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Effect of Reliability of Water Releases Downstream Abu Ushar Head Regulator, Gezira Scheme, Sudan

Ahmed M. Babiker[1], Amir B. Saeed[2], Abu Obieda B. Ahmed[3], and Amira Mekawi[4]

[1] Department of Agric. Eng., Faculty of Agricultural Sciences, University of Gezira, Sudan.
[2] Hydraulic Research Center, Wad Medani, Sudan.
[3] Department of Agric. Eng., Faculty of Agriculture, University of Khartoum, Sudan.
[4] Hydraulic Research Center, Wad Medani, Sudan.

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ABSTRACT

Reliability of water releases is of essential importance, as it is the basis of water delivery scheduling as well as water resources planning and management. This study was conducted in Abu Ushar head regulator of Gezira Main Canal, Gezira Scheme (GS) at 169 Km from Sennar Dam. The main objective was to study reliability of water releases downstream Abu Ushar head regulator. This regulator serves irrigation water operation of the North GS. It consists of a number of canals namely Turabi, North West Branch, Abu Ushar Major, Debaba Major, Baranco Minor, Tatai Minor, Wad Elmagdi Minor and Abu Ushar Scape. The field work was conducted by measuring water levels during the period from 1st Oct. to 31th Dec. 2005 at the control structures of the canals under study. Also, the openings of the gates and the heads over weirs were daily measured to calculate the discharges passing through the investigated canals by using the corresponding equations. The study showed that the average difference between the recorded discharge (Q_R) and the calculated discharge (Q_C) was (0.4%) for Turabi, and (0.1%) for North West Branch. The small differences between calculated and recorded discharges were attributed to the adoption of appropriate discharge equations by the irrigation authority. This is also valid for Abu Ushar (4.6%) and Debaba (4.4%) majors. It was found out that there was disagreement between the recorded and measured discharges in the case of the minor canals. The study gave differences in order of 25.6%, 23.6% and 16.7% for Baranco,Tatai and Wad Elmagdi minor canals, respectivly. This could be attributed to the deterioration of gates and weirs, which led the irrigation authority to adopt constant daily rates of 10,000 m^3 (Baranco and Tatai) and 40,000 m^3 (Wad Elmagdi minor).

INTRODUCTION

Water is one of the natural renewable resources essential for economic and social development. Yet, water resources have been taken for granted as a free good to be used at will, with little or no regard to the long-term consequences of their mismanagement. However, many voices have raised a note of alarm for some time now (Abu-Zeid and Hamdy, 2002)., Agricultural water users must plan an annual water budget in semiarid and arid lands and areas where water usage is regulated due to ecological protection programs, limited resources and competitive demand (Barrett, 1999). It is reasonable to expect that improved crop water requirement estimate may make a substantial change in system specifications and profitability. Sustainability of irrigated agriculture both environmentally and economically depends primarily on the efficiency of irrigation water use, including crop water requirement and delivery and on-farm systems, management of degraded soils and water re-use (Howell, 2001).Therefore, a better management of water in irrigated agriculture is necessary to enhance crop production while preserving soil and water quality. Water Supply the quality, quantity, and temporal distribution characteristics of the source of irrigation water have a significant bearing on the irrigation practice. Crop water demands are essentially **5** continuous during the growing season, although varied in magnitude. A small, readily available water supply is best utilized in a small capacity irrigation system which incorporates frequent applications. The depths applied per irrigation are therefore small in comparison to systems having a large discharge available less frequently. The quality of water in conjunction with the frequency of irrigations must be evaluated. Salinity is generally the most significant problem, although other elements, such as boron, can be important. A highly saline water supply must be applied more frequently and in larger amounts than good-quality water and The control of water within the conveyance system involves flow measurement, sediment and debris removal, divisions, checks, drops, energy dissipaters, and water-level controls. A few of the more common flow-measuring structures for open channels it is include various weirs, flumes, and orifices. An array of checks, drops, dividers, and water-level controllers (Wynn R. Walker 2003).

Water management of large irrigation systems is a key issue to increase productivity and assure future food security. The efficient operation, well executed and effective management of irrigation schemes are needed for improving the hydraulic performance of the canals, enhancing the water distribution systems to achieve sustainable production. The Gezira Scheme is one of the largest irrigation schemes under a single management in the world. It is located in the arid and semi-arid region between the Blue Nile and the White Nile south of Khartoum, (Figure 1) (Osman et *al*., 2011).

Irrigation in Gezira Scheme is primarily by gravity flow. Two parallel canals leave Sennar Dam and merge into a common pool at 57 kilometres downstream the dam. From there one main and three subsidiary canals diverge westwards to serve Managil Extension, and a second main canal continues northwards into the older part of the scheme (Idriss, 1999). The main canals are divided into reaches controlled by head regulators maintaining upstream pools at constant levels to enable branches and majors to draw the required amount of water. The major canals are also divided into reaches of about 3 km in length by head requlators to command the minor canals (Ibrahim, 1984).

The Gezira Scheme was originally designed for continuous daily flow in all canals (1925 – 1928). Due to practical difficulties associated with irrigation water application during the nights, the Night Storage System (NSS) was adopted in 1928. The theory of the NSS is principally based on storing water in the minor canals during the night to a decided command level. The level and volume stored in any minor depend on the length of the reach, the head slope, maximum depth and the depth for uniform flow at given discharge. Therefore, only the minor canals were modified to cope with the new requirements (Idriss, 1999). The most commonly used water measuring devices are: weirs, flumes, orifices and meter gates. In these devices the rate of flow is measured directly by making a reading on scale which is a part of the instrument and computing the discharge rate from standard formulate. The discharge rate can also be obtained from standard tables or calibration curves prepared specially for the instrument. The choice between one or the other devices depands on the expected flow rate and site conditions (Michael, 1978).

PROBLEM STATEMENT

Abu Ushar head regulator serves irrigation water for a total area of 83400 feddans in the Northern GS. In some seasons, cultivated crops witness thirst due to mismanagement of irrigation water, and other associated reasons, therefore, regular calibration of the hydraulic structures is a must ensure release of the appropriate crop water requirements (CWR) is a must. These group regulators at km 169 have never been calibrated before and this work has measured the water releases (water discharges) downstream Abu Ushar head regulator across Gezira Main Canal and reflected concrete results on its performance to ensure optimal irrigation water supply to farms. Correlations between the recorded and measured discharges all over the study period have been established and overall differences of up to 5% can are considered practically insignificant.

MATERIALS AND METHODS

The experimental work was conducted at the Northern part of the Gezira Scheme namely at Abu Ushar head regulator across Gezira Main Canal, which is at km 169 down stream Sennar dam. The data was collected during the period from Oct. to Dec. 2005. Characteristics of the regulators under study are shown in Table (1). A steel angle of two meters long was fixed at a distance of about 200 m upstream on the left bank of the main canal and on the downstream side one steel angle was fixed within varying distances on the left bank of all other canals, Table (2).

Water reduced levels at upstream and downstream of the regulators group were determind using ordinary levelling (Table 3). The water levels at both upstream and dawonstream of the control structures were recorded on daily basis. Also, the gates opening and the water depths above the crest of the weirs were daily registered.

The passing discharge was calculated by using the following equation:

$$Q = C \times O \times \sqrt{H} \quad \ldots\ldots (1)$$

Where

Q = Discharge (Mm^3/day)

C = Coefficient (gate coefficient)

O = Total gate opening (m)

H = Head difference between u/s and d/s (m)

While discharge for movable weir was calculetd using the following equations taking into consideration water level & weir width

i. $Q = 2.18\ W * D^{1.6}$ . . . . . (2)

Where

Q = discharge of water (m^3/s), up to 1 m^3/ s

2.18 = constant (factor).

W = width of weir (m), not greater than 1.3 m

D = depth of water over crest (m), not greater than 0.6 m

ii. $Q = 2.3\ W * D^{1.6}$ . . . . . (3)

Q = discharge of water (m^3/s), from 1 to 5 m^3/s

W = width of weir (m), up to 4 m

D = depth of water over crest (m), not greater than 0.8 m

And for Field Outlet Pipe (FOP), the discharge was calculated by using the equation as follows

iii. $Q = 2.44\ D2 \sqrt{h}$ . . . . . (4)

Where

Q = discharge of water (m^3/s)

D = diamter of the pipe (m)

H = the head over the pipe (m)

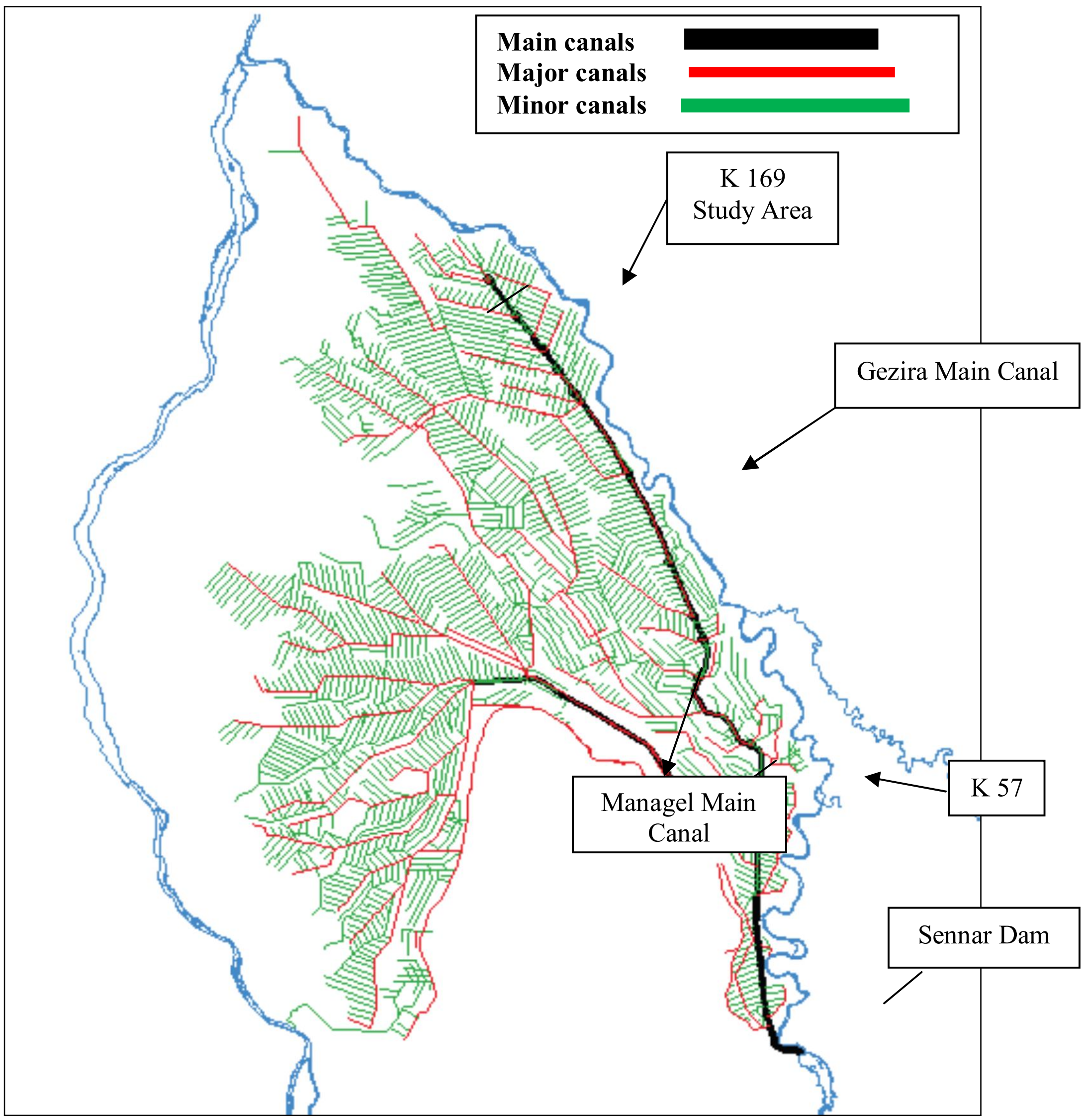


Figure 1 : Gezira Scheme irrigation system layout

Source: (Osman *et al.,* 2011)

Table1 : Basic information of the canais off-taking from Abu Ushar head regulator

No.	Name of canal	Type of canal	Type of structure	Width of structure (m)	Length of canal (km)	Design capacity (m^3/s)
1	Turabi	Main canal	1 R.S.G. 1 R.W.G	3	35	26.04
2	North West	Branch	2 R.S.G. 1 R.W.G	3	26	28.36
3	Abu Ushar	Major	1 M.W II	2	5.26	2.91
4	Debaba	Major	1 M.W II	3	14.57	2.87
5	Abu Ushar	Escape	2 R.S.G.	3	3.10	13.80
6	Barnco	Minor	1 M.W.	0.35	1.51	0.197
7	Tatai	Minor	1 M.W.	0.35	1.50	0.174
8	Wad Elmgdi	Minor	1 M.W.	1.3	9.59	0.670

Source: Ministry of Irrigation
R.S.G. = Roller Sluice Gate, R.W.G. = Rack and Warm Gate, M.W. = Moveable Weir

Table 2: Location of the installed gauges at Abu Ushar head regulatar

No.	Code	Distance from off-take (m)	Location	Water reduced level (m)
1	Gx1	200	U/S Main Canal: on the left bank	397.10
2	Gx2	100	D/S Main Canal: on the left bank	396.13
3	Gx3	100	D/S N.W. Branch: on the left bank	396.53
4	Gx4	60	D/S Abu Ushar Major: on the left	395.35
5	Gx5	50	D/S El debaba Major: on the left	395.53
6	Gx6	30	D/S Barnco Minor: on the left bank	395.40
7	Gx7	30	D/S Tatai Minor: on the left bank	395.40
8	Gx8	40	D/S Wad Elmgdi Minor: on the left	395.40
9	Gx9	200	D/S Main Drian (Escape): on the	-

Gx = Gauge Code, D/S = downstream, U/S = upstream

Table 3: Reduced levels of the crest of the installed gauges

B. M. = 397.773 m

Gauge of ruller from B.M. = 1.2 m

Datum of set (1) = 397.77 + 1.20 = 398.973 m

Canals	Water level (m) (IS - FS)	Water reduced level (m) RL = HI - FS
U/S Main Canal	1.873	397.10
D/S Main Canal	2.843	396.13
D/S N.W. Branch	2.44	396.53
D/S Barnco	3.573	395.40
D/S Tatai	3.573	395.40
D/S Wad Elmagdi	3.573	395.40

Gauge of ruller = 0.7 m

Datum of set (2) = 397.2 + 0.7 = 397.9 m

Canals	Water level (m)	Water reduced level (m)
Abu Ushar	2.55	395.35
Debaba	2.37	395.53

B.M. = Bench Mark
HI = Height of level
BS = Back sight
FS = Fore sight
IS = Intermediate sight

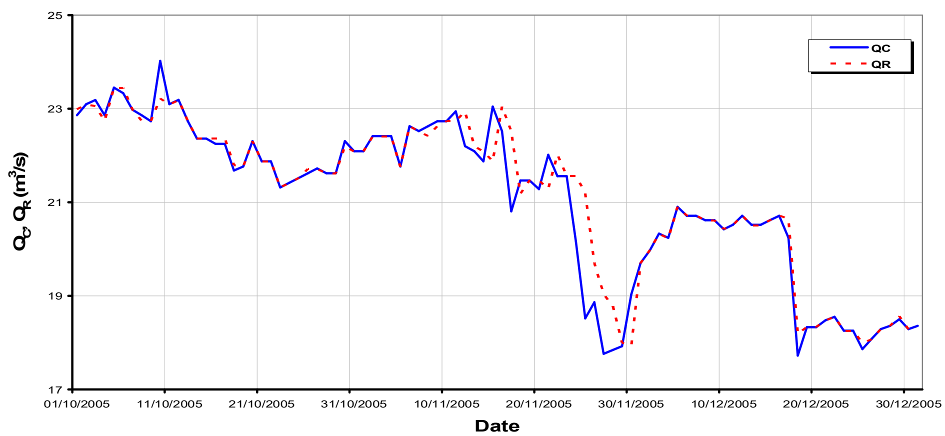
RESULTS AND DISCUSSION

Results of Turabi Main Canal and North West branch **:** Figures (2 and 3) give the relationship between the recorded discharges (Q_R) as given by the irrigation office and the calculated discharges (Q_C). The fitted relationship is given as follows:

$Q_R = 0.9997\ Q_C$ (Turabi)

$Q_R = 0.999\ Q_C$ (North West branch)

The overall difference between the recorded and calculated discharges was found to be 0.4 and 0.11% for Turabi and NW branch respectively. These differences are less than 5%, which is not significant.



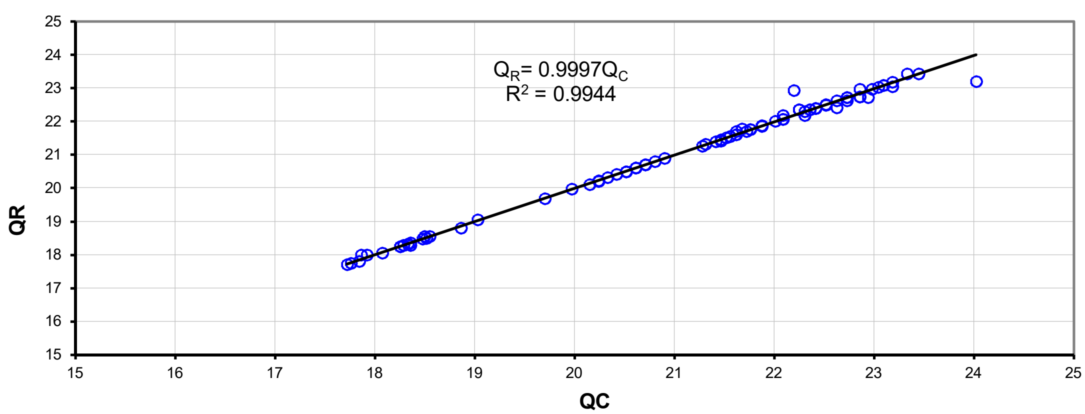
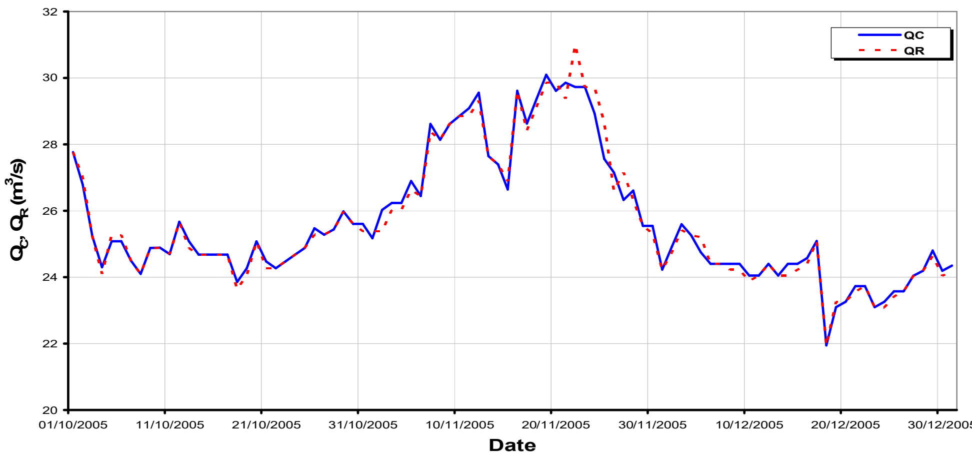


Figure 2 : Time series of recorded and calculated discharges at Turabi main canal @ D/S K 169 (above), and corresponding established relationship (below)



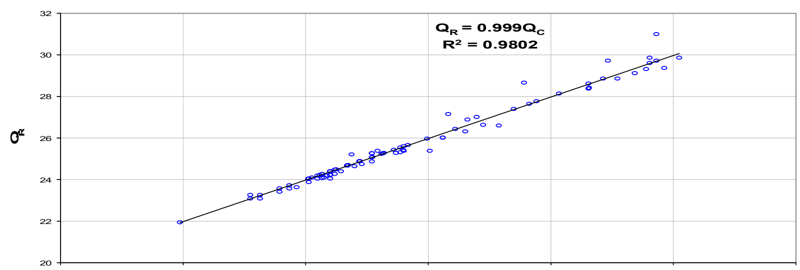
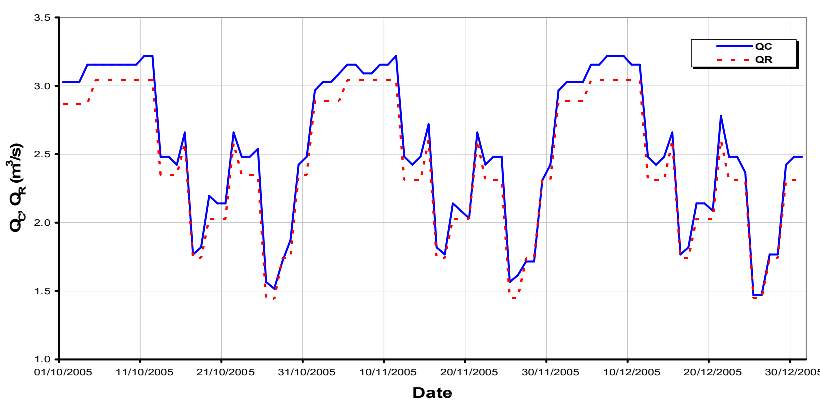


Figure 3 : Time series of recorded and calculated discharges of the North West branch @ D/S K 169 (above), established correlation (below)

Results of the major canals under study: Figures 4 and 5 show the established relationships between the recorded discharges (Q_R) as given by the irrigation office and the calculated discharges (Q_C) for Abu Ushar and Debaba majors. The fitted relationships is given as follows:

$$Q_R = 1.008\ Q_C \text{ (Abu Ushar)}$$
$$Q_R = 0.9563\ Q_C \text{ (Debaba)}$$

The overall difference between the recorded and calculated discharges was found to be 4.6 and 4.4% for Abu Ushar and Debaba respectively. These figures are less than 5%, which is not significant.



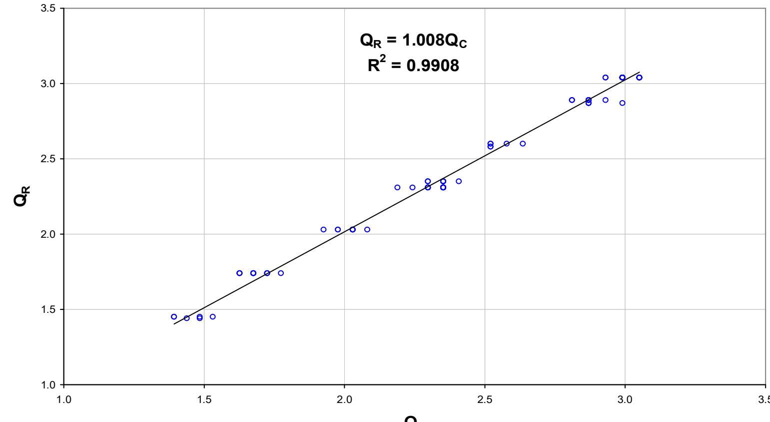
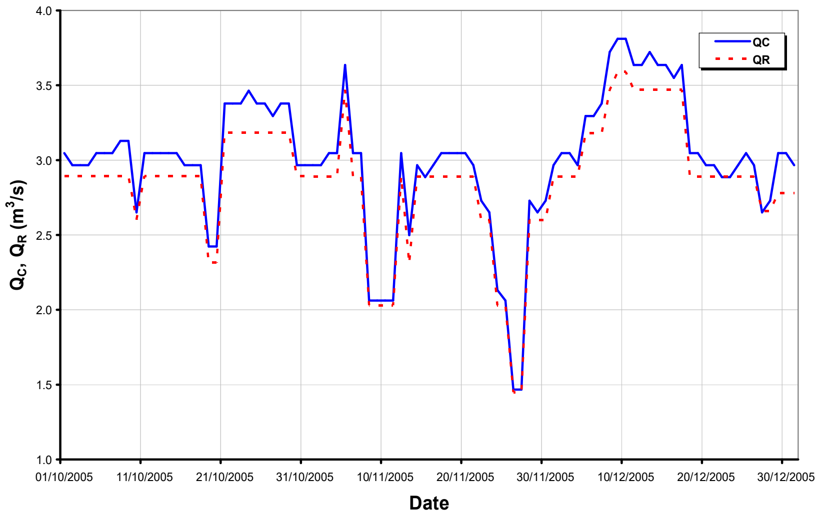


Figure 4 : Time series of recorded and calculated discharges of Abu Ushar major (above), established correlation (below)



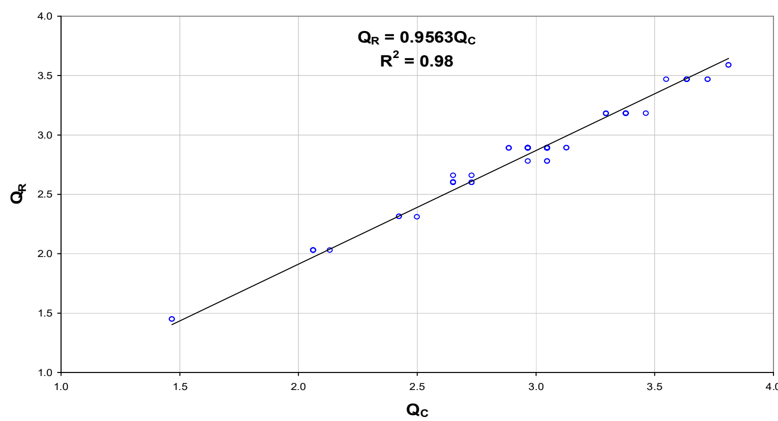


Figure 5 : Time series of recorded and calculated discharges of Debaba major (above), established correlation (below)

Results of the minor canals under study: For the three minor canals under investigation, Table (4) gives summary of the established relationships. Figures (6-8) give the pattern of the calculated and recorded discharges on daily basis.

Table 4 : Results of the minors calibration

Minor canal	Q_R Vs Q_C	Diff. (%)
Branco	$Q_R = 1.0558\ Q_C$	25.6
Tatai	$Q_R = 1.0017\ Q_C$	23.6
Wad Elmagdi	$Q_R = 0.868\ Q_C$	16.74

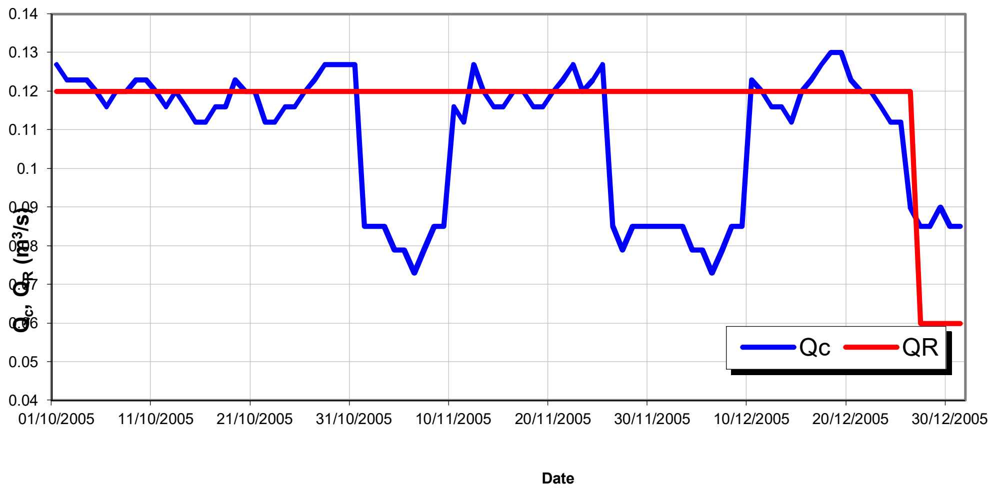


Figure 6 : Time series of calculated and recorded discharges at Baranco minor

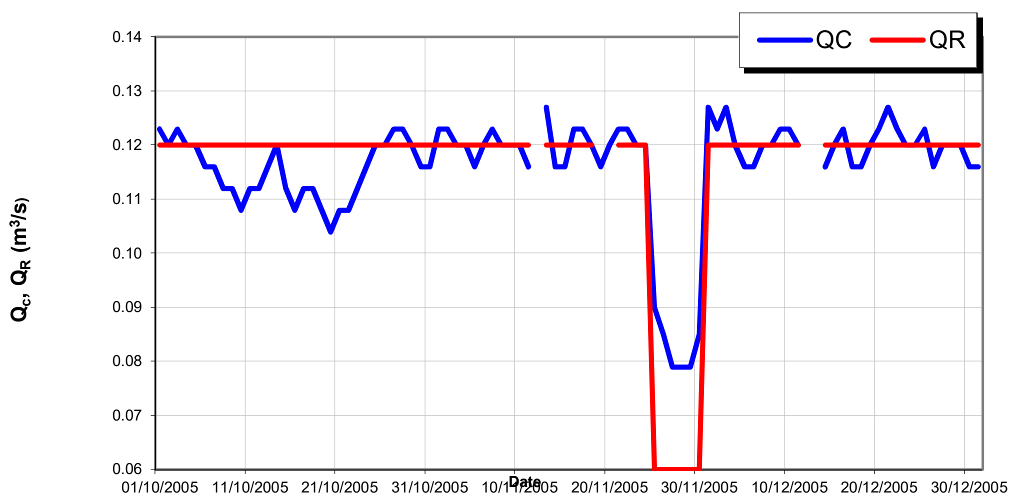


Figure 7 : Time series of calculated and recorded discharges at Tatai minor

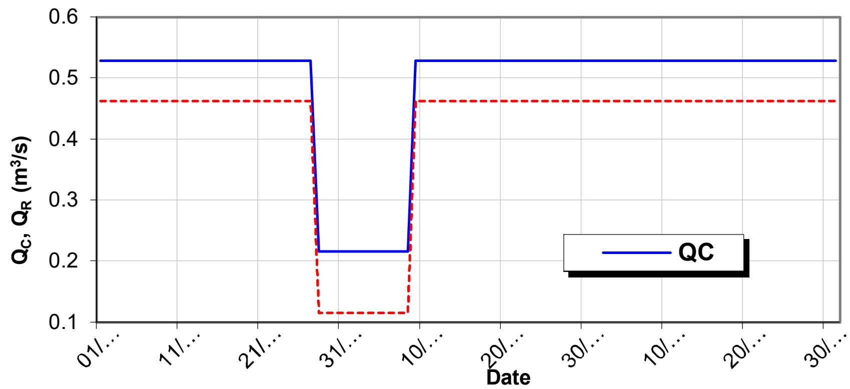


Figure 8 : Time series of calculated and recorded discharges at Wad Elmagdi minor

CONCLUSIONS & RECOMMENDATIONS

CONCLUSIONS

From the study, it could be concluded that:

1. The overall difference between the recorded discharge (Q_R) and the calculated discharge (Q_C) for Turabi and North West branch amounts to 0.4% and 0.11%, respectively. Being less than 5%, this is practically considered insignificant.
2. The same conclusion is valid for Abu Ushar (4.6%) and Debaba (4.43%) majors.
3. For minor canals, the obtained differences are sigificant and in order of 25.6% for Barnco, 23.6% for Tatai and 16.74% for Wad Elmagdi.

RECOMMENDATIONS

1. Review of the discharge equations adopted in Baranco, Tatai and Wad Elmagdi minor offtakes.
2. From site visits and observations, it was clear that most of the canal offtakes under study were subjected to detoreoration due to sedimentation and weed growth which necessiate urgent maintenance and rehabilitaion actions and consequenctly recalibration of the offtaking structures.
3. Further studies are needed regarding the group of regualtors under study. This should include water balance studies.
4. Introducing of computerized database technology (water levels, discharges, amount of sediment cleared, etc…), this is essentional for proper operation as well as future studies of evalutation and assessment.
5. Regular calibration for the hydraulic structures of the Gezira Scheme canalization system is essential especially after Gezira Act of 2005.

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