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Assessment of hydraulic changes due to construction of a barrage in the Shatt Al-Basrah canal using one dimension model (Mike 11)

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Abstract - Shatt Al-Basrah is an artificial Canal, started in 1971 and completed in 1983. It was established to reduce flood and drain the excess water during the flood seasons, as a canal alternative to Shatt al-Arab during the Iran-Iraq war. It delivers water to the Zubair area and Al Faw town for agricultural purposes. A deterioration of the water quality of the canal was occurred due to many reasons; most importantly was the close of the canal at the junction of Garmat-Ali which is affected by the semidiurnal rhythm of the Arabian Gulf. There is a regulator located at about 22 km from the head of the canal. The main purpose of the canal is to control water drainage during flood and mitigating the effects on both sides land. In this paper the canal was simulated by the existence of controlled barrage on the water way, closed during the flood tide time and opened at the ebb tide. The simulation results after calibration of the mathematical model with field measurements, matched with high accuracy. The tidal effects on the canal can be determined, and the rehabilitation of the canal and water management in the surrounding areas can be preformed. The results indicate the sensitivity of the mathematical model to predict the measurements of water level, volume of water, flow speed of the current, discharge, downstream and upstream direction of discharge and the effect of tidal range at any point along the canal at the closure and opening of the regulator.

Introduction

Shatt Al Basrah canal is selected as a study area. It is 40 km long and extends from Garmat Ali River (Upstream) at North West Basrah city (30 11 51.23N, 47 52 52.33 E) to the head of Khor Al Zubair Navigational Channel located south east of Basrah (Downstream) (30 35 37.10 N, 47 41 49.01 E). (Figure 1).

As the main purpose of Shatt Al-Basrah canal is to control water drainage flooding and mitigating the effects on land located at both sides, so it was necessary to study the discharge in the Tigris and the Euphrates, Al-Hammar marsh and Shatt Al-Arab channel. The Iraqi Directorate General of dams decided to undertake a detailed study on this matter through the design of Shatt Al-Basrah with a proposed discharge of 500m^3/sec.

The canal was connected with the Main Drain canal and closed by a weir at Al-Hammar marsh in Garmat-Ali area. The influence of semi diurnal tide regime of the Arabian Gulf is pronounced in this region as the average tidal amplitude at Khor Al-Zubair port was 4-5 m (Hussain, 1986).

The aim of the present paper is to applicator a one dimensional mathematical model - Mike11-to predict water level measurements, volume

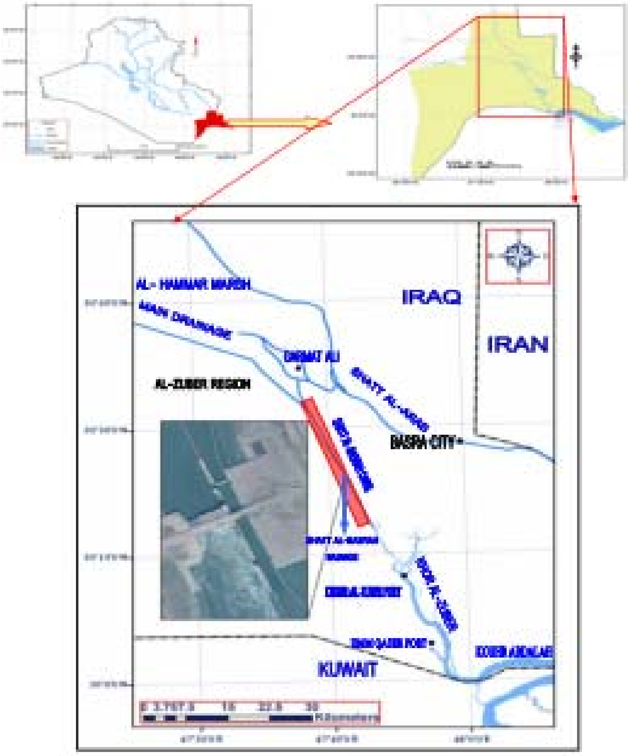

Figure 1. Location map of the study area.

of water, flood speed of currents, discharge, downstream and upstream direction of discharge and the effect of the tidal range at any point along the canal at the closure and opening of the regulator.

Hydrology of Shatt Al-Basrah Canal:

Shatt Al-Basrah is an artificial Canal operated in 1983 to transfer the flood water from the Euphrates river to Al-Hammar marshes during the flood periods, to Khor Al-Zubair navigational channel, and then to the Arabian Gulf.

The length of Shatt Al-Basrah canal is 37.150 km. The cross section consists of a portion for the purposes of maritime shipping. The canal has undergone several changes due to wars and human labor. The closure of the canal is made to provide water to Garmat Ali river by weir so the water does not reach the sea due to the damage of the Barrage of Shatt Al-Basrah during the war. This regulator is located about 22 km from the upstream of the canal. It has also been linked to the Main Output Drain canal, draining water from the Euphrates basin. This led to dramatic changes of water quantity and quality of the channel and thus disrupting the target of the design of the canal.

The canal occupies the eastern and northern part of Basrah province within the contour line of 5 meters above sea level. The topography of the western part is inclining slightly from north-west to south-east towards the Arabian Gulf, where the rate of decline is 26.7 cm/km, the rate of decline of Shatt Al-Basrah is 5.45 cm/km, the section of Shatt Al-Basrah consists of navigation part for the movement of small motor boats (Al-Khiat, 2002). (Figure 1).

The canal was considered as a transporting waterway, and designed to discharge water of about 200 m^3/sec in the main dredged canal, and 500 m^3/sec when the water level is 1.3m above the surrounded ground surface (Al-Katib, 1972). The ground surface in this area is 2 – 2.33 m above mean sea level .The canal was controlled by a barrage to prevent the entrance of marine water from Khor Al-Zubair during the flood tide (Al-Ramadhan, 1986).

Simulation of hydrodynamic condition:

A simulation of the hydrological conditions of Shatt Al-Basrah canal was done by using a one dimensional numerical model using Mike 11 program system. Some of the simulated cases of the canal were also considered like a comparison between the hydrological situations by controlling the Barrage at the closure and opening. The model begins with the first cross-section, upstream at chainage 0.00 m, and ended with the last cross-section, downstream at (chainage 34331 m). During 30 days, time series readings of the water level at different period were taken and the hydrodynamic conditions were simulated.

Calibration of model:

Calibration is the process whereby selected parameters of the model are adjusted to make the model outputs match observations. The purpose of calibration is to obtain a reasonable set of parameters in order to be used in simulation. In the Hydrodynamic module, Manning number (n) is called calibration parameter. Data measurements during 26/2/2009 and 3/3/2009, including water level and flow velocity in chainage (4800 m). At the beginning a simulated value of Manning number (n) (0.02) was used for the Iraqi rivers (Buringh, 1960).

By adjusting the Manning number (n), the simulated water levels become fit with the observed water levels (Figures 2 and 3). After successive trials the Manning's number (n) was adjusted as below. The Manning number (n value) must be 0.03 to obtain the best matching between water level measured and simulated value.

In order to quantitatively assess the accuracy of the MIKE 11 model, the Root Mean Square Errors (RMSEs) between the modeled and measured values of water levels were computed. The results of the error analysis between the modeled and recorded values, illustrated by the Root Mean Square Error values and percentages for each station, defined as follows:

Root Mean Square Error (RMSE) $=\sqrt{\frac{\sum_{i=1}^{N}(Oi-Pi)^2}{N}}$ =0.2m

Coefficient of Efficiency $=1-\frac{\sum_{i=1}^{N}(Oi-Pi)^2}{\sum_{i=1}^{N}(Oi-\bar{O})^2}$ = 0.9

Where *Oi* is the observed value; *Pi* is the model predicted value; $\overline{O}$ is the avarage of the observed values; *N* is the number of observations.

The calibration of the model boundary condition that uses water level at 1/2/2008 to 28/2/2008 and discharge value of 200 m^3/sec, the hydrodynamic factor Manning (n) used is 0.03, indicates that the value lies within the range of Manning number 0.02-0.03 of the flood plain regions (DHI, 2007).

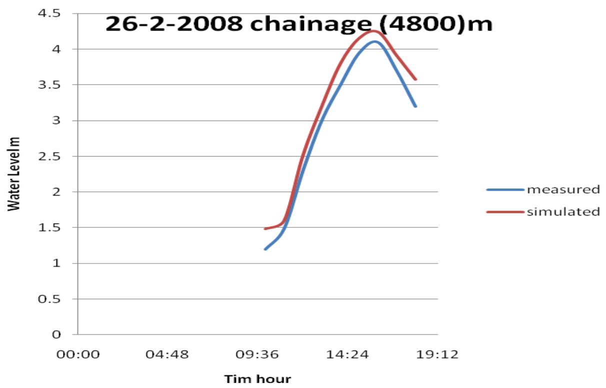

Figure 2. Measured and simulated water level at chainage (4800) m at 26/6/2008.

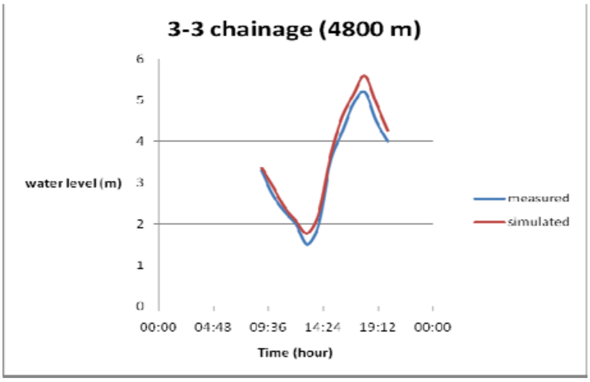

Figure 3. Measured and simulated water level at chainage (4800) m at 3/3/2008.

Case study:

Rehabilitation of the destroyed Barrage structure located on the canal. In this case the canal has been simulated by the existence of controlled barrage on the water, where by being closed in flood tide time and opened at ebb tide.

Results and Discussion

The results of cross section models at chainages 0.0 m and 34331 m at Shatt Al-Basrah Canal are explained in Figures (4) and (5), respectively. Also, the Figures show models of water levels ranges at selected cross sections during simulation period of 30 days. The range of tide was 2.8 m and 4.5 m at chainage 0.0 m and 34331 m, respectively. The water level at the right and left banks were less than that at chainage 0 m. At chainage 34331 m the water level reaches over the right bank 1m, and the left bank 1.2 m.

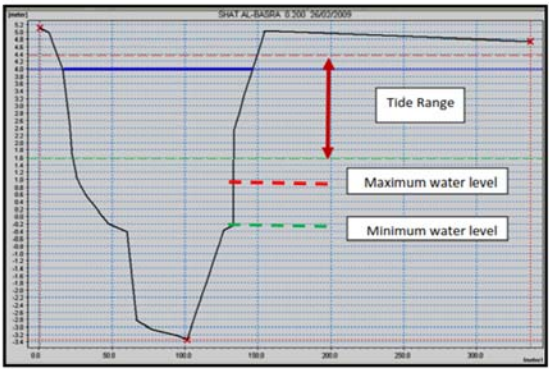

Figure 4. Cross-section model at chainage (0).

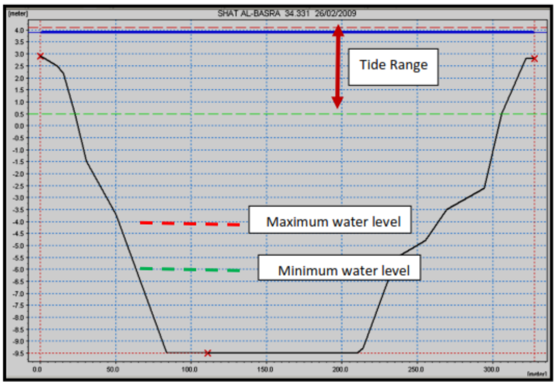

Figure 5. Cross-section model at chainage (34331).

The relationship model between water level and discharge is explained in Figures (6) and (7) of the chainages 0.0 m and 34331 m, respectively. The figures show that at chainage 0.0 m the maximum value of discharge was 203 m^3/s, but the minimum value was 194.3 m^3/s. The maximum value of water level was 4.36 m, the minimum value was 1.5 m. While at chainage 3433 m, the maximum value of discharge was 1400 m^3/s, whereas the minimum value was 24 m^3/s.

Uncertainties affecting hydraulic and hydrological models can be classified as: (1) uncertainties in the input data that drive the model, (2)

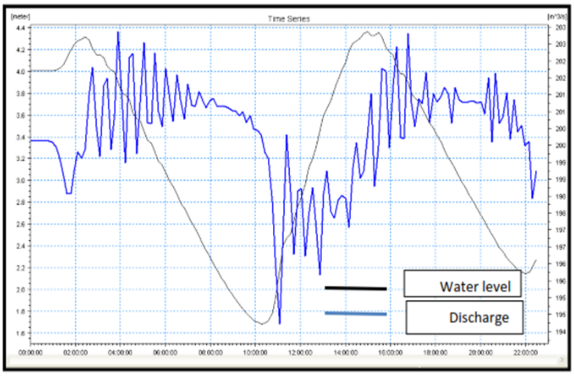

Figure 6. Relationship between time series discharge and water level at chainage (0).

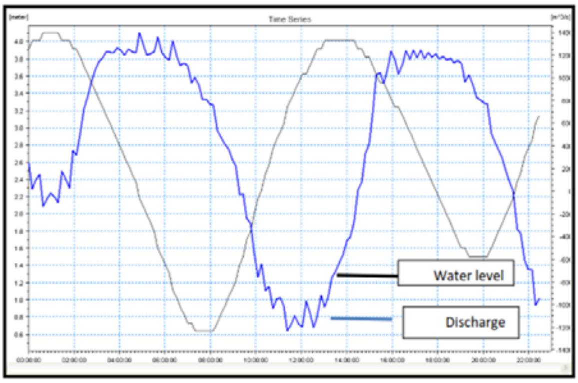

Figure 7. Relationship between time series discharge and water level at chainage (34331).

uncertainties in the data used for calibration, (3) uncertainties in model parameters, and (4) uncertainties related to the model structure and formulation. The last two sources of uncertainties are caused by imperfect representation of the model of the physical processes of interest and by the lack of accurate information about the model parameters used to simulate these processes. The current study investigates some uncertainty aspects that affect the estimation of model parameters during the calibration process of the 1-D model. Amongst the most important parameters in developing hydrodynamic modes are bed roughness coefficients, although such coefficients are linked to physical properties of the modeled river reach, their values have to be determined through a calibration process (DHI, 2007). In general, the aim of the calibration process is to reduce uncertainties in estimating the mode parameters while taking into consideration uncertainties in the data used to drive the mode and in the ability of the model to accurately represent the physical processes of interest (Thiemann *et al.*, 2001). Ideally, model calibration should yield wellidentified parameters with narrow uncertainty ranges. However, since hydrodynamic models are only an approximate description of reality, and because the data used for calibration contain their own errors, estimates of bed roughness coefficients are usually not error-free.

In the present region, the water level fluctuations are influenced by the semi-diurnal tide (Al-Ramadhan, 1986). Field observation and monitoring of water velocities and their directions in the Shatt Al-Basrah canal showed that the flow direction is always to the south of Khor Al-Zubair channel (downstream). In Shatt Al-Basrah canal the time of high water on the banks during the flood tide is a short period. This agrees with (Al-Ramadhan, 1986). The discharge measurements are affected by the water levels and the phase of tide in the Canal. It means that the water velocity, water level, flow direction, and tidal amplitude could be changed. Downstream, the canal is connected with the head of navigational Khor Al-Zubair channel, where it is wide in the south, with a high tidal range. The results are high discharges and increase water velocity in which the high quantity of water could be directed upstream. These quantities are coming from the inlet water during the high tide and pass to Shatt Al-Basrah canal, subsequently causing a reduction in the discharge, and the water level in the canal will rise to overflow the banks in the upstream.

Before the confluence of the Main Output Drain canal and the Shatt Al-Basrah canal, the salinity in the latter is less than that in the lower part of Khor Al-Zubair (Al-Ramadhan, 1986), as the Khor Al-Zubair is influenced by the marine tides and the salinity is 34000 ppm (Al-Mahdi, 1990). This is considered as a lagoon environment. This feature is related to the distribution of fresh water inputs to the canal. Thus, the high discharge of the canal after opening of the Main Drain canal tends to suppress the salinity in the downstream, and the water of this canal become fresher than before. Shatt Al-Basrah canal is controlled by a Barrage which prevents the salt water of Khor Al-Zubair to leak during high tide especially in the spring phase. Simulation period and boundary conditions are presented in Table (1) which explains the deference between the upstream at chainage 0 and downstream at chainage 34331. The water level upstream dose not rises over the two banks at the time when the Barrage is closed. The difference between discharge values is minimum at ebb tide. This is due to the prevention of downstream water by the Barrage to pass in the canal upstream.

Table 1. Values of discharge, water levels and tide ranges at the upstream and downstream for of the Shatt Al-Basrah canal.

Upstream					downstream				
Discharge m^3/sec		Water level m		Tide Range m	Discharge m^3/sec		Water level m		Tide Range m
max	min	max	min		max	min	max	min	
203	194.3	4.36	1.5	2.76	1400	24	4.1	0.5	3.6

Acknowledgements

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تقييم الأثر الهيدروليكي في قناة شط البصرة بسبب الناظم الموجود باستخدام نموذج رياضي احادي Mike 11

قاسم مزعل العيساوي[1]، صادق سالم عبدالله[1] ومقداد حسين الجباري[2]

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المستخلص - قناة شط البصره قناة اصطناعيه بوشر العمل فيها عام 1971 وانتهى عام 1983 ،انشأت لتفادي مياه الفيضان اثناء مواسم الفيضانات، استخدمت القناة كقناة بديله لشط العرب اثناء الحرب العراقيه الايرانيه، ولايصال المياه للاراضي الزراعية في منطقة الزبير وتجهيز مدينة الفو والاراضي الواقعه غرب شط العرب بالمياه. تأثرت نوعية المياه بعدة تغيرات اهمها غلق القناة عن نهر الفرات في منطقة كرمة علي، ويتأثر الجزء الاسفل للقناة بالمد والجزر النصف اليومي للخليج العربي. يوجد ناظم شط البصرة على بعد 22 كم من اعلى القناة الغرض الاساسي منه التحكم بحركة مياه المد والسيطرة على المياه ومنعها من الفيضان على جانبي القناة. تم محاكاة القناة عن طريق التحكم بناظم شط البصره عند اغلاقه في حالة المد الفيضي وفتحه خلال الجزر. اظهرت نتائج المحاكلة بعد معايرتها مع القياسات الحقليه تطابق عالي الدقه وبينت مدى تأثير المد البحري على القناة. كما اظهرت نتائج البحث مدى حساسية تنبؤ الموديل الرياضي في قياسات، منسوب المياه، وحجم المياه، وسرعة جريان الماء، وتصريف الماء، واتجاه التصريف نحو اعلى القناة او اسفلها وتاثير مستوى المد في اي نقطه على القناة عند غلق او فتح الناظم في حالة المد والجزر.