibrated the. channel roughness coefficient (Manning's "n" value) along the river Mahanadi, Odisha through simulation of floods using HEC-RAS . (6) has estimated the Manning's Roughness coefficient for Hila River in Iraq through calibration using HEC-RAS Model. (10) was calibrated the channel roughness for large number of semiarid rivers of Western Australia having variable channel characteristics for development of rating curves . Therefore , in the above context, there is a need to calibrate the channel roughness coefficient for Gharraf river in Wasit government (Iraq) , by comparing observed water surface profiles with computed data , using HEC-RAS model .

Study Reach

The study area is located on the main stream of the Gharraf river between Kut city and Hay city that is located southwest of Kut city. Fig. (3.1). The Kut-Hay reach is 58.3km long. Gharraf Regulator is located at the upstream of reach and the Hay Regulator is located at the downstream of reach. The discharge varies along the reach since there are some main channels branching out form the Gharraf River in the reach such as Um khala channel, Um Nebra channel, project Alrumea channel, mdeleel channel, Al dhahaa channel, Al Haider channel, Al Rejawiy channel, Al Janabea channel and many other small channels upper design discharge range between (0.2 – 15) m³⁄sec.

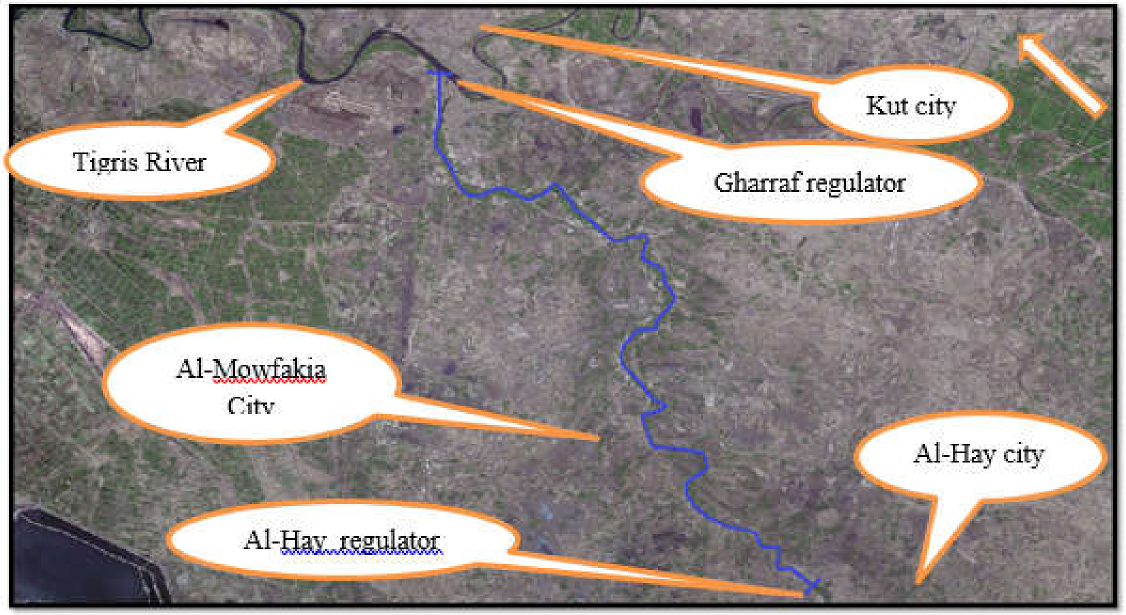

Fig. 1 Satellite image showing the locations along Al-Gharraf River

Model Description

The present version of HEC-ARS supports the calculation of one dimensional water surface profile for steady gradually varied flow in natural channels or network of channels .

Subcritical, supercritical, and mixed flow regime water surface

profiles can be calculated . So, water surface profiles are computed from one cross section to the next by solving the energy equation with an iterative procedure. The energy equation is only applicable when flow is steady gradually varied and flow is assumed to be one dimensional . At locations where the flow is rapidly varied, the program switches to the momentum equation (USACE , 2008) .

Equation (1) and illustrate the main computing process based on solution of one dimensional energy equation and basic profile calculation , in steady flow (USACE , 2008).

$$y_1 + \frac{\alpha v_1^2}{2g} + z_1 = y_2 + \frac{\alpha v_2^2}{2g} + z_2 + h_e .. \quad (1)$$

Where:

y_1, y_2 : depth of water at cross-section, m.

z_1, z_1 : elevation of the main channel inverts, m.

v_1, v_2: Averaged velocity at the section, m/sec.

α_1 , α_1 : is the weighted speed coefficient

g : gravitational acceleration, m/sec^2.

h_e : head loss (the total energy loss, m).

Field Measurement

Field measurements were carried out along Kut-Hay reach. They included cross section surveys and hydrological measurements**.**

Field surveys and Cross Section

The survey works included establishment of benchmarks and cross section measurements. Seven benchmarks were established along reach of location Points is downstream on the right bank with flow direct , the GR3 used all The survey works to measure and cross section on the river , The location and description of bench marks see Fig. 4. 22 a cross sections were measured along Kut- Hay reach. Fig. (3) and Fig (5) shows locations of cross sections. Acoustic Doppler Current Profiler (ADCP) was used to measure cross section under water surface and total station was used to measure distances along the flood plain and bank.

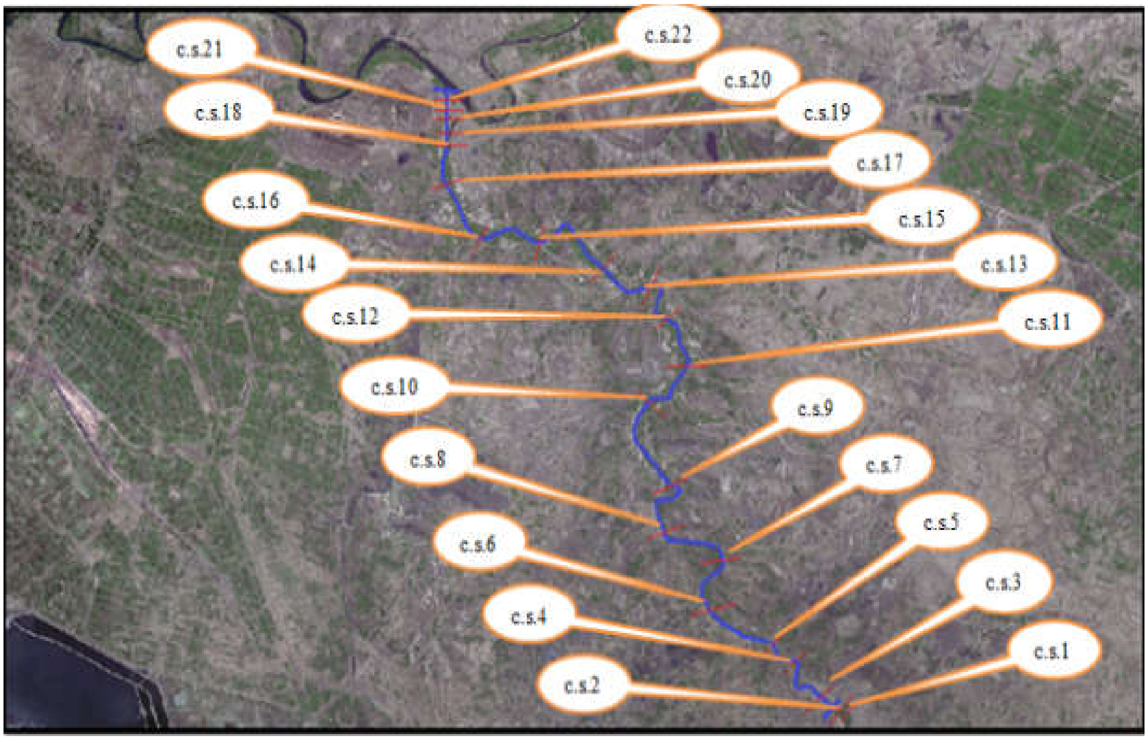

Fig. 3 Satellite image showing the locations of cross sections for Kut-Hay reach in Gharraf River

Fig. 4 Photo of benchmarks and the base point

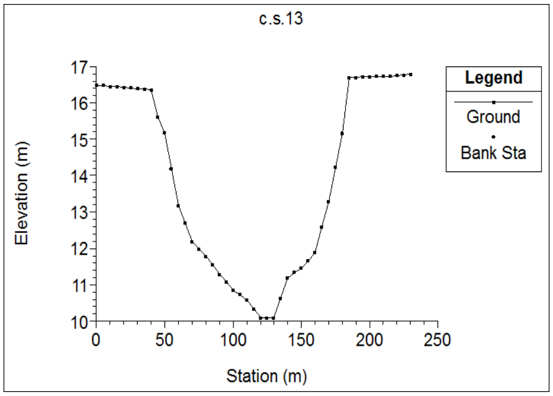

Fig. 5 Cross section data window

Geometric and Hydrologic Data

The hydrological study reach field measurements were achieved at seven sections during period from Nov 2016 to May 2017.The measurements included discharges and water levels .The seven cross sections (C.S.5, 7, 8 , 11 , 13 , 15 and 22) are shown in **Table 1.**Six sets of discharge and water level were performed. Each set document seven discharge and water level measurements. Each set of discharges and water levels at the seven sections was performed during the same day by using Acoustic Doppler Current Profiler (ADCP) and GPS for compute Water-surface elevations were read at the stream portion of the study reach.

Table. 1 Six sets were measured in period from 28Nov2016 - 18May 2017

Description		First Set on Nov2016		Second Set on Dec-2016		Third Set on Jan-2017	
Name of cross section	**Station (m)**	**Discharge (m^3/sec)**	**Water level (m)**	**Discharge (m^3/sec)**	**Water level (m)**	**Discharge (m^3/sec)**	**Water level (m)**
C.S.22	58+200	135.0	15.20	147.0	15.34	113.0	14.78
C.S. 16	40+300	133.3	14.65	144.0	14.69	109.6	14.24
C.S. 15	36+800	127.5	14.58	142.8	14.56	108.0	14.19
C.S.12	26+800	122.7	14.48	141.5	14.44	106.0	14.12
C.S.8	17+300	119.2	14.36	140.1	14.06	103.0	13.64
C.S.5	9+800	166.6	13.95	136.9	13.56	95.50	13.22
C.S.3	0+600	110.0	13.45	135	12.9	91.00	12.65
Description		**Fourth Set on Mar-2017**		**Fifth Set on Apr-2017**		**Sixth Set on May-2017**	
Name of cross section	**Station (m)**	**Discharge (m^3/sec)**	**Water level (m)**	**Discharge (m^3/sec)**	**Water level (m)**	**Discharge (m^3/sec)**	**Water level (m)**
C.S.22	58+200	130	15.08	173	15.66	155	15.40

C.S. 16	40+300	126.5	14.50	165	15.09	152	14.97
C.S. 15	36+800	125	14.37	164	15.04	149.5	14.85
C.S.12	26+800	123.8	14.27	162.5	14.97	148.2	14.74
C.S.8	17+300	121	13.78	157	14.42	147.5	14.18
C.S.5	9+800	119.3	13.50	152.5	13.85	146.3	13.74
C.S.3	0+600	115	12.9	147	13.65	145	13.35

Calibration and simulation of Stages and Flow for Different Value of Manning's '*n*'

Each value of global Manning's roughness coefficient (0.022-0.030) was input for all profiles for calibration. Calibration process was carried out using stage measurements along Kut -Hay reach. The obtained stage values along Kut - Hay reach course were used to calibrate the model.

One set of data (sixth set on 28-11-2016) was used for the verification process is presented by the discharge and water level along Kut - Hay reach and using the global Manning's *n* derived from the calibration runs. The verification process of the steady flow model has been achieved by making a comparison between the observed and computed water surface.

The root mean square error (R.M.S.E) test was used to compare The computed and the observed water surfaces, Eq.(2). Table (2) shows the statistical test of the calibration results.

$$\mathrm{RMSE}=\sqrt{\tfrac{1}{N}\sum_{i=1}^{N}(\mathrm{C.W.S_i}-\mathrm{O.W.S_i})^2}\quad ..(1)$$

where,

N= number of data.

C.W.S= computed water surface

O.W.S= observed water surface

The results showed that Manning's n ranged from (0.025 to 0.027) for several discharges with normal operation of Gharraf regulator (gate openings of fully in both regulators.

The value of n=0.026 was adopted for the reach and used to calculate the rating curve since this value was obtained for discharges which were the most common in the reach.

obtained for discharges which were the most common in the reach.

The value of Manning's n (0.026) which is slightly lower than that in cases others , represents the data of the set on the 22th Dec, 8th March , 4th April and 18th May where the vegetation in the reach was less dense than that of the subsequent sets of the 28th Nov, and the 12th Jan when the growth of vegetation increased indicating seasonal variation in resistance to flow

In case of lower water levels upstream of Al-Hay regulator down to (12.65 m.a.m.s.l.) in normal operation the value of Manning's n may be increased to 0.027 in the reach since higher levels introduce areas of higher resistance

Manning's n was affected by variation of water level and backwater curve of Al-Hay regulator by raising water levels along upstream reach.

Manning's n was affected by variation of water level and backwater curve of Hay Regulator by raising water levels along upstream reach. The global Manning's n is a good indicator for Kut-Hay reach. and different water level between observed and computed.

The comparison of observed and computed water surface profiles for values of Manning's n are shown in Fig.(6), Fig.(7), Fig.(8), Fig.(9), Fig.(10), and Fig.(11). For more details.

Table. 2 Statistical test of the calibration results

Manning s n	$\sum$ R.M.S.E (water surface profile)					
	PF1	PF2	PF3	PF4	PF5	PF6
0.022	**0.16174**	**0.24018**	**0.30711**	**0.27640**	**0.23210**	**0.23616**
0.023	**0.12525**	**0.18864**	**0.26632**	**0.18068**	**0.19048**	**0.18807**
0.024	**0.10624**	**0.15297**	**0.23167**	**0.13908**	**0.18154**	**0.14793**
0.025	**0.09259**	**0.10549**	**0.19730**	**0.10869**	**0.13538**	**0.12201**
0.026	**0.11569**	**0.09142**	**0.18012**	**0.09725**	**0.13490**	**0.11116**
0.027	**0.14615**	**0.10750**	**0.15906**	**0.10810**	**0.15165**	**0.12575**
0.028	**0.18682**	**0.14177**	**0.15951**	**0.13856**	**0.17968**	**0.15548**
0.029	**0.21391**	**0.18605**	**0.17167**	**0.17399**	**0.21798**	**0.19379**
0.030	**0.271819**	**0.232256**	**0.188225**	**0.216531**	**0.26139**	**0.23516**

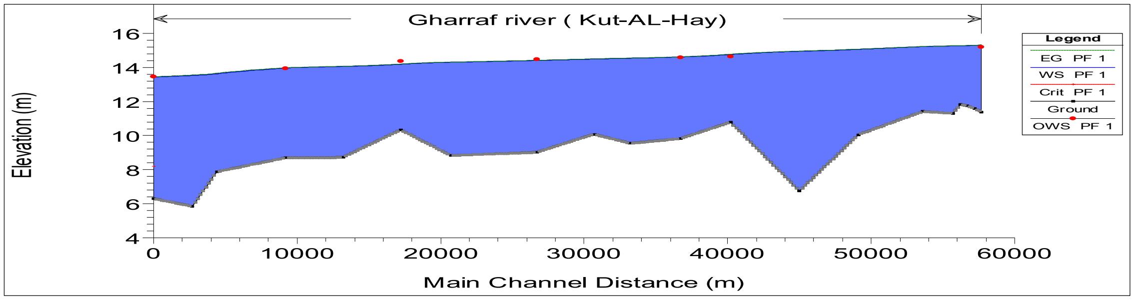

Fig 6 Computed and observed W.L. profile along reach for PF1 and Manning's *n* =0.025

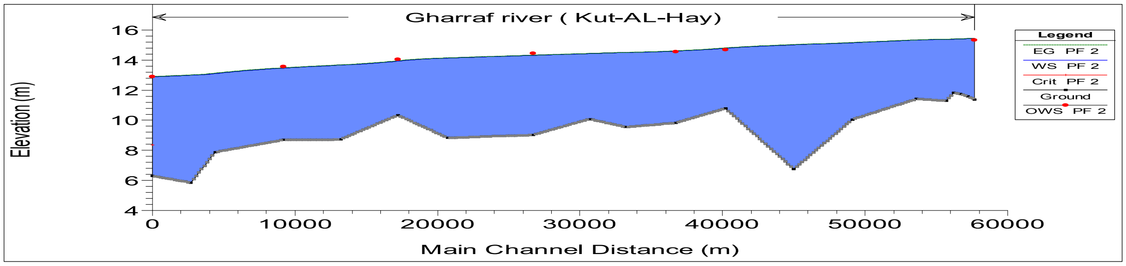

Fig. 7 Computed and observed W.L. profile along reach for PF1 and Manning's *n* =0.026

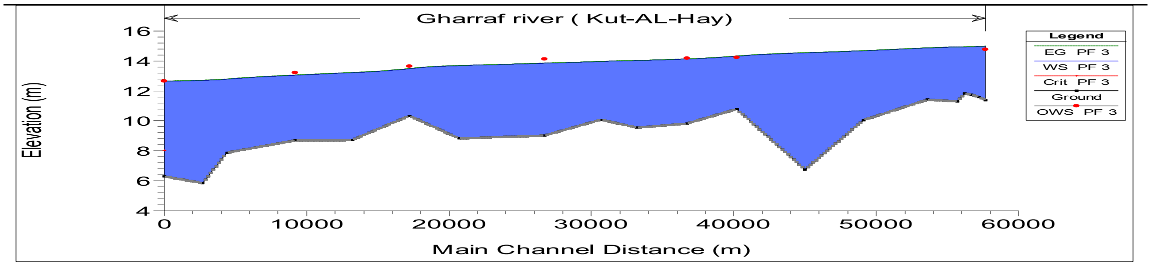

Fig. 8 Computed and observed W.L. profile along reach for PF3 and Manning's *n* =0.027

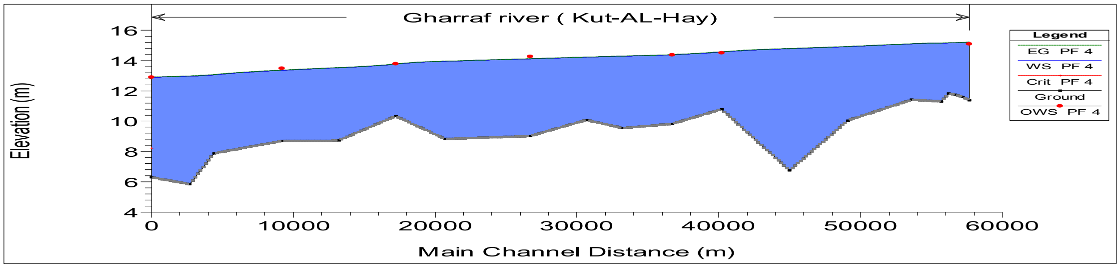

Fig. 9 Computed and observed W.L. profile along reach for PF4 and Manning's *n* =0.026

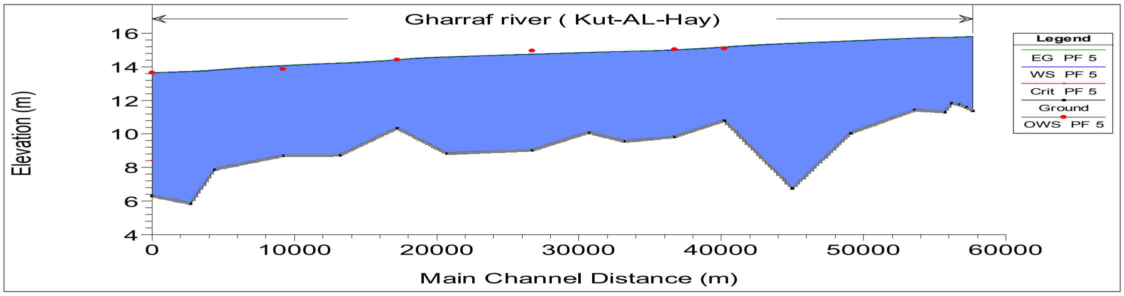

Fig 10 Computed and observed W.L. profile along reach for PF2 and Manning's *n* =0.026

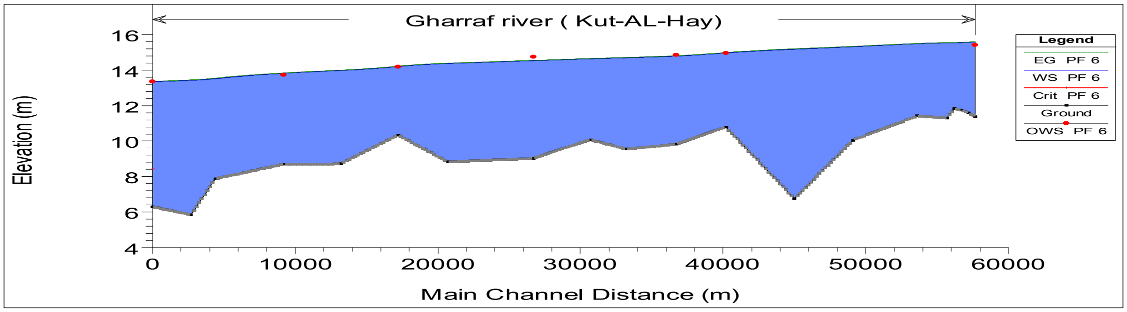

Fig. 11 Computed and observed W.L. profile along reach for PF2 and Manning's *n* =0.026

Backwater curve

The available discharges at upstream reach were used as boundary condition. The discharge is spatially varied and the relationship between the discharge of upstream reach and discharges of other sections was determined from the data.

Investigation of the operation data of Hay Regulator shows that gate openings which were the most widely used were (0.95, 1.10 and Fully) *m,* and these have been used to compute rating curve in HEC-RAS model. The available discharges at upstream reach were used to compute the rating curve.

Manning's n coefficient (0.026) and gate openings (0.5, 0.65 , 0.75, 0.90, 0.95, 1, 1.2, 2, 4, and 5.8 (fully) *m*, were adopted to compute the rating curve for upstream reach to know the effect of Hay Regulator on upstream reach.

The results show that effect of Hay Regulator on upstream reach because of backwater curve was evident for cases which has gate opening less than (0.5)*m* for all available discharges at upstream reach, for gate opening more than (0.65)*m* to (0.9)*m* for discharge more than (175 m^3/sec) at upstream reach, for gate opening more than (0.9)*m* to (4)*m* for discharge more than (210 m^3/sec) at upstream reach and for gate opening more than (4)*m* to (5.8)*m* for discharge more than (350 m^3/sec) at upstream reach as shown in Fig.(12).That mean the Gharraf Regulator are affected by Hay Regulator operation for cases above ,therefore the rating curve of Gharraf Regulator is not valid due to effect of backwater curve which occur during Hay Regulator operation**.**

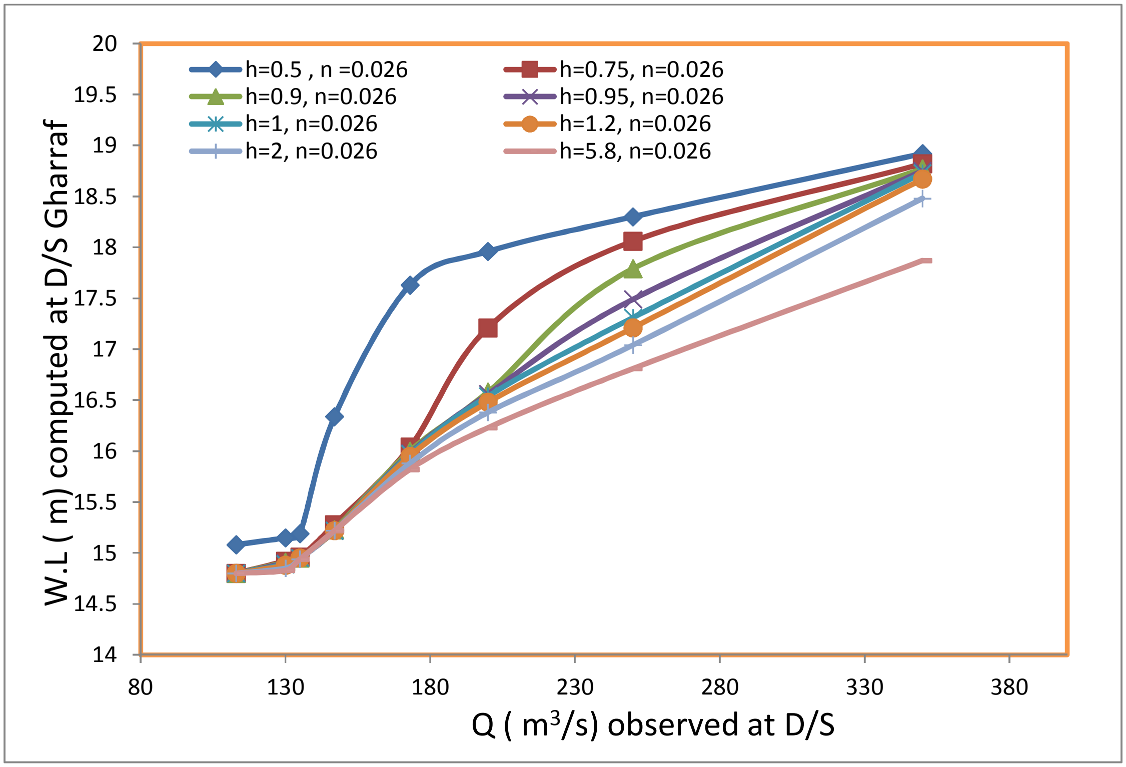

Fig. 12 .Rating curve of U/S reach (C.S.22, D/S Gharraf Reg.) for multi gate openings

Roughness impact on flow depth

Change of the Manning's n coefficient did affected the rating curve of upstream reach (gate openings Fully and 1.1) as shown in Fig.(13) and Fig.(14) . The effect of the Manning's resistance coefficient n; on flow depth increasing the value of Manning's n from 0.022 to 0.026 led to increase the water depth about 30 *cm* , and also increasing the value of Manning's n from 0.026 to 0.030 led to increase the water depth about (40) *cm* too. Rating curves computed for upstream reach included the gate openings (0.5-0.9)*m*, with Manning's n (0.026). The observed rating curve differed from the computed ones and generally fell between the computed rating curves for the 0.5*m* to 0.9*m* openings of Hay regulator.

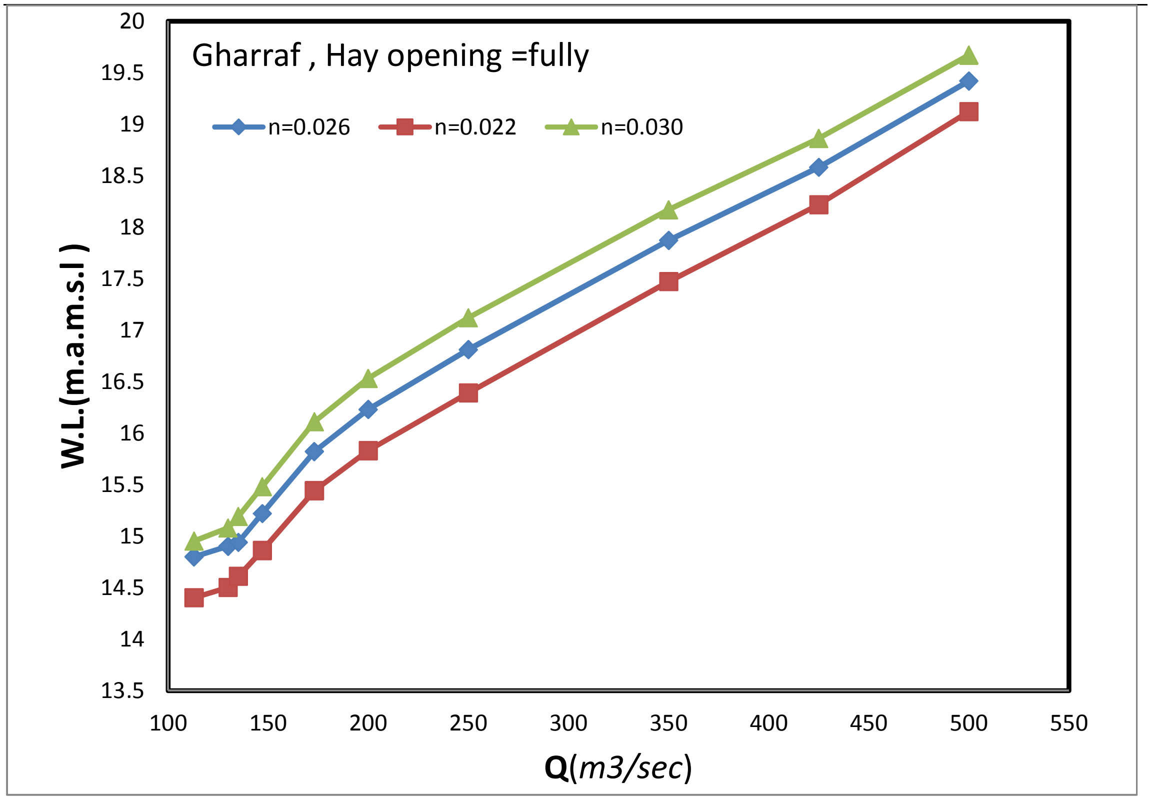

Fig.13 Change of rating curve with Manning's *n* at upstream (C.S.22)

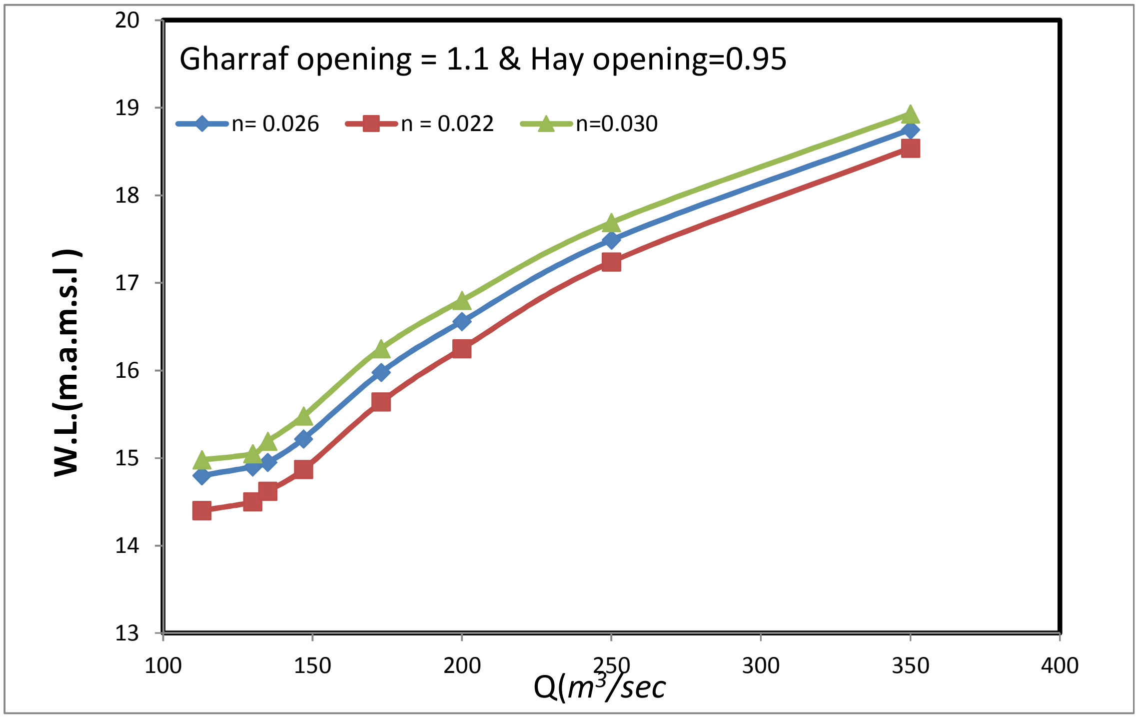

Fig.14 Change of rating curve with Manning's n at upstream (C.S.22)

Conclusions

According to results of the present study, the following conclusions
were reached:

1- Global Manning's *n* coefficient was calculated steady state for all data sets and ranging between (0.025 to 0.027) with average equal to 0.026.

2- The Kut-Hay reach and Al-Gharraf Regulator are affected by Al-Hay regulator.

3- Water levels fluctuation is influenced by several factors, including the value of the roughness coefficient, which varies with flow depth.

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خصائص الخشونة لنهر الغراف مقطع (كوت- حي) وتأثيره على ناظم الحي

أ. د . عبد الأله يونس محمد
علي ناظم مانع عرار
علي عبد الحسين عبد الصاحب

الخلاصة:

تمثل دراسة هذا البحث مشاكل تذبذب مستويات المياه لمختلف التصريف في مؤخر ناظم الغراف لنهر الغراف لمقطع الكوت الحي وعلى طول 58.3 كم. حيث تم حساب معاملات الخشونة التي لم يتم تحديده من قبل وكذلك تم التحقيق من منحي ظاهرة المياه الراجعة وتأثيرها على المناسيب خلال فترة الدراسة لاستخدامها في محاكاة نموذج HEC-RAS. ان معامل الخشونة هو أحد العوامل التي تؤثر على عمق التدفق في الأنهار ولقد قام العديد من الباحثين بتقدير معاملات خشونة الأنهار، نظرا لأهميتها. لا يمكن تطبيق الأساليب المذكورة أعلاه لكل مقطع نهر بسبب الاختلافات في العوامل التي تؤثر على معامل خشونة (كما في منحنى المياه الراجعة ، الفيضانات، الرواسب، التوجيه المائي الخ). وتعتبر دراسة هذه الامور مهمة بسبب تنوع النهار الطبيعية وعدم انتظامها.

تم اجراء قياسات حقلية على طول المقطع كوت-حي خلال الفترة من تشرين الثاني 2016 إلى أيار 2017 التي شملت 22 مقطعا عرضيا وقياسات هيدرولوجية باستعمال مخطط التصريف المحسوب بواسطة جهاز الدوبلر وادخالها في برنامج ال HEC-RAS لتنفيذ الموديل وتم تنفيذ ست مجموعات من قياسات التصريف و مناسيب المياه . فوجد أن قيمة معامل خشونة ماننك (n) نهر الغراف لمقطع كوت- حي عندما وجد تقارب بين المناسيب المقاسة و المحسوبة هي (0.026)

كذلك أظهرت النتائج أن تأثير ناظم الحي على مقدم المقطع بسبب منحنى المياه الراجعة. كان دليلا معتمدا على حالات تشغيل ناظم الحي . فاذا كانت فتحات ناظم الحي أقل من (0.5) م فان جميع التصاريف في مؤخر الغراف تتأثر عند هذه الفتحة ، واذا فتحت البوابات من (0.65 - 0.9) م فان التصريف الذي يتأثر بظاهرة رجوع المياه الأكبر من (175 م ^{3} / ثانية) , واذا كانت فتحة البوابات تتراوح من (0.9 - 4) م فان التصريف المتأثر اكبر من (210 م ^{3} / ثانية)، ، أما بالنسبة لفتحة البوابات التي تتراوح فيها الفتحات من (4 - 5.8) م فالتصريف المتأثر الاكبر من (350 م ^{3} / ثانية) في مقطع كوت –حي

الكلمات المفتاحية: - نهر الغراف – معامل الخشونة - معامل ماننغ. برنامج HEC-RAS