Kufa Journal of Engineering (K.J.E)
ISSN 2207-5528
Vol. 5, Issue 1, Dec., 2013,P.P.141-156
Printed in Iraq

PREDICATION OF SEDIMENT TRANSPORT In Al-ABBASYIA BARRAGE USING THE INVERSE MONITORING METHOD

Lect. Dr. Majid H. Hobi
Construction and Water Resources Department, Collage of Engineering, University of Kufa
majidhamed73@yahoo.com

Abstract

Iraq has the two biggest rivers, Tigris and Euphrates. In the past few years, a considerable level drop in these rivers has been observed due to the reduction in upstream water flow rate. There are many problems concurrent with this drop like the movement of sediment and it's trapped. In recent years, the science of computational fluid dynamics (CFD) has increasingly been used to investigate sediment transport problems in rivers and reservoirs. The current presentation will give examples of our research in this topic. First, the main numerical algorithms for water and sediment flow are briefly introduced. Then, the data from the numerical model are compared with measurements (Verification). The second goal is more oriented towards fundamental research and involves idealized flow downstream barrage. Al Abbasyia barrage was selected as a case study. It is located near Najaf governorate and controlled the discharges toward downstream land. This study present the new technique to predicate the sediment movement and its amount called Inverse Monitoring Method (IMM). The new method was depended on by monitoring the downstream barrage (sediment movement and amount) to find the optimum operation running in upstream. This study divided to two parts, first one was verification the model in this region and second one was predicate the amount of sediment for one year in study reach. The CFD model (**S**imulate **S**ediment Intake in Multi-block option) was used to do this study. This Model is new software produced by The Norwegian University of Science and Technology (Olsen, 2006). Al Abbasyia barrage consist of six radial steel gate. In each time the CFD model was simulated one gate opening or in operation running for one year. That mean it has six cases to simulate the best gate. In this study found the best running gate to reduce the amount of the sediment in upstream was when used gate number four with 7.51×10^4 Ton that mean 28127 m^3 as a volume if taken the field density 2670 kg/m^3 in consideration.

Keywords: Sediment, CFD, IMM, 3D Model , Al Abbasyia Barrage.

الخلاصة

للعراق نهران كبيران هما دجلة والفرات. تعرض هذان النهران في الآونة الاخيرة الى انخفاض حاد في مستويهما. يرافق هذا الانخفاض في المستوى الكثير من المشاكل مثل ظهور الرسوبيات ومشاكل حركة هذه الرسوبيات. ظهرت الكثير من البرامج التي تختص بعلم الجريان الحركي والتي تدعى برامج علم حسابات المائع الحركي (CFD) Computation Fluid Dynamic. ساعدت هذه البرامج في حسابات الجريان وحساب كميات الرسوبيات ودراسة حركتها. سدة العباسية كانت هي المنطقة المختارة لتكون منطقة الدراسة بسبب وجود مشكلة للرسوبيات فيها وهذه السدة تقع قرب محافظة النجف وهي تسيطر على الاطلاقات المائية للمنطقة التي تليها باتجاه الجنوب (الكفل–الشنافية). تحتوي هذه السدة على ستة بوابات قطرية حديدية. بنيت هذه الدراسة على جزأين اولهما تحقيق الموديل الرياضي لمنطقة الدراسة والجزء الثاني هو التنبؤ بكمية الرسوبيات المتولدة من فتح البوابات على عدة مراحل "بوابة واحدة في كل مرحلة ولمدة عام واحد". أستخدمت طريقة جديدة في هذه الدراسة وهي طريقة المتابعة العكسية (IMM) لمتابعة الجريان والرسوبيات. الموديل الرياضي CFD أستخدم كأداة في هذه الدراسة. هذا الموديل انتج من قبل الجامعة النرويجية للعلوم والتكنولوجيا 2006. تم تقديم ستة حالات للبوابات وتم تشغيل بوابة واحدة في كل حالة تمثيل ولمدة عام واحد. النتيجة كانت أن التشغيل الامثل هو للبوابة الرابعة حيث اعطت أعلى قيم من كميات الرسوبيات لمؤخر السدة وهو مؤشر على أكبر كمية عابرة خلال غسيل السدة في مقدم السدة. بقيم أقتربت من 7.51×10^4 طن وهذا ما يعادل 28127 متر مكعب خلال السنة الواحدة اذا ما تم اعتماد الكثافة الحقلية هي 2670 كغم/م^3.

Kufa Journal of Engineering (K.J.E)
ISSN 2207-5528
Vol. 5, Issue 1, Dec., 2013,P.P.141-156
Printed in Iraq

1.Introduction

In the last years the amounts of water start decreasing in Iraq. This decrease was much accelerated, didn't uniform with time but it was clear. The drop in levels of water in most resources of water in Iraq was due to many reasons such as political, economic, inattention in the modern management of water resources in Iraq. All or most Hydraulic structures designed for standard conditions and applied to normal running for discharges and levels. But in real these structures applied for special conditions or drought time for long term. For this reasons the behavior of operations for this structures was changed. The main clear results were sediments and its transports. In Iraq the problem of sediment is one of complex problems.

Many river engineering problems had to be solved through field investigations and laboratory physical models (also called scale models). With recent advancements in computer technology, computational models have been greatly improved and widely applied to solve real-life problems. Sediment transport is among the most complex and least understood processes or phenomena in nature. It is very difficult to find analytical solutions for most problems in river engineering, and it is very tedious to obtain numerical solutions without the help of high-speed computers. Therefore, before 1970s, One-dimensional (1-D) models have been used in short- and long-term simulations of flow and sediment transport processes in rivers, reservoirs, and estuaries. Two-dimensional (2-D) and three-dimensional (3-D) models have been used to predict in more detail the morphodynamic processes under complex flow conditions in curved and braided channels and around river training works, bridge piers, and water intake structures. Physical modeling and computational simulation are the two major tools used in river engineering analysis. Both have their advantages and disadvantages. Physical modeling can provide directly visible results, but it is expensive and time-consuming.

Sediment transport, flow of it's and bed change processes in rivers are very complicated, it is difficult to ensure similarity between a physical model and its prototype. That mean, To solve an engineering problem correctly and effectively, the integration of field investigation, physical modeling, and computational simulation is needed. Field investigation is the first thing to do for a comprehensive understanding of the problem. In Iraq Al-Abbasyia barrage was selected to make this study. In this barrage the operation for running gates was changed due to the drop in levels of water in most rivers in Iraq. These changes in running of gates caused to accumulate of sediment amount downstream time and in upstream barrage other time.

2. Region of Study

The field of sediment transport in Iraq is one of new subjects, so that there are no clear or direct studies on this region to analyze and solve problem of sediment since its inception to the present day, but there are some scattered observations of the river by the project management on the amount of sediment accumulated. Al-Abbasyia barrage was constructed on Kifil-Shanafiyah branch of Euphrates River downstream of Babylon governorate for irrigation purpose since (1982). The barrage controls the flow for the downstream regulator in the middle Euphrates region.

The flood discharge of the barrage is 1000 m^3/sec as designed to this barrage, with a downstream water level at 23.8 m above sea level. The operational discharge range from (50 to 230) m^3/sec with a water level as mentioned in the operational report is 23.5 m above sea level. The barrage contain of six rectangular openings, each with a dimension (12x6.3)m supplied with a steel radial gate. The region of study was 3 km downstream of barrage. Figures 1,2, location of Al-Abbasyia barrage.

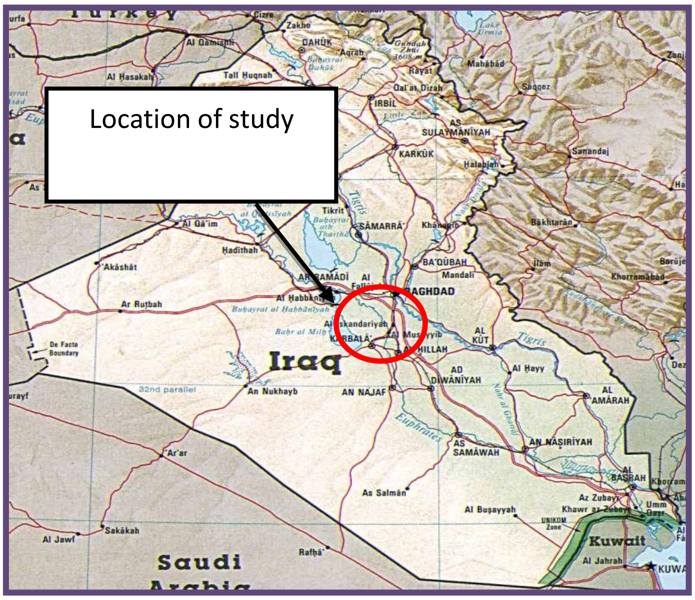

Fig.1 Location of Al-Abassyia Barrage.

Fig.2 The Region of Study, by Google Earth.

The problem in this region it was because the decrease in water levels. This decrease leads to change in the operation running of opening gates. The department of the process of opening the doors has changed, so that there is always open some doors. Laundering

Kufa Journal of Engineering (K.J.E)
ISSN 2207-5528
Vol. 5, Issue 1, Dec., 2013,P.P.141-156
Printed in Iraq

operations in barrage are in turn changed. This study presented operations for these gates to avoid the accumulated of amount sediment in upstream. By downstream it can monitoring the upstream, i.e. with the more accumulated in downstream there are more flashing in upstream. This is new technique used the inverse monitoring for this case. This technique was useful to predicate the amount of sediment in upstream adding to downstream, Figure.3 (Explaining the study and the process in the region), The reasons behind taking downstream not upstream to make this study:

1. That easily to predicate the amount the sediment from constant sources (gates) of sediment discharge.
2. Another reason there are no any constructions in this area “closed system” inversely in upstream there are some constructions like bridge.
3. No uplift forces in the downstream to carry the sediment. In the other side, the flashing was one of most method to remove the accumulative of sediment in the upstream and export problem to downstream.

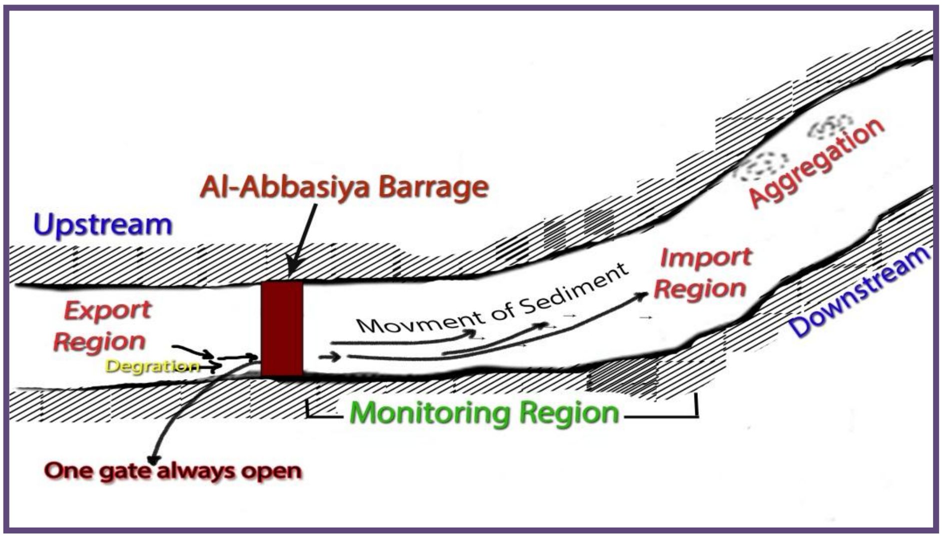

Fig.3 Explaining the Study and the Process in the Region, (not to Scale).

3. Methodology

This study depended on three types of data:

1- Official Data: All data available and presented from the management of barrage to this study such as map of site and specifications of Hydraulic design for this barrage. These specifications were contained also to operation efficiency, prime data for bed level in site and age of barrage.

2- Secondary data: Some of collection data were available in database of this project such as data of monitoring data in barrage (levels, discharges, velocities and locations of these data).

3- Main data: All data in this study. These data is very important to continue with taken the decision about effected the sediment on study region. “Figure. 4, show the methodology of search”.

Kufa Journal of Engineering (K.J.E)
ISSN 2207-5528
Vol. 5, Issue 1, Dec., 2013,P.P.141-156
Printed in Iraq

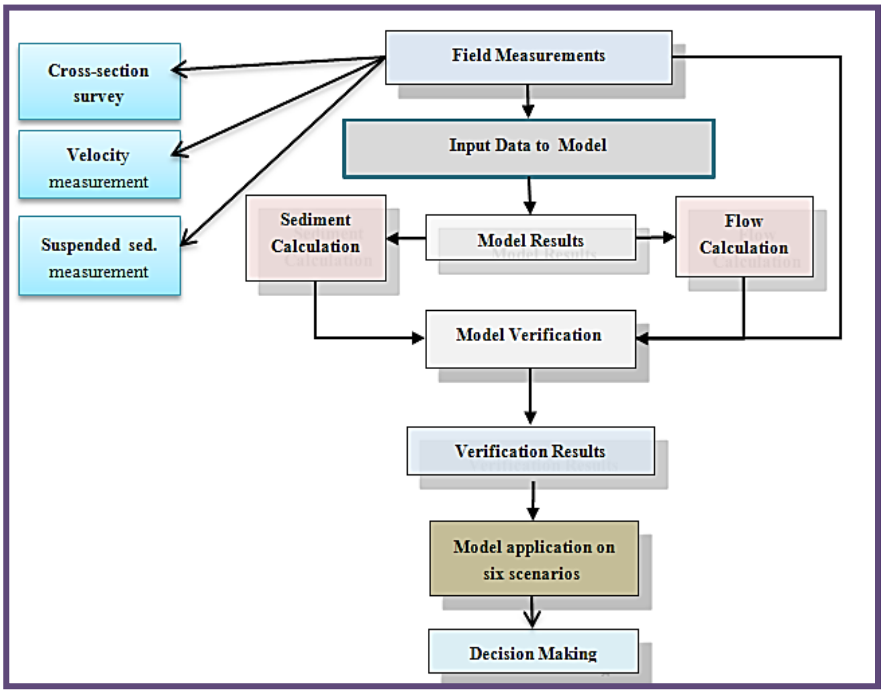

Fig. 4 The Plan of Methodology in this Study.

In this study 10 sections were selected. These sections were located in downstream of barrage. All data given from these sections for make initial case and to make verification for model. The rang of distances between these sections were (150-200)m. (Figure. 5) shown the locations of cross sections in region of study.

The widths of cross sections were ranged between 114 to 171 m as shown in Table1 GPS adapter and theodolite device were used to make these measurements.

Table 1 Width of Cross Sections.

No. of Section	Width (m)
1	127
2	120
3	124
4	133
5	171
6	135
7	127
8	114
9	123
10	122

Kufa Journal of Engineering (K.J.E)
ISSN 2207-5528
Vol. 5, Issue 1, Dec., 2013,P.P.141-156
Printed in Iraq

Fig.5 The Locations of Cross Sections in Study Region.

The wading rod of length (5 m) was used to measure the total depth in the vertical column. The measurement was conducted for one spacing for each cross-section to cover the bed configuration for all sections to enable to draw the mesh for the numerical model. For more accuracy in the final of study had been Acoustic Doppler Current Profiler, ADCP adapter. This device is useful to measure the discharge, velocity and bed elevation. Figure. 6. All data for bed configuration was used as input data to running SSIIM model.

Fig. 6 ADCP Device.

The bed sampling in reach of study was taken for each section. Because the difficult in process of grain size analysis for each sample, in this study some selected samples were taken as consideration. These locations was in the beginning, the middle and in the end of reach. According to the length of region of study, three samples was enough to recovered all reach of study.

Kufa Journal of Engineering (K.J.E)
ISSN 2207-5528
Vol. 5, Issue 1, Dec., 2013,P.P.141-156
Printed in Iraq

The sampling verticals were chosen at 1/4 , ½ and ¾ of the width of stream at each cross-section. This procedure was very convenient and more practical for study reach. It was followed according to (Interagency Committee on Water Resources, 1963). The selection of sampling vertical and horizontal shown in Figure7.

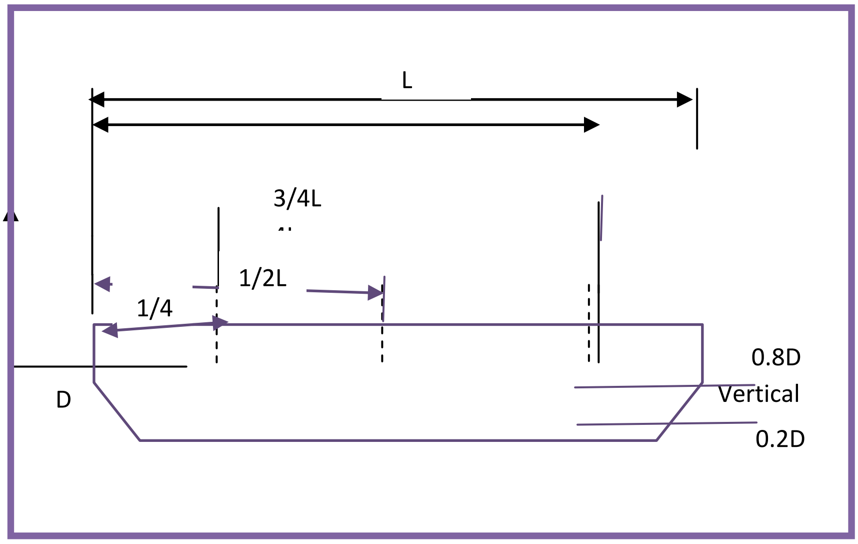

Fig.7 Sampling Method at Vertical and Horizontal Section.

A current meter was used in this study to measure the velocity as shown in Figure 8. Each cross-section was divided to three parts. First at the ¼ of width, second at ½ of width and third at ¾ of width. In each column three measurements were taken at 0.2,0.4 and 0.8 of the depth. The number of all measurements were 180 for one outflow discharge from barrage. The velocity-area principal was used to compute discharge from current-meter data. This method was useful to verify the barrage outflow discharges which ranged from 30-135m^3/sec during the study period. Total discharge was determined by summation of partial discharges. Data are usually determined over a useful range of total discharges.

Fig. 8 : The Current Meter in this Study.

Kufa Journal of Engineering (K.J.E)
ISSN 2207-5528
Vol. 5, Issue 1, Dec., 2013,P.P.141-156
Printed in Iraq

4. The Sampling of Sediment

Transect sampling involves establishing one or more transect lines across a surface. Samples were collected at regular intervals along the transect lines at the surface and/or at one or more given depths. The length of the transect line and the number of samples to be collected determine the spacing between sampling points along the transect. Transect sampling can best be accomplished when surface water bodies are small in size and the sampling locations within the transect grid boundaries are easily accessible. Multiple transect lines may be parallel or non-parallel to one another, or may intersect. If the lines are parallel, the sampling objective is similar to systematic grid sampling. The primary benefit of transect sampling is the ease of establishing and relocating individual transect lines. Transect sampling is applicable to characterizing water flow and contaminant characteristics and contaminant depositional characteristics in sediments, such as distinguishing erosional versus depositional zones. Three-dimensional sampling is similar to systematic sampling. First, the water body is divided along three axes (x, y, z), as opposed to the two horizontal axes in grid sampling. Then, a systematic approach (random or grid) is used to select sampling locations across the surface and at different depth. Three-dimensional sampling is useful in water bodies which exhibit distinct strata with depth but for which few data are available on contaminants and/or contaminant locations. (Hobi, 2010).

5. Verification of Model with Normal Case

The model must be certificated before taken to simulate the amount of sediment in this region. The model was certificated by two ways. First with flow calculations and second with sediment calculations. These two methods are given to this study more confidence to continue with model or not.

6. Flow Calculations and Sediment Verification

If the field measurements or lab measurements are available the calibration test of the model should be made for determining different factors and parameters to be put into the model for later use. In this particular study only some verification tests were made for the model because will used model to predicate the amount the sediment. The first verification was made for the water flow in the river by comparing the result of the field measurements and model. The model has several options to define input files, in numerical parameter menu it is possible to calculate the flow at water level points by interpolating the values at the corner of each grid cells or direct calculating at the middle of the grid cells. In the Table 2 the value of correlation factors for velocities at each section.

Table 2 The Correlation Factors for Model with Velocities and Sediment Concentration.

Cross-sec. No.	1	2	3	4	5	6	7	8	9	10	Aver
Corr. Factor (R^2) velocity	0.957	0.946	0.942	0.913	0.947	0.894	0.885	0.957	0.923	0.951	0.931
Cross-sec. No.	1	2	3	4	5	6	7	8	9	10	Aver.
Corr. Factor (R^2) Sedi. Conc.	0.942	0.920	0.935	0.962	0.963	0.953	0.919	0.943	0.955	0.942	0.943

According to the results from above, Now it can continue to make simulation model. The correlation factors for sediment concentration was more accuracy than correlation factors for velocities. This is because many reasons first, the SSIIM specialized in sediment movement and design for this purpose mainly. Another reason that the current meter used in this study was analog type and this type not like digital one in accuracy option. The deviation between bed configuration in prototype and model was also make this error. There are separate study about the verification of model will present thereinafter. (Hobi, 2010).

7. The Results of Six Scenarios for Operation Gates in Barrage

The Al Abbasyia barrage consist of six radial steel gates. The numbering of gates were from left to right. The influences of discharges between 50-250 m^3/s in the last years. In this model the average of discharge at one year was taken. The discharge was 55 m^3/s.

The 3D numerical model CFD was successfully used to estimate the deposition profiles in a partly vegetated open channel. The running model was presented a six cases of results as shown in Table 3 to Table 8.

Figure 9 illustrates the amount of sediment accumulation per one year for six cases. In this bar chart shown the large amount of sediment transport is coming from gate number four with highest value of sediment accumulation per one year. The bed sediment (Kg/sec) vs. number of section for six cases of gate shown in Figure 10. The calculations were based on the number of gate and the sections as a curves illustrated the drop in values of suspended sediment at section number three and take high value at section number one all that shown in Figure 11. According to the Figures 13 to 15, the flow distributions of velocities, horizontal velocities and selected section at mid and end of study region are deflected towards the outer part of the bend producing two large recirculation zones. Due to the lack of velocity data, the results of the simulation could not be verified; however, the velocity field produced by the CFD model had been tested previously on an intake.

Table 3 The SSIIM Model Results with Gate Number One in Operation.

Cross sec. No.	The total sediment discharge pass (Kg/sec)	The total bed sediment (Kg/sec)	The accumulation of sediment (per1 year) Ton
1	7.555	1.063	8.95×10^{3}
2	7.169	1.052	8.86×10^{3}
3	6.168	1.017	8.57×10^{3}
4	6.812	9.304×10^{-1}	7.84×10^{3}
5	6.401	8.925×10^{-1}	7.52×10^{3}
6	5.885	8.446×10^{-1}	7.11×10^{3}
7	5.444	7.850×10^{-1}	6.61×10^{3}
8	5.496	7.431×10^{-1}	6.26×10^{3}
9	5.148	6.765×10^{-1}	5.70×10^{3}
10	5.010	6.157×10^{-1}	5.19×10^{3}
		Total	$\mathbf{7.26\times10^{4}}$

Kufa Journal of Engineering (K.J.E)
ISSN 2207-5528
Vol. 5, Issue 1, Dec., 2013,P.P.141-156
Printed in Iraq

Table 4 The SSIIM Model Results with Gate Number Two in Operation.

Cross sec. No.	The total sediment discharge pass (Kg/sec)	The total bed sediment (Kg/sec)	The accumulation of sediment (per1 year) Ton
1	7.71	1.09	9.14×10^{3}
2	7.32	1.07	9.05×10^{3}
3	6.30	1.04	8.75×10^{3}
4	6.96	9.50×10^{-1}	8.00×10^{3}
5	6.54	9.11×10^{-1}	7.68×10^{3}
6	6.01	8.62×10^{-1}	7.26×10^{3}
7	5.56	8.01×10^{-1}	6.75×10^{3}
8	5.61	7.59×10^{-1}	6.39×10^{3}
9	5.26	6.91×10^{-1}	5.82×10^{3}
10	5.12	6.29×10^{-1}	5.29×10^{3}
		Total	7.41×10^{4}

Table 5 The SSIIM Model Results with Gate Number Three in Operation.

Cross sec. No.	The total sediment discharge pass (Kg/sec)	The total bed sediment (Kg/sec)	The accumulation of sediment (per1 year) Ton
1	6.46	1.11	9.44×10^{3}
2	7.11	1.10	9.19×10^{3}
3	6.67	1.06	8.96×10^{3}
4	6.15	9.70×10^{-1}	8.53×10^{3}
5	5.70	9.30×10^{-1}	8.11×10^{3}
6	5.74	8.80×10^{-1}	7.24×10^{3}
7	5.37	8.18×10^{-1}	6.16×10^{3}
8	5.23	7.75×10^{-1}	5.93×10^{3}
9	1.10×10^{-1}	7.05×10^{-1}	5.84×10^{3}
10	1.07×10^{-1}	6.42×10^{-1}	5.41×10^{3}
		Total	7.48×10^{4}

Table 6 The SSIIM Model Results with Gate Number Four in Operation.

Cross sec. No.	The total sediment discharge pass (Kg/sec)	The total bed sediment (Kg/sec)	The accumulation of sediment (per1 year) Ton
1	7.40	1.04	9.77×10^{3}
2	7.02	1.03	9.67×10^{3}
3	6.04	9.96×10^{-1}	9.39×10^{3}
4	6.67	9.11×10^{-1}	8.67×10^{3}
5	6.27	8.74×10^{-1}	7.36×10^{3}
6	5.76	8.27×10^{-1}	6.96×10^{3}
7	5.33	7.69×10^{-1}	6.47×10^{3}
8	5.38	7.27×10^{-1}	6.13×10^{3}
9	5.04	6.62×10^{-1}	5.58×10^{3}
10	4.90	6.03×10^{-1}	5.08×10^{3}
		Total	7.51×10^{4}

Table 7 The SSIIM Model Results with Gate Number Five in Operation

Cross sec. No.	The total sediment discharge pass (Kg/sec)	The total bed sediment (Kg/sec)	The accumulation of sediment (per1 year) Ton
1	9.18	2.15	8.95×10^{3}
2	8.76	1.05	8.86×10^{3}
3	7.68	1.02	8.56×10^{3}
4	8.37	9.30×10^{-1}	7.83×10^{3}
5	7.93	8.92×10^{-1}	7.51×10^{3}
6	7.37	8.44×10^{-1}	7.11×10^{3}
7	6.90	7.85×10^{-1}	6.61×10^{3}
8	6.95	7.43×10^{-1}	6.26×10^{3}
9	6.58	6.76×10^{-1}	5.70×10^{3}
10	6.43	6.15×10^{-1}	5.18×10^{3}
		Total	7.26×10^{4}

Kufa Journal of Engineering (K.J.E)
ISSN 2207-5528
Vol. 5, Issue 1, Dec., 2013,P.P.141-156
Printed in Iraq

Table 8 The SSIIM Model Results with Gate Number Six in Operation.

Cross sec. No.	The total sediment discharge pass (Kg/sec)	The total bed sediment (Kg/sec)	The accumulation of sediment (per1 year) Ton
1	6.47	9.31×10^{-1}	7.85×10^{3}
2	6.14	9.22×10^{-1}	7.76×10^{3}
3	5.28	8.91×10^{-1}	7.51×10^{3}
4	5.83	8.15×10^{-1}	6.87×10^{3}
5	5.48	7.82×10^{-1}	6.59×10^{3}
6	5.04	7.40×10^{-1}	6.23×10^{3}
7	4.66	6.88×10^{-1}	5.79×10^{3}
8	4.71	6.51×10^{-1}	5.48×10^{3}
9	4.41	5.93×10^{-1}	4.99×10^{3}
10	4.29	5.39×10^{-1}	4.54×10^{3}
		Total	6.36×10^{4}

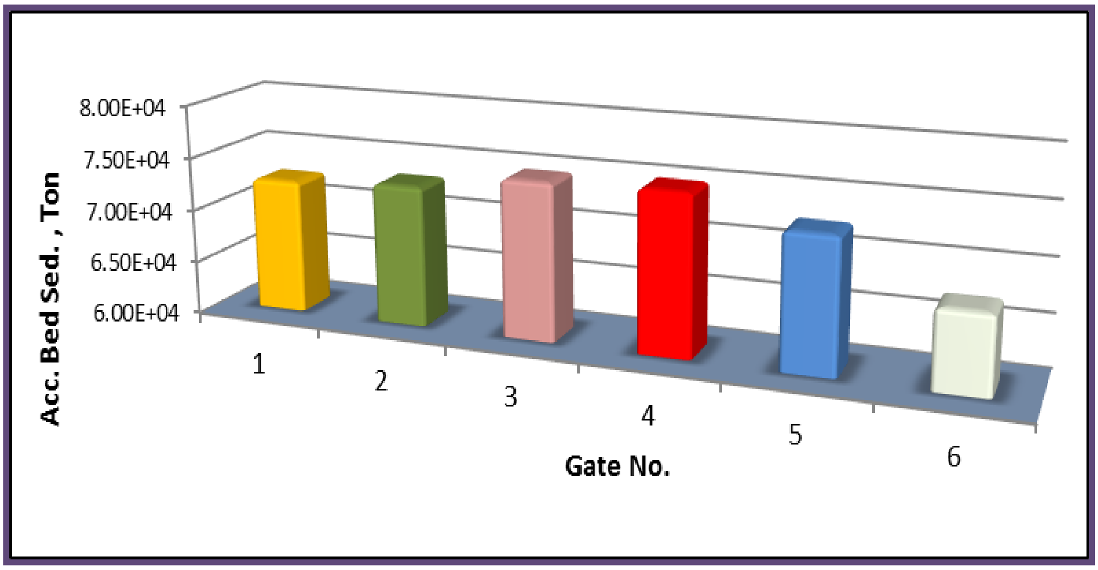

Fig.9 The Amount of Sediment Accumulation per One Year for Six Cases.

Kufa Journal of Engineering (K.J.E)
ISSN 2207-5528
Vol. 5, Issue 1, Dec., 2013,P.P.141-156
Printed in Iraq

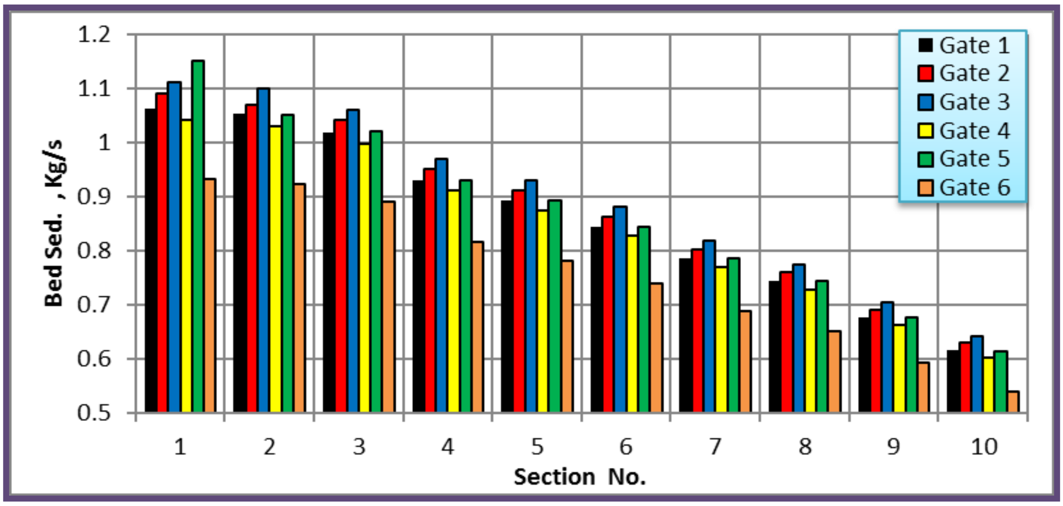

Fig.10 The Amount of Bed Sediment for Six Cases.

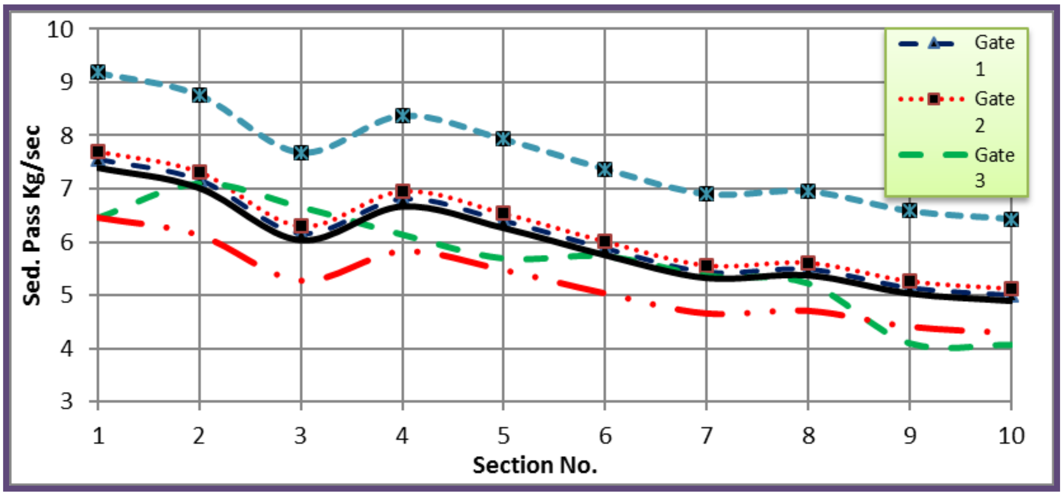

Fig. 11 The Amount of Suspended Sediment Pass for Six Cases.

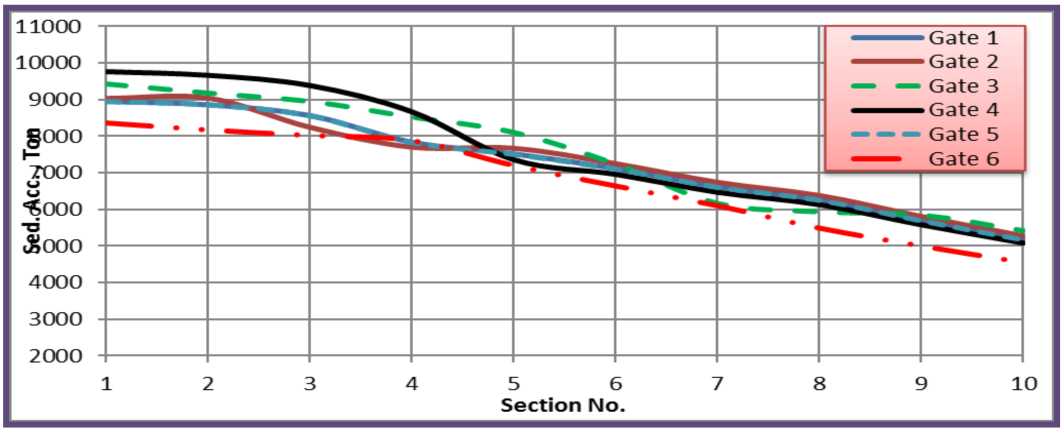

Fig.12 The Amount of Sediment Accumulation per One Year for each. Gate in Six Cases.

Kufa Journal of Engineering (K.J.E)
ISSN 2207-5528
Vol. 5, Issue 1, Dec., 2013,P.P.141-156
Printed in Iraq

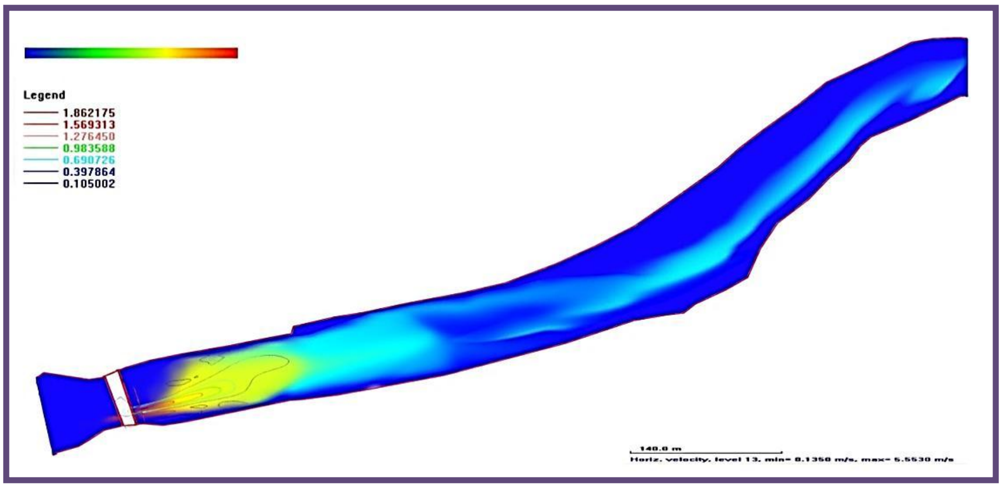

Fig.13 The horizontal Velocity Distributions when Gate No. 1 at Surface Water Level.

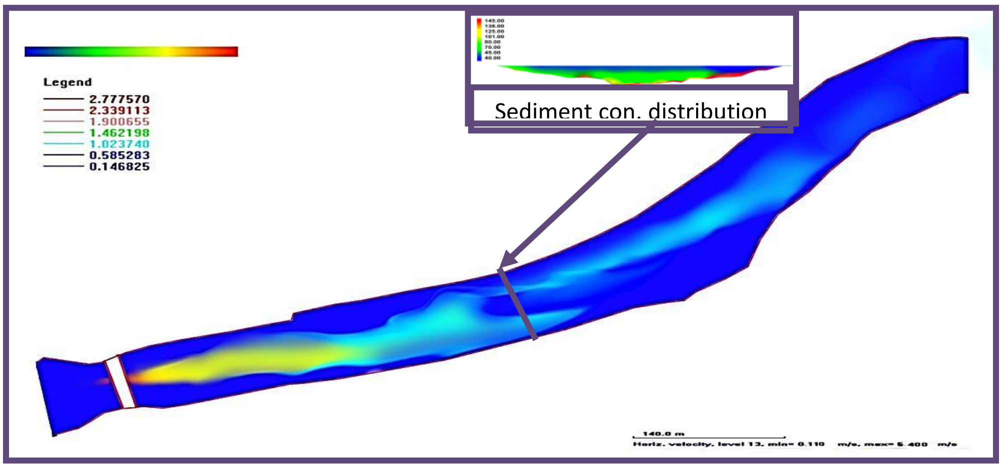

Fig.14 The Horizontal Velocity Distributions when Gate No. 4 at Surface Water Level.

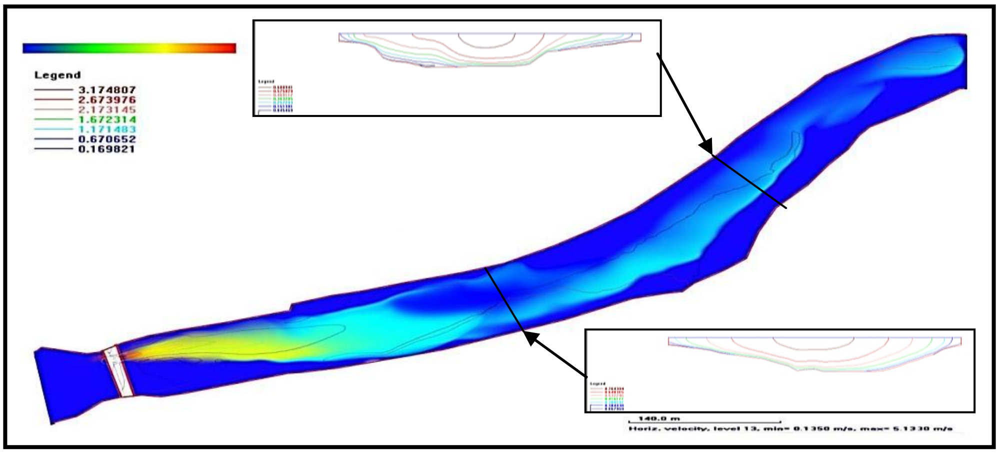

Fig. 15 The Horizontal Velocity Distributions when Gate No. 6 at Surface Water Level and some Selections Sections.

Kufa Journal of Engineering (K.J.E)
ISSN 2207-5528
Vol. 5, Issue 1, Dec., 2013,P.P.141-156
Printed in Iraq

8. Discussion and Conclusion

A three-dimensional numerical model of suspended sediment transport has been proposed. The mathematical model presented the results for six cases of operation running in Al-Abbasyia barrage. The operation running in this barrage was depended on open one gate in each time. This simulate it was same to what happen in this barrage in real life due to the low levels in water. This operation was to avoid the accumulation in sediment amount in upstream. The operations of running of this barrage was not completely analysis with the sides effects and it was depended on field visions only from management barrage.

The model given results for the optimum running for this barrage in two situations. First one it was when opening gate number four to remove the maximum amount of sediment in upstream i.e. the beset case to remove the sediment upstream of barrage. Second it was when opening gate number six to remove the maximum amount of sediment to downstream of barrage. The two cases it must be used if the decrease level of river and if there are not enough of discharge to opening more of one gate.

The running gate number four achieved the perfect running. This lead to search behind the reasons to outing this results:

1- The gate number four is located in near middle the body of barrage. This is help to pass the largest amount of suspended sediment.
2- No boundaries are discouraging the flow if gate number four in running. This is because the distances between the position of gate and the banks. The banks doing as trapped region is study reach. This trapped not allowed to crosses more of sediment. The Model showed the behavior of flow in this region.
3- The gate number four located on the shortest way to arriving the middle of river (locate of max. velocity). The act of velocity as enough uplift forces for the particles of sand in the river.
4- The topography of bed and its configuration caused these results.

In addition, it can be see the regime of study region that the barrage is built on it. This region contain some bends in study area (Figure. 3). The affection of this bends was by reduction the values of velocity distribution on the inside bank in this bend. (See Figures 13 and 15). In all cases (scenarios) the discharges of suspended sediment load were ranged between 7.555 kg/sec to 5.010 kg/sec where gate number one in running. In the gate number six the discharges of suspended sediment load were ranged between 6.47 kg/sec to 4.29 kg/sec on all sections at long the study reach. This given indicating the gate number six it's the best one in the inverse case. i.e the best running gate to reduce the amount of sediment in downstream of barrage.

The model given more useful tools to predicate the velocity distributions and sediment (suspended load and bed load) distributions. The predication for sediment and velocity in any region help the engineer to make good decisions for more things. The model contain more thirty one variables and it can see the effect of these variables on region at any time. These attributes not found in any CFD model. These variables were velocity vectors, horizontal velocity, vertical velocity, pressure,…..etc. (see Figure. 16).

Kufa Journal of Engineering (K.J.E)
ISSN 2207-5528
Vol. 5, Issue 1, Dec., 2013,P.P.141-156
Printed in Iraq

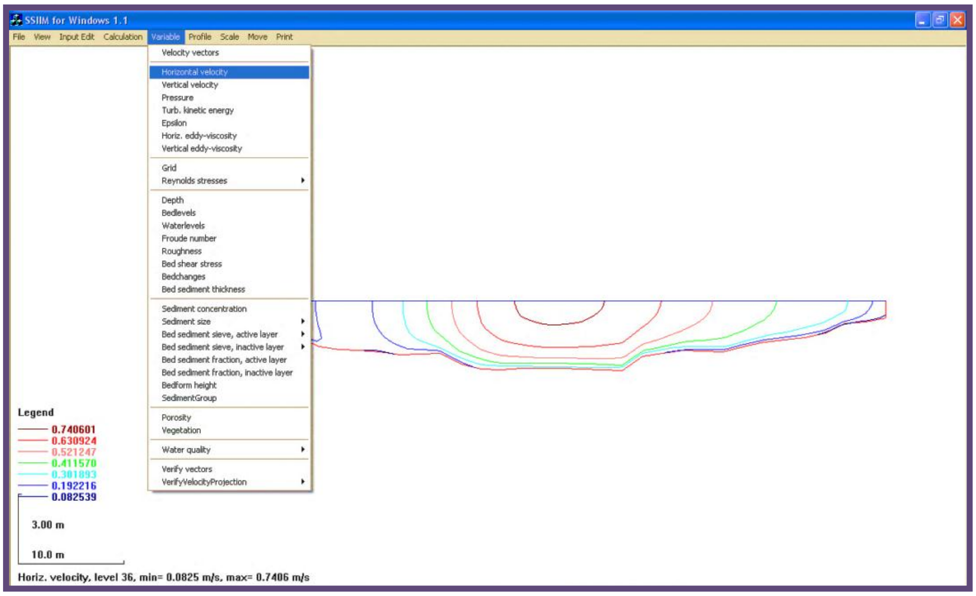

Fig. 16 The Interface of SSIIM Model in Running and its Variables.

References

Dyer KR (ed), (1979) "Estuarine hydrography and sedimentation". Cambridge University, Press, Cambridge.

Farnworth EG (1979) "Impact of sediment and nutrients on biota in surface water of the United States". United states environmental protection agency, Georgia, USA.

Håkanson L, Jansson M (1983) "Principles of Lake Sedimentology". Springer-Verlag,

Hobi, M. H., (2010), Thesis, "Three Dimensional Model of Sediment transport Downstream Kuffa Barrage on Euphrates River", University of Technology, Iraq.

Howard-Williams C, (1989) "Cycling and retention of nitrogen and phosphorous in wetlands: A theoretical and applied perspective". Freshwater Biology Vol. 15 No.4 pp391-431.

Olsen, N. R., (2006), "A Three-Dimensional Numerical Model For Simulation Of Sediment Movements In Water Intakes With Multiblock Option ", The Norwegian University of Science and Technology.

Sly PG (1978) "Sedimentary processes in lakes: chemistry, geology, physics. Springer", Berlin Heidelberg New York, pp 65-89.

Weiming, Wu, (2008), "Computational River Dynamics", National Center for Computational Hydroscience and Engineering, University of Mississippi, MS, USA, Taylor & Francis group, London, UK.

Wetzel R.G. (1983) "Limnology (2nd Edition) ". Saunders College Publishing, USA, 858PP.