Evaluation of the Hydraulic Performance Indicators for Al-Ibrahim Irrigation Canal in the South of Iraq

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ABSTRACT
This study was concerned for steady flow in open canals of different flow conditions that may exist in irrigation system. To achieve this objective, AL-Ibrahim Canal Located South of Iraq has been selected from numerous irrigation systems having deficiencies between demand requirements and actual supply, due to a problematic of distribution and management. The field works consists the measurements of stages at outlets, at upstream, and at downstream head regulators .The study adopted nineteen actual cases of discharge along six months, two or more measurements at each month during the study period, between November 2013 to April 2014.The main objectives of the present study are; analysis the actual operation of irrigation canal and evaluated indicators then the HEC-RAS model was applied to achieve these objectives. The max. stage and discharges measurements at head regulator during the study period was 4.415 m^3/sec at Jan.2014,where it less than a target discharge , so the outlets along canal should not be operated at the same time especially if the gate of the outlets are fully opened , because for entire operation numerous outlets will take discharge higher than the target. The study has shown that it doesn't operate the channel and access to the standard of performance but several scenarios have been prepared depending on the discharge at head regulator.

Keywords: Discharge Measurements, Delivery Performance Ratio (DPR), Discharge Deviation. (ΔQ), Flexibility (F).

تحليل مؤشرات الأداء لقناة شط آل أبراهيم الأروائية جنوب العراق

الخلاصة
تهتم هذه الدراسة بالجريان الثابت في القنوات المفتوحة وحسب الشروط المختلفة للجريان في منظومات الري.ولتحقيق هذا الهدف تم اختيار قناة ري ال إبراهيم في جنوب العراق من بين العديد من منظومات الري والتي تعاني عجزا في متطلبات الري مقارنة مع المجهز الفعلي وذلك بسبب مشاكل التوزيع والإدارة للمياه. تمت الأعمال الحقلية بأجراء تسعة عشر حالة قياس فعلية لمناسيب المياه والتصريف في ناظم الصدر والمنافذ الحقلية وعلى مدار ستة أشهر ولمواسم زراعية مختلفة للفترة من شهر تشرين الثاني لعام ٢٠١٣ ولغاية شهر نيسان من العام ٢٠١٤ وبمعدل حالتين أو أكثر لكل شهر.الأهداف الرئيسية لهذه الدراسة هي تحليل التشغيل الفعلي للقناة وتقييم مؤشرات الأداء وتطبيق نموذج هيدروليكي باستخدام برنامج (HEC-RAS).وبينت الدراسة أن أعلى تصريف مسجل لناظم الصدر خلال فترة الدراسة كان بمقدار ٤.٤١٥ م^3/ثانية في شهر كانون الثاني من العام ٢٠١٤. وهو اقل من التصريف المطلوب، لذلك فان المنافذ الحقلية الموزعة على طول القناة لايمكن تشغيلها في وقت واحد إذا كانت بواباتها مفتوحة بالكامل لان بعض

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المنافذ الحقلية سوف تأخذ تصريف أكثر مما هو مطلوب . بينت الدراسة انه لايمكن تشغيل القناة والوصول إلى الموشرات القياسية للأداء ألا من خلال سيناريوهات محددة تم إعدادها اعتمادا على التصريف عند ناظم الصدر.

INTRODUCTION

Water resources management is an important issue in Iraq, because the water supplies become scarcer due to rapid growth in water demands, weakness in planning and implementation of relevant sector. Whenever the water available is less than the expected amount or the irrigation water requirements exceed the availability, the water shortage takes place even in the irrigated area, thus planning should be based on the sound of scientific findings in order to optimize and conserve the precious land and water resources.

More beneficial of irrigation water allocation need a good evaluation of irrigation water demand, cropping pattern, designated area and project head operation. Best irrigation management supported by realistic analysis techniques during drought season will help to make the right choice with respect to management aspect. The mismatch between the supply and demand, inequitable distribution and the over irrigation of water consuming crops are the main constraints that are faced in implementation of the best irrigation water management (Awadi, A. T, 2013).

The absence of; interaction database management, good economic planning tools options for selecting crop patterns and present water consumption lead to more losses in water irrigation project. Generally, almost irrigation projects in Iraq are suffering all of these problems.

Al-Ibrahim Irrigation Canal in the province of Thi-Qar is one of the most important irrigation projects in the south region of Iraq, which reflects the weakness default, and lack of knowledge of management, of irrigation during the drought season. Therefore, it was chosen as a case study. The main problems that have been faced in the study area could be clarified by the following:

- The stage and discharges measurements at head regulator during the study period are less than target discharge so the outlets along canal doesn't operated at the same time especially for fully opening it will take a discharge greater than the desired discharge .
- Unsuitable planning tools for selecting crop patterns area during the drought season according to water and land availability, also there is no consideration for the maximum net benefit according to selected crop patterns area and the economic value of water, in spite of limited availability of water resources.
- There is no evaluation for the present state of crop pattern (present state of agriculture area in the project) and its water irrigation demand at the head of project.
- There is no estimation for the excess or deficit water irrigation used for present agriculture pattern according to available discharge that released from the head regulator.
- Poor management in the project due to lack of an efficient database, misunderstanding between the directorates of Water Resources and the Agriculture in the study area and unavailability of easily technical reports for decision makers.

The main objectives of the present study are analysis the actual operation of irrigation canal and evaluate indicators (Delivery Performance Ratio(DPR), Discharge Deviation.(ΔQ), Flexibility(F)).The HEC-RAS model was applied to achieve these objectives.

Case of study.

Al-Ibrahim Irrigation Canal, located south of Iraq. Its stream path from Gharraf city to the Saiddekhel city .The total length is 38km (st.38+00) the present study is restricted up to station 4+00.Along st.0+00 to st.4+00, the project includes 12 outlets (offtakes) sluice gates are used in all structure for controlling water level (Figure1) .The irrigated area by the Al-Ibrahim canal from st.0+00 to st. 4+00 is 1000 hectares, it lies within the boundaries of Gharraf and Saiddekhel cities. The design geometric and hydraulic data of Al-Ibrahim canal with its structures and command area was taken from irrigation Management Office of Thi-qar province. The data include; design discharge; design water level; canal cross-sections; and offtakes geometrical and hydraulic data. Table (1) illustrates a summary of the design data. A description for the head regulator of Al-Ibrahim canal is briefly presented herein based on the geometric and hydraulic design data. A regulator consists of two squares in cross section 2m x 2m opening with 8m in length. The sluice gates are used for flow regulation. The maximum discharge was $8m^3/s$ and target discharge was $5m^3/sec$.

Table (1). Summary of the design Data of Al-Ibrahim Irrigation Project.(Irrigation Management offices of Thi-qar provines,2013)

outlets No.	distance from head reg.	area(CCA) (dounms)	bed width (m)	bed level (m)	pipe crest level (m)	Pipe.dia (m)	Water level (m)	$Q_{des.}$ (m^3/sec)	velocity channel (m/s)	bed slop (S)
1 L	1100	170	2.8	4.88	5.770	0.25	6.159	0.021	0.58	0.0001
2 L	1200	204	2.8	4.87	5.741	0.25	6.149	0.026	0.58	0.0001
3 L	1500	386	2.8	4.84	5.625	0.25	6.110	0.048	0.58	0.0001
4 L	1700	134	2.8	4.82	5.720	0.25	6.088	0.017	0.58	0.0001
5 L	1800	658	2.8	4.81	5.501	0.25	6.074	0.082	0.58	0.0001
6 L	1900	1280	2.8	4.8	5.333	0.4	6.053	0.160	0.58	0.0001
7 L	2000	467	2.8	4.79	5.524	0.25	6.037	0.058	0.58	0.0001
8 L	2400	125	2.8	4.71	5.592	0.25	5.920	0.011	0.57	0.0001
9 L	2800	80	2.8	4.69	5.599	0.25	5.954	0.016	0.57	0.0001
10 L	3000	180	2.8	4.63	5.463	0.25	5.928	0.010	0.57	0.0001
11 R	3600	210	2.8	4.59	5.407	0.25	5.857	0.023	0.57	0.0001
12 L	4000	230	2.8	4.55	5.335	0.25	5.817	0.026	0.57	0.0001

Analysis the actual operation.

Discharge Measurements

Set of nineteen stage measurements, two or more measurements at each month during the study period; between November 2013 to April 2014, has been carried out at head regulator. However, the difference in head between supply canal at upstream and at downstream for each outlet undertaken were measured. All these measurement where done using measuring scale installed at upstream and downstream for head regulator and difference in water level between upstream and downstream at each outlet. For free flow offtake (semi-modular outlet), the head measured from center of pipe to full water level in supply canal at a time of measurement.

The discharges measurements of head regulator during the study period was done after of taking the difference in staff reading located at upstream and downstream. The difference in reading is the total head that lost across the regulator. However mathematically, the head loss also calculated by the following equation:

$$H_L=(K_1+K_2\frac{2gn^2L}{R^{4/3}})\left(\frac{V^2}{2g}\right) \quad \text{..... (1)}$$

Where;

H_L the total head loss, K_1 and K_2 is the entrance and exit loss coefficient ,respectively, R is the hydraulic radius, n is the manning's coefficient, L is the length of regulator barrel, and V is the velocity a across the regulator . From, related text references K_1 and K_2 were taken equal to 0.16 and 1, respectively (Normann et.al. 1985. The velocity of flow was then calculated from continuity equation the discharge corresponding to each measurement was calculated. The list of mean monthly discharge during a study period and the percentage of mean actual monthly discharge relative to design or target discharge ($Q_{des.}=5m^3/s$) is listed in Table (2).

Table (2). Summary of the mean monthly discharge of the study area at head regulator.

Time, month	actual mean monthly discharge(m^3/sec)	actual mean monthly discharge relative to a design in %
Nov-2013	3.762	75
Dec-2013	3.948	78
Jan-2014	4.415	88
Feb-2014	3.947	79
Mar-2014	3.073	61
Apr-2014	3.621	72

However, the discharge calculated for outlets was based on head measurements via related deterministic formula have been selected according to hydraulic modules of outlets (i.e.; non-modular or semi-modular outlet).The authors refer to, R.K. Sharma et.al, 2008, for background details about the type, hydraulic modules, and related formulas for discharge calculation. Also, many text of irrigation engineering address this problem. Thereby, according to the measurements at outlet along a study reach of Al-Ibrahim canal during a period undertaken the measured discharge are shown in Table (3)

Table (3). Summary of the mean actual monthly outlets discharge of the study area.

outlets No.	distance from head Reg.	Mean monthly discharge at outlets in m^3/sec					
		Nov.2013	Dec.2013	Jan.2014	Feb.2014	Mar.2014	Apr.2014
1 L	1100	0.015	0.030	0.045	0.017	0.074	0.031
2 L	1200	0.040	0.069	0.042	0.021	0.076	0.032
3 L	1500	0.017	0.041	0.042	0.021	0.086	0.032
4 L	1700	0.015	0.018	0.038	0.000	0.037	0.035
5 L	1800	0.015	0.024	0.063	0.076	0.096	0.033
6 L	1900	0.027	0.082	0.168	0.203	0.278	0.000
7 L	2000	0.031	0.072	0.062	0.040	0.090	0.049
8 L	2400	0.026	0.042	0.056	0.036	0.063	0.042
9 L	2800	0.072	0.023	0.062	0.050	0.070	0.017
10 L	3000	0.064	0.085	0.046	0.037	0.040	0.012
11 R	3600	0.060	0.062	0.006	0.030	0.051	0.014
12 L	4000	0.066	0.049	0.048	0.038	0.090	0.036

Analysis of indicators.

- Delivery performance ratio (DPR).

The simplest, and probably the most important, operational performance indicator is the Delivery Performance Ratio (DPR) (Clemmens and Dedrick, 1984; Clemmens and Bos, 1990; Molden and Gates, 1990; Bos et al., 1991). The average monthly measured discharge for each outlet have been compared with intended (design) discharge by the form of Eq. (2) to get the DPR see Table(4).

As this ratio increase above unity that is mean the outlet deliver more than the intended discharge and a reveres situation occur when the DPR value become less than unity. The discrete a performance type with number of outlet for each month of study period is well listed in Table (5).The performance of outlet considered excessive when the DPR values exceed 0.9 but could be considered at an adequacy performance if not greater than 1.15.While when DPR drop to values less than 0.9 the performance of outlet classified as in adequacy (Wahaj, 1995). Twelve outlets are located between st.0+00 and st.4+00 is. As can be seen from Table (5) the less adequacy and the larger excessive performance at Mar.2014.

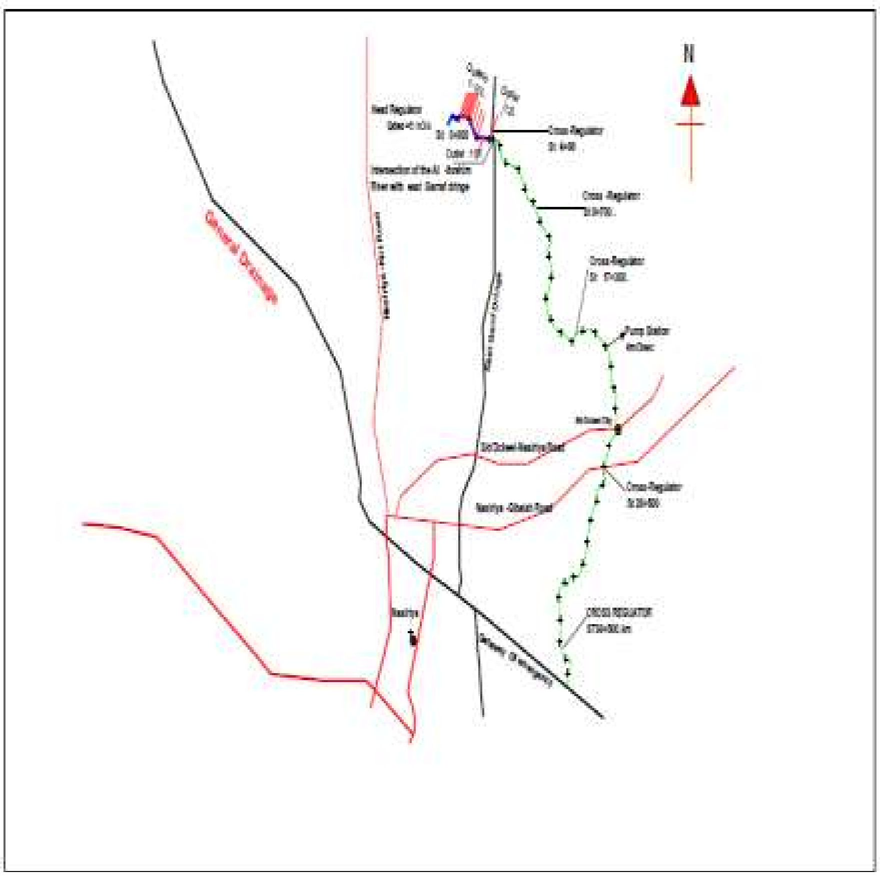

Figure (1) Geographical Location for AL-Ibraheam Project

Table (4). Summary of the measured indicators of study area (Nov-2013 to Apr.2014).

Time, month	Indicators	Outlet No.											
		1 L	2 L	3 L	4 L	5 L	6 L	7 L	8 L	9 L	10 L	11 R	12 L
Nov-2013	DPR	0.71	1.58	0.35	0.91	0.18	0.17	0.54	2.38	4.63	6.36	2.65	2.53
	ΔQ	-0.29	0.58	-0.65	-0.09	-0.82	-0.83	-0.46	1.38	3.63	5.36	1.65	1.53
Dec-2013	DPR	1.41	2.71	0.85	1.06	0.29	0.51	1.23	3.88	1.48	8.45	2.74	1.85
	ΔQ	0.41	1.71	-0.15	0.06	-0.71	-0.49	0.23	2.88	0.48	7.45	1.74	0.85
Jan-2014	DPR	2.13	1.64	0.87	2.28	0.77	1.05	1.06	5.18	3.99	4.60	0.29	1.83
	ΔQ	1.13	0.64	-0.13	1.28	-0.23	0.05	0.06	4.18	2.99	3.60	-0.71	0.83
Feb-2014	DPR	0.80	0.81	0.43	2.03	0.93	1.27	0.68	3.28	3.18	3.65	1.31	1.44
	ΔQ	-0.20	-0.19	-0.57	1.03	-0.07	0.27	-0.32	2.28	2.18	2.65	0.31	0.44
Mar-2014	DPR	3.48	2.99	1.79	2.93	1.17	1.74	1.54	5.75	4.46	4.02	2.27	3.41
	ΔQ	2.48	1.99	0.79	1.93	0.17	0.74	0.54	4.75	3.46	3.02	1.27	2.41
Apr-2014	DPR	1.45	1.25	0.67	2.07	0.40	0.00	0.85	3.84	1.11	1.16	0.61	1.36
	ΔQ	0.45	0.25	-0.33	1.07	-0.60	-1.00	-0.15	2.84	0.11	0.16	-0.39	0.36

Table (5). Summary discrete a performance type with number of outlet for each month of study period (DPR).

Time, month	No. of outlets at performance related to DPR		
	excessive	adequate	inadequate
Nov-2013	6	1	5
Dec-2013	8	1	3
Jan-2014	7	2	3
Feb-2014	7	1	4
Mar-2014	12	0	0
Apr-2014	6	1	5

Discharge Deviation. (ΔQ).

Percentage of discharge deviation in outlets is assessed as:

$$\frac{\quad}{\quad} \text{x}100 \qquad . ..(3)$$

In which Q_1 is the target discharge (m^3/s), Q_2 is the discharge after the change in the gate opening at a location (m^3/s) and ΔQ is the percentage of deviation in the discharge at a location (%). Molden and Gates, 1990 see Table (4). Perform that the outlets is considered good if ΔQ restricted within ±10% of the target discharge ,which is the criterion used by the Irrigation Department (Government of North West Frontier Province (NWFP), 1992).However the indicator recommended by Murray-Rust and Halsema,1998,were within ±30%, outer this, the performance of an outlet was considered unacceptable. The discrete a performance type with number of outlet for each month of study period is listed in Table (6).According to the above limitation Table (6) shows that the greater unacceptable performance were at Mar.2014, whereas the good was recorded at Jan.2014.This can be attributed to, at Jan.2014 the discharge that delivered by head regulator where its percent to the design discharge is 88%. According to this deficit or excess in flow rate the outlets was rested near an acceptable performance.

Table (6). Summary discrete a performance type with number of outlet for each month of study period (ΔQ).

Time, month	No.of outlets at performance related to ΔQ.		
	good	Possible use	unacceptable
Nov-2013	1	2	9
Dec-2013	1	2	9
Jan-2014	2	2	8
Feb-2014	1	3	8
Mar-2014	0	1	11
Apr-2014	0	4	8

Flexibility (F).

The proportionality indicator often named hydraulic flexibility aims to characterize the relative variations of discharge in the dependent and parent canals. This indicator has usually been referred to as "flexibility", and is well adapted to structured systems. (Ankum; 1993; Essen, van der Feltz, 1992).The flexibility (F) calculated using the equation (4) see Table (7).

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Where; y is a depth of flow at supply channel, H is the available head for outlet, and — is outlet index/channel index.

The outlet will be proportional when F=1, so for proportional outlet (i.e., the rate of change of outlet discharge equals the rate of change of supply discharge), Eq. (4) will take the form; – = – .The outlet said to be Hyper-proportional if its flexibility is greater than unity then; – < – .And the outlet is considered operated as Sub- proportional when its flexibility is less than unity, thus; – > – .

The proportionality between – and – referred to the setting indicators of outlet. Generally m=0.5 for pipe outlet(i.e,full flow like orifice),m=1.5 for weir type outlet(i.e, flow entering the outlet like overflow over weir crest),and n=5/3 for a trapezoidal channel.(Santosh Kumar Garg,2012;Madan Mohan Das,2009; R.K.Sharma,2008;Ankum,1993; Essen, van der Feltz, 1992; Hart,1996; Shanan, 1992 and Horst, 1998).When measured water level at outlets along main canal during the study period according to his condition at the time of measurement. The resultant of proportionality between – and – discrete a performance type with each outlet for each month of study period is well listed in Table(8).According to the limitation as referred above, the greater percentage of sub-proportional flexibility were at all months ,whereas the less percentage of sub-proportional flexibility was at Mar.2014.This can be attributed to, at Mar.2014 the less discharge was delivered by head regulator where its percent to the design discharge is 61%.Then according to this deficit in flow rate the outlets was rested near hyper-proportional flexibility. However, in all cases, there is no proportionality recorded along the study period as can be seen from Table (8).

Table (7).Summary of the measured flexibility for outlets of study area. (Nov.2013 to Apr.2014)

Time, month	Date	Outlet No.											
		1 L	2 L	3 L	4 L	5 L	6 L	7 L	8 L	9 L	10 L	11 R	12 L
Nov-2013	9-11-2013	0.58	0.57	0.52	0.59	0.48	0.44	0.53	0.64	0.68	0.62	0.61	0.58
	15-11-2013	0.80	0.77	0.67	0.82	0.58	0.48	0.62	0.79	0.81	0.72	0.71	0.67
	22-11-2013	0.91	0.87	0.73	0.93	0.63	0.50	0.67	0.89	0.92	0.81	0.79	0.73
Dec-2013	5-12-2013	0.78	0.75	0.65	0.79	0.57	0.47	0.61	0.77	0.79	0.71	0.69	0.65
	13-12-2013	0.73	0.71	0.63	0.75	0.55	0.46	0.59	0.72	0.74	0.67	0.66	0.63
	20-12-2013	0.64	0.63	0.57	0.65	0.51	0.44	0.53	0.64	0.65	0.60	0.59	0.57
	28-12-2013	0.73	0.71	0.63	0.75	0.55	0.46	0.59	0.72	0.74	0.67	0.66	0.63
Jan-2014	15-1-2014	0.54	0.53	0.49	0.54	0.46	0.41	0.47	0.54	0.54	0.51	0.51	0.49
	30-1-2014	0.62	0.61	0.55	0.63	0.50	0.43	0.52	0.61	0.63	0.58	0.57	0.55
Feb-2014	10-2-2014	0.92	0.88	2.22	0.94	0.63	0.50	0.67	0.90	0.68	0.81	0.80	0.74
	14-2-2014	0.58	0.57	0.52	0.59	0.48	0.42	0.50	0.58	0.59	0.55	0.54	0.52
	28-2-2014	0.67	0.65	0.58	0.68	0.52	0.45	0.55	0.66	0.68	0.62	0.61	0.58
Mar-2014	7-3-2014	1.25	1.17	0.91	1.29	0.73	0.55	0.80	1.21	1.26	1.04	1.01	0.96
	14-3-2014	1.16	1.09	0.87	1.20	0.71	0.54	0.77	1.43	1.67	1.40	1.67	1.37
	21-3-2014	1.20	1.13	0.89	1.24	0.72	0.57	0.85	1.36	1.21	3.57	3.27	1.82
Apr-2014	15-1-2014	0.98	0.94	0.78	1.03	0.65	0.51	0.71	0.98	1.01	0.87	0.85	0.78
	30-1-2014	0.90	0.86	0.73	0.92	0.62	0.50	0.67	0.89	0.92	0.81	0.79	0.73
	10-2-2014	0.67	0.65	0.58	0.68	0.52	0.45	0.55	0.66	0.68	0.62	0.61	0.59
	14-2-2014	0.70	0.68	0.60	0.71	0.54	0.46	0.57	0.69	0.71	0.65	0.64	0.61

Table (8). Summary discrete a performance type with number of outlet for each month of study period (F)

Time, month	Date	No.of outlets at performance related to F.		
		sub-proportional	proportional	hyper-proportional
Nov-2013	9-11-2013	12	-	-
	15-11-2013	12	-	-
	22-11-2013	12	-	-
Dec-2013	5-12-2013	12	-	-
	13-12-2013	12	-	-
	20-12-2013	12	-	-
	28-12-2013	12	-	-
Jan-2014	15-1-2014	12	-	-
	30-1-2014	12	-	-
Feb-2014	10-2-2014	12	-	-
	14-2-2014	12	-	-
	28-2-2014	11	-	1
Mar-2014	7-3-2014	4	-	8
	14-3-2014	4	-	8
	21-3-2014	5	-	7
Apr-2014	15-1-2014	12	-	-
	30-1-2014	12	-	-
	10-2-2014	12	-	-
	14-2-2014	10	-	2

HEC-RAS model.

The model of operation and efficient hydraulic management scenario is a subject of this paper. The HEC-RAS software was used for analysis the problem and presented a more efficient scenario. Generally, the focus of this paper is on the performed model calibration which is to document inputs and assumptions used in the development of Al-Ibrahim canal via HEC-RAS software for several scenarios concerning with the description of operation optimized for project. The data required to develop a steady flow hydraulic model, includes all design information about layout, cross section, discharges stages related structures and its facilities, are taken from Ministry of Water Resources, State Commission on Operation of Irrigation and Drainage Projects-Thi-Qar. However the measurements of stages at different times have been carried out at head regulator, and at all outlets along reach undertaken. From these data, the models were than prepared using HEC-RAS at a steady state. One dimensional analysis has been adopted to demonstrate the behavioral operation of Al-Ibrahim channel and put a judgment for more optimized state. All the input data required to run the Al- Ibrahim canal HEC-RAS model are presented in the following sections.

Simulation of Operational Scenarios.

Twelve different operational modules consists a fully opened outlets(modules **a**) and a partial opened outlets(modules **b**).with six scenarios as 60%,70%,75%78%,80% and 100% of design discharge based on supply discharge were assessed in order to determine the performance levels of Al-Ibrahim canal. It should be noticed here that the percentage of the design discharge used for operation of the above scenarios were choose based on the actual mean monthly discharge of head regulator (see Table 2).

Analysis of Indicators

Results from HEC-RAS model, design geometric and hydraulic data for Al-Ibrahim canal with its structures and command area, those collected from Office of Irrigation Management in Thi-qar have been used in equations (2),(3) and (4) to calculate indicators DPR, ΔQ and F respectively for several scenarios see Table(10). A summary of the results for different scenario within a study period are listed in Table (11). As can be seen from Table(11) the greater adequacy and excessive performance related to DPR were at modules (b) and (a) respectively for scenarios 100% and 60% of design discharge, whereas the less excessive performance were for modules (b) at scenario 60% of design discharge. However, the greater good performance related to ΔQ were at modules (b) for all scenarios and a greater unacceptable at modules (a) for all scenarios. About the flexibility the greater sub- proportional performance were at modules (b) at scenarios 100% and 80% of design discharge, whereas the less sub- proportional performance were for modules (a) at scenario 60% of design discharge . However, the greater hyper-proportional for modules (a) at scenario 60% of design discharge. However, in all cases, there is proportionality recorded for modules (b) at scenario 60%, 70% and 78% of design discharge.

- Operating System**.**

Using the results of the application HEC-RAS model and calculation indicators demonstrate matching criteria with the majority of previous studies. Therefore, an operating elevations gate was selected for all outlets in all the scenarios mentioned above as shown in Table (9) or closed. Using the same results in above is to show head discharge relations for outlets. It is through knowing of any head can see the value of discharge.

Table (9). Summary of operating elevations gate for outlets and equations

NO. of outlet	Crest level(Design)	Gate position level	Eq.
1 L	5.770	5.870	$Q=0.031H^{0.5}$
2 L	5.741	5.841	$Q=0.038H^{0.5}$
3 L	5.625	5.750	$Q=0.061H^{0.5}$
4 L	5.720	5.820	$Q=0.115H^{0.5}$
5 L	5.501	5.701	$Q=0.098H^{0.5}$
6 L	5.333	5.553	$Q=0.169H^{0.5}$
7 L	5.524	5.649	$Q=0.081H^{0.5}$
8 L	5.592	5.692	$Q=0.022H^{0.5}$
9 L	5.599	5.699	$Q=0.022H^{0.5}$
10 L	5.463	5.563	$Q=0.034H^{0.5}$
11 R	5.407	5.507	$Q=0.038H^{0.5}$
12 L	5.335	5.585	$Q=0.034H^{0.5}$

Table(10). Summary of the indicators of modules(a and b) results of 60%,70%,75%,78%,80% and 100% design discharge scenario.

—	Ind.	Outlet No.																							
		1 L		2 L		3 L		4 L		5 L		6 L		7 L		8 L		9 L		10 L		11 R		12 L	
		a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b
60 %	DPR	3.0	1.0	2.7	1.0	1.7	1.0	4.0	0.9	1.0	1.0	0.9	1.0	2.2	1.0	17	0.9	4.7	0.9	13	0.9	3.8	1.1	0.0	0.0
	ΔQ	2.0	0.0	1.7	0.0	0.7	0.0	3.0	-0.1	0.0	0.0	-0.1	0.0	1.2	0.0	16	-0.1	3.7	-0.1	12	-0.1	2.8	0.1	-1.0	-1.0
	F	2.5	1.5	2.1	1.3	1.2	0.9	4.0	1.6	1.0	0.8	0.6	0.6	1.1	0.8	2.6	1.3	9.7	1.6	1.8	1.0	3.7	1.1	4	1.1
70 %	DPR	3.3	1.0	2.9	1.0	1.8	0.9	4.5	1.0	1.1	0.9	1.0	1.0	2.3	1.1	18	0.9	5.2	0.9	13	0.9	4.4	1.2	0.0	0.0
	ΔQ	2.3	0.0	1.9	0.0	0.8	-0.1	3.5	0.0	0.1	-0.1	0.0	0.0	1.3	0.1	17	-0.1	4.2	-0.1	12	-0.1	3.4	0.2	-1.0	-1.0
	F	1.6	1.1	1.4	1.1	1.0	0.8	2.0	1.2	0.9	0.7	0.6	0.5	0.9	0.7	1.6	1.0	2.8	1.2	1.3	0.9	2.1	0.9	2.4	0.9
75 %	DPR	3.5	1.0	3.1	1.0	1.9	1.0	4.7	1.0	1.2	0.9	1.0	1.0	2.3	1.0	19	0.9	5.5	1.0	13	0.9	4.6	1.2	0.0	1.0
	ΔQ	2.5	0.0	2.1	0.0	0.9	0.0	3.7	0.0	0.2	-0.1	0.0	0.0	1.3	0.0	18	-0.1	4.5	0.0	12	-0.1	3.6	0.2	-1.0	0.0
	F	1.4	1.0	1.3	1.0	0.9	0.8	1.7	1.1	0.8	0.7	0.6	0.5	0.9	0.7	1.4	0.9	2.2	1.1	1.2	0.8	1.8	0.9	2.1	0.8
78	DPR	3.6	1.0	3.1	1.0	1.9	1.0	4.8	1.0	1.2	1.0	1.0	0.9	2.3	1.2	20	0.9	5.6	1.0	13	0.9	4.6	1.0	0.0	1.0
	ΔQ	2.6	0.0	2.1	0.0	0.9	0.0	3.8	0.0	0.2	0.0	0.0	-0.1	1.3	0.2	19	-0.1	4.6	0.0	12	-0.1	3.6	0.0	-1.0	0.0
	F	1.3	1.0	1.2	0.9	0.9	0.7	1.5	1.0	0.8	0.6	0.6	0.5	0.8	0.7	1.3	0.9	1.9	1.0	1.1	0.8	1.6	0.8	1.8	0.8
80 %	DPR	3.7	1.0	3.2	1.0	1.9	1.0	4.8	1.0	1.2	1.0	1.0	1.0	2.3	1.0	20	0.9	5.7	1.0	13	0.9	4.7	1.2	0.0	1.0
	ΔQ	2.7	0.0	2.2	0.0	0.9	0.0	3.8	0.0	0.2	0.0	0.0	0.0	1.3	0.0	19	-0.1	4.7	0.0	12	-0.1	3.7	0.2	-1.0	0.0
	F	1.2	1.0	1.1	0.9	0.9	0.7	1.4	1.0	0.8	0.6	0.6	0.5	0.8	0.7	1.3	0.9	1.8	1.0	1.1	0.8	1.5	0.8	1.6	0.8
100 %	DPR	3.3	1.0	2.9	1.0	1.8	1.0	4.4	0.9	1.1	1.0	1.0	1.0	2.3	1.0	18	0.9	5.2	0.9	13	0.9	4.3	1.0	1.9	1.0
	ΔQ	2.3	0.0	1.9	0.0	0.8	0.0	3.4	-0.1	0.1	0.0	0.0	0.0	1.3	0.0	17	-0.1	4.2	-0.1	12	-0.1	3.3	0.0	0.9	0.0
	F	1.6	0.8	1.4	0.7	1.0	0.6	2.1	0.8	0.9	0.6	0.6	0.5	0.9	0.6	1.7	0.7	2.9	0.8	1.3	0.6	2.0	0.7	2.3	0.6

Table(11). Summary discrete a performance type with number of outlet for each scenario of study period (DPR), (ΔQ) and (F)

scenario	modules	No. of outlets at performance related to DPR			No. of outlets at performance related to ΔQ			No. of outlets at performance related to F		
		excessive	adequate	inadequate	good	Possible use	unacceptable	Sub-proportional	proportional	hyper-proportional
60 % of design discharge	a	9	2	1	2	0	10	1	0	11
	b	0	11	1	10	1	1	4	1	7
70 % of design discharge	a	10	1	1	1	1	10	4	0	8
	b	0	11	1	9	2	1	7	2	3
75 % of design discharge	a	10	1	1	1	1	10	3	0	9
	b	1	11	0	11	1	0	9	0	3
78 % of design discharge	a	10	1	1	1	1	10	4	0	8
	b	1	11	0	11	1	0	11	1	0
80 % of design discharge	a	10	1	1	1	0	11	4	0	8
	b	1	11	0	11	1	0	12	0	0
100 % of design discharge	a	11	1	0	1	1	10	4	0	8
	b	0	12	0	12	0	0	12	0	0

CONCLUSIONS

Based on the overall results analysis of this study, the following conclusions can be extracted Al-Ibrahim canal.

1. The water level and discharges measurements at the head regulator during the study period are less than the target discharge; accordingly the outlets do not operate at the same time, especially for full gate opening because they will take discharge greater than the design.
2. Through the analysis under actual operation, the results via HEC-RAS model of relevant indicators induced towards best values when the outlet controlled by gate setting.
3. The mean max. and min. discharge at head regulator was 4.415 m^3/s at Jan.2014 and 3.073 m^3/s at Mar2014 respectively.
4. When the max. discharge at head regulator are 60%,70%,75%,78,80 and 100% in the present condition of Al-Ibrahim canal, it should be control the gates of outlets (b; partial opened outlets)with scenarios above to reach the optimal operation for project and get on with respect to the standard indicators DPR,ΔQ and F .

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