Developing the Discharge Capacity of Al Husa'chi River

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Abstract

Al Husa'chi River is one of the three main branches of Al Ka'hla River in Maissan governorate. Its length is 25 km. the river directly feeds Al Huwayza Marsh by overpass pipes at its end. It is also used for irrigating the nearby agricultural areas. A study for evaluating the hydraulic performance of the river has been carried out in order to develop its ability to accommodate the excess inflow required for feeding the marsh and the surrounding agricultural projects. All the necessary hydraulic measurements, needed to construct rating curves, at stations along the river course were carried out for a period of six months. A steady one dimensional hydraulic model has been prepared to simulate the flow in this river using the HEC-RAS software (Version 3.1.3). The calibration and verification processes of the model have been carried out by making use of the field measurements. The obtained maximum allowable discharge of this river for the present conditions is ranged from 20m^3/sec to 35m^3/sec for the water surface elevation of the marsh from 7.0m to 2.8m amsl, respectively, and the first flood section is located at 23.5km downstream of the river inlet. The required cross sections to develop the capacity of the river have been obtained considering the marsh and agricultural requirements.

تطوير سعة التصريف لنهر الحسيجي

الخلاصة

نهر الحسيجي هو أحد الفروع الرئيسية الثلاثة لنهر الكحلاء في محافظة ميسان. طول نهر الحسيجي 25كم. يغذي هذا النهر هور الحويزة مباشرة عن طريق معبر انبوبي في نهاية النهر. ويستخدم في أرواء الأراضي الزراعية المجاورة له. تم إجراء دراسة لتقييم الأداء الهيدروليكي لهذا النهر لتطوير قابليته على إستيعاب الزيادة في التصاريف المطلوبة لتغذية الهور والمشاريع الزراعية. تم إجراء كل القياسات الهيدروليكية اللازمة لإيجاد منحنيات الإستتباع في محطات على طول مجرى النهر ولمدة ستة أشهر.

تم إعداد نموذج هيدروليكي للجريان الثابت احادي البعد لمحاكاة الجريان في هذا النهر باستخدام برنامج ال HEC-RAS (Version 3.1.3). وتم إجراء عمليات المعايرة والتحقق من النموذج بالإستفادة من القياسات الحقلية إن اعلى تصريف مسموح به للنهر في الضروف الحالية هو 20م3/ثا الى 35م3/ثا عندما تكون مناسيب الهور من 7م الى 2.8م فوق مستوى سطح البحر و المقطع الفيضاني الاول يقع على بعد 23.5كم من بدية النهر. ولغرض تطوير الطاقة الإستيعابية للنهر فقد تم إيجاد المقاطع العرضية اللازمة اخذين بنظر الإعتبار إحتياجات الهور والزراعة.

1. Introduction

Al Husa'chi River is one of the three main branches of Al Ka'hla River. Al Ka'hla River extends from its intake, head regulator, located north of Al Am'arah Barrage on Tigris River to the center of Al Ka'hla City. Al Husa'chi River branched from Al Ka'hla River at the center of Al Ka'hla City and flows towards Al Huwayza Marsh, as shown in Plate 1. The length of this river reach is 25 km [1]. This river directly feeds Al Huwayza Marsh by a pipe overpass at its end [2], it also irrigates the nearby agricultural areas.

2. Hydrological Field Measurements

The hydrological field measurements were carried out at two gauging stations during the study period, from January to July 2006, Plate 1, [3]. The fist station was at the Al Husa'chi

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Bridge and the second was at the end of Al Husa'chi River course. The field work includes the discharges, figure1, and the corresponding stages, figure 2. a set of twelve measurements were carried on an average of two measurements monthly during the study period.

2.1. Discharge Measurements

A Set of twelve discharge measurements, two measurements at each month during the study period were carried out at the two stations (Al Husa'chi Bridge, station 1 and Al Husa'chi River end, station 2).

A current meter was used to measure the discharge. The measured discharges at the two stations during the study period are shown in Figure 1.

2.2 Stage Measurements

A Set of twelve stage measurements, two measurements at each month during the study period were carried out at two hydrological measurement stations (Al Husa'chi Bridge, station 1 and Al Husa'chi River end, station 2). These measured stages are shown in Figures 2**.**

3. Flow Routing Hydraulic Models

A steady one dimensional flow hydraulic model using the HEC-RAS software (Version 3.1.3) [4] was used to simulate the flow in Al Husa'chi River in order to obtain the water surface elevation along the river course under a set of steady flow conditions.

This software allows the user to perform one-dimensional steady and unsteady flow hydraulics. It is an integrated system of software, designed for interactive use in multi-tasking, multi-user network environment. The system is comprised of a graphical user interface (GUI), separate hydraulic analysis components, data storage and management capabilities graphics and reporting facilities.

3.1 Theoretical Basis for One-Dimensional Flow Calculations

In steady flow, Water surface profiles are computed from one cross-section to the next by solving the energy equation. The energy equation is:

$$y_1 + \frac{a_1 v_1^2}{2g} + z_1 = y_2 + \frac{a_2 v_2^2}{2g} + z_2 + h_e$$

Where:

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

z_1, z_2: elevation of the main channel inverts, m.

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

g: gravitational acceleration, m^2/sec.

he: head loss ,m.

The head loss in a reach of length L may be calculated as :

$$h_e = L * \bar{S}_f + C\left[\frac{a_1 v_1^2}{2g} + \frac{a_2 v_2^2}{2g}\right]$$

Where:

$\bar{S}_f$: Representative friction slope between the two sections.

C: Expansion or contraction loss coefficient.

3.2 Geometrical Data

The surveyed river cross sections [2], left and right banks, downstream reach length, proposed initial Manning's roughness coefficient, n, of the main channel, and other reaches information were the geometrical data required to run the model. These data were input to the model through the menu of cross section geometrical data.

All the hydraulic structures (bridge, culverts, spillway, weir etc…..) on the rivers were specified and their details input to the model using bridge or culvert geometrical data menu.

3.3 Boundary Condition

The HEC-RAS model deals with the boundary conditions depending on the flow regime. In a sub critical flow

regime, which is the flow regime in the river under consideration, boundary conditions are only necessary at the D/S ends of the river system and deals with its data in a separated window.

The discharges at the upstream boundary required to run the model are shown in Table 1.

Flow change locations were specified and the net flow through the river reaches was input to the model using the steady data menu.

A known constant stage type boundary condition was adopted in all runs of the hydraulic model.

The downstream boundary conditions of a constant stage of the river are shown in Table 2. These data were input to the model through the menu of steady flow data**.**

3.4 Hydraulic Model Calibration

A calibration process was carried out using stage measurements along Al Husa'chi River, the obtained stage values, Table 3, measured along Al Husa'chi River course were used to calibrate the model. The discharge at the upstream end of the river, at Al Husa'chi Bridge, station 1, during the measurements was 21m^3/sec.

The flow change locations and their corresponding discharges are listed in Table 4.

The calibrated Manning's n values along the main channel and its left and right banks are listed in Table 5.

An acceptable agreement was achieved between the model predicted stage values using the calibrated data and the measured stage values as shown in Figure 3.

3.5 Hydraulic Model Verification

A set of data that was used for the verification process is represented by the rating curve that was predicted at Al Husa'chi Bridge, station 1, Table 6. The comparison between the model predicted rating curve and the measured rating curve at Al Husa'chi Bridge, station 1 is shown in Figure 4, declares an acceptable agreement.

4. Maximum allowable discharge of Al Husa'chi River at the present conditions

Field inspections and measurements showed that while the maximum inflow discharge to the river was 27.9 m^3/sec, the river discharges as a maximum outflow to Al Huwayza Marsh only 14 m^3/sec. which means a half of that maximum inflow is lost through an over bank flow.

The relation between Al Huwayza Marsh water surface elevations and the maximum allowable discharges of the river has been studied by making use of the developed hydraulic model. While the water surface elevation of Al Huwayza Marsh has been increased gradually a minimum allowable elevation of 2.8 m amsl, to the maximum allowable elevation of 7 m amsl [4], the inflow discharge of the river was increased gradually for each water surface elevation. The flooded section and discharge and the maximum allowable discharge of each water surface elevation have been specified for the river at the present conditions. It has been found that the first flooded section is located at 23.5km downstream of Al Husa'chi Bridge and the maximum allowable water surface elevation at the marsh according to the present capacity of the river is 7.0m amsl.

The relations between Al Huwayza Marsh water surface elevations and the maximum capacity of the river for the present conditions at the flooded section is shown in Figures **5.** According to this figure the Maximum allowable discharge of Al Husa'chi River is ranged from 20m^3/sec to 35m^3/sec for the water surface elevation of the marsh from 7.0m amsl to 2.8m amsl.

5. Developing the discharge capacity of Al Husa'chi River.

According to the proposed hydrological routing of Al Huwayza

Marsh [4] and the maximum allowable discharge of the river with the corresponding maximum allowable marsh water surface elevation. The proposed Maximum allowable inflow to the marsh from Al Husa'chi River was found to be 70m^3/sec.

The present agricultural requirements assumed equal to the maximum total discharge measured at the irrigation channels during the study period which is found equal to 11.2m^3/sec. the future agricultural requirements is 3.3m^3/sec [1], then the total water required to feed the agricultural projects is 14.5 m^3/sec. The design discharge of the river represented by the total requirements of the marsh and agricultural projects should be84.5m^3/sec.

According to the above computed design discharges and considering that no lateral outflow the developed cross sections of the river have been obtained through applying the prepared hydraulic model. It was found that the existing culvert must be developed or removed to prevent flooding of the river upstream of it. It is recommended to be replaced by a bridge with a three circular piers (0.50m diameter) each.

6. Conclusions

The following conclusions may be drawn from this study:

1. The value of the maximum allowable discharge of Al Husa'chi River is affected by the water surface elevation of Al Huwayza Marsh.
2. The Manning's n value for the main channel is ranged between 0.025 at the upstream and 0.045 at the downstream end of the river.
3. The Manning's n value for the Left and right overfill banks is ranged from0.030 at the upstream end to 0.045 at the downstream end of the river.
4. The first flooded section in the river at the present condition is located at 22.5km downstream of the Al Husa'chi Bridge.
5. The maximum allowable water surface elevation in Al Huwayza Marsh according to the present capacity of Al Husa'chi River is 7.0m amsl.
6. The maximum allowable discharge of the river at the present condition is ranged from 20m^3/sec to 35m^3/sec correspond the water surface elevation in the marsh from 7m to 2.8m amsl according to the relation shown in figure 5.
7. The computed design discharge according to the present and future requirements of Al Huwayza Marsh and the agricultural projects is 84.5m^3/sec.
8. The left and right banks elevations of the river must be 11.0m amsl at the upstream end of the river down to 8.0m amsl at the downstream end of the river considering 1.0m as a free board.
9. The existing pipes overpass must be replaced by a bridge consists three circular piers of 0.50m diameter.

7. References

[1] The New Eden group, August, 2005, "Design Criteria for Optimum Regulation of Al Huwayza Marshes", vol. no.1

[2] Center of Restoration of the Iraq Marshlands (CRIM), 2006 " Al Huwayza Marsh and its Feeders Topographical Survey ", Final Report,

[3] Ministry of Water Resources, Baghdad, Iraq.

[4] Center of Restoration of the Iraq Marshlands (CRIM), 2006 "Study The Rehabilitation of Al Huwayza Marsh Ecological System ", Ministry of Water Resources, Baghdad, Iraq.

[5] U.S. Army Corp of Engineers, 2005, "River Analysis System", Version 3.1.3, Hydrology Engineering Center, Davis CA 95616. www.hec.usace.army.mil.

Table (1) Upstream discharge at station 1.

Run No,	Discharge (m^3/sec)
1	13.8
2	13.7
3	13.5
4	14.0
5	14.0
6	21.0
7	27.9
8	24.7
9	22.2
10	20.6
11	19.6
12	19.9

Table (2) Downstream boundary conditions at station 2

Run No.	Stage (m amsl)
1	5.22
2	4.77
3	5.19
4	5.09
5	4.31
6	5.31
7	4.79
8	4.79
9	4.99
10	4.79
11	4.79
12	4.14

Table (3) Measured stage along Al Husa'chi River.

Cross section No.	Easting (m)	Northing (m)	Stage (m amsl) at Q=21 m^3/sec
1	717234	3506218	6.44
3	717001	3503780	6.43
5	718243	3501096	6.40
6	720387	3499527	6.32
7	723087	3499161	6.30
8	725840	3498688	6.05
9	727905	3497550	6.18
10	730516	3498331	6.02
11	732609	3496893	5.90

Table (4) Flow change locations along Al Husa'chi River for upstream discharge of 21m^3/sec.

Cross section No.	Easting (m)	Northing (m)	Discharge m^3/sec
1	717233	3506218	21.00
11	732609	3496893	10.50
12	732677	3496895	5.30
13	734243	3496182	5.30

Table (5) Calibrated Manning's n values along Al Husa'chi River.

Cross section no.	Manning's n Value		
	Left overfill bank	Main channel	Right overfill bank
1	0.030	0.025	0.030
2	0.030	0.025	0.030
3	0.030	0.025	0.030
4	0.030	0.025	0.030
5	0.030	0.025	0.030
6	0.030	0.025	0.030
7	0.030	0.025	0.030
8	0.030	0.025	0.030
9	0.030	0.025	0.030
10	0.035	0.030	0.035
11	0.035	0.030	0.035
12	0.045	0.045	0.045
13	0.045	0.045	0.045
14	0.045	0.045	0.045
15	0.045	0.045	0.045
16	0.045	0.045	0.045
17	0.045	0.045	0.045

Table (6) Measured rating curve data at Al Husa'chi Bridge station 1.

Discharge (m^3/sec)	Water Surface Elevation (m amsl)
14.00	6.23
13.95	6.43
21.00	6.73
27.90	6.63
24.70	6.33
22.20	6.38
20.60	6.36
19.60	6.33

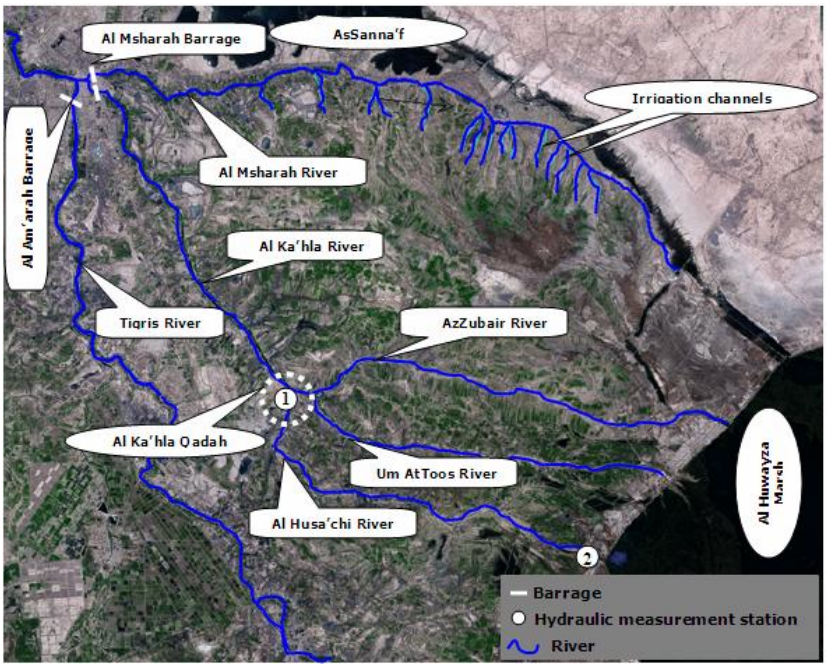

Plate (1) Al Husa'chi River layout.

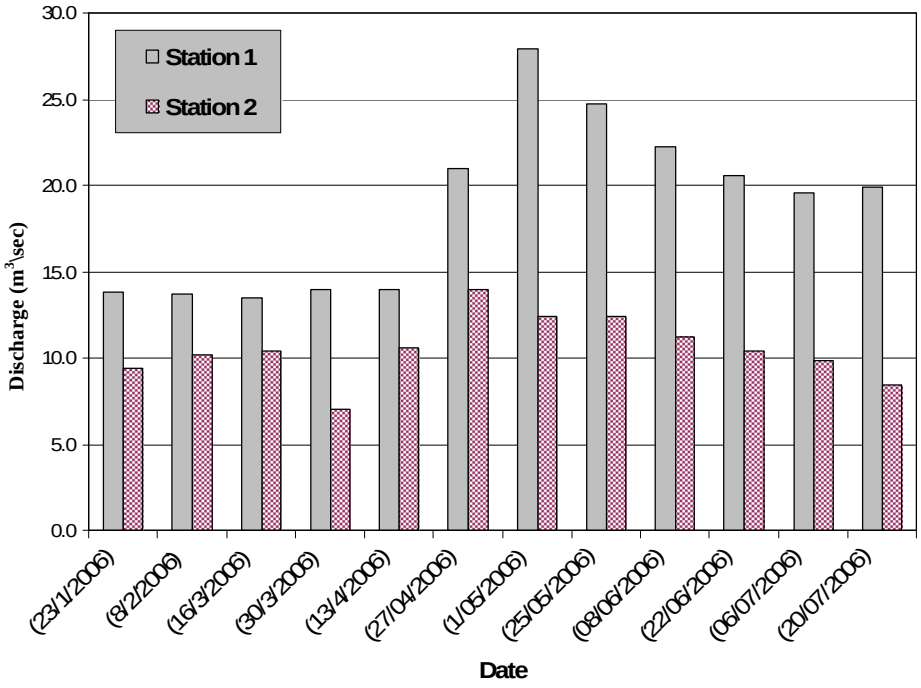

Figure (1) Measured discharge at the two hydrological measurement stations.

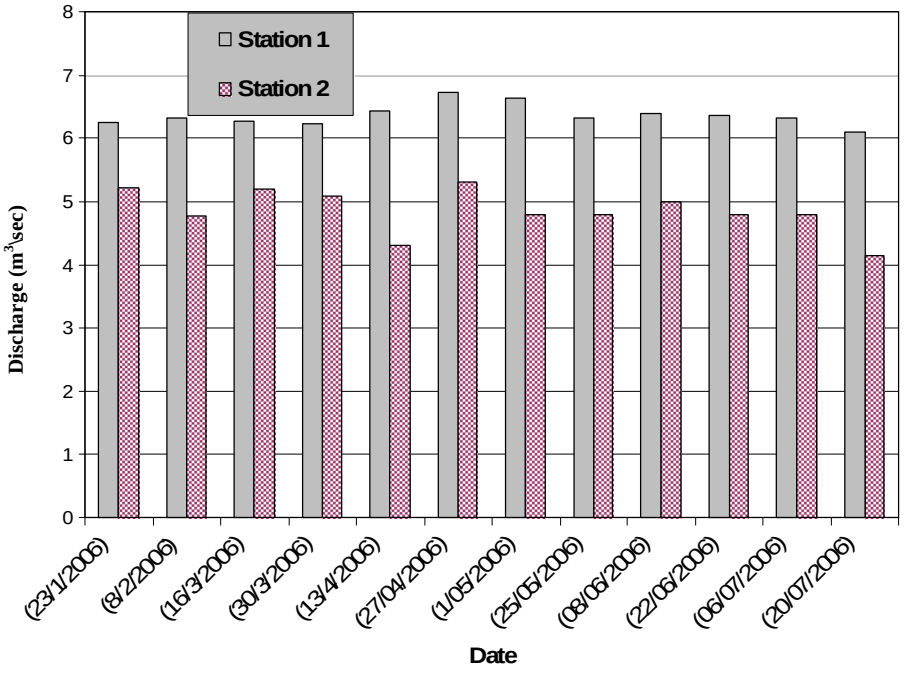

Figure (2) Measured stages at the two hydrological measurement stations.

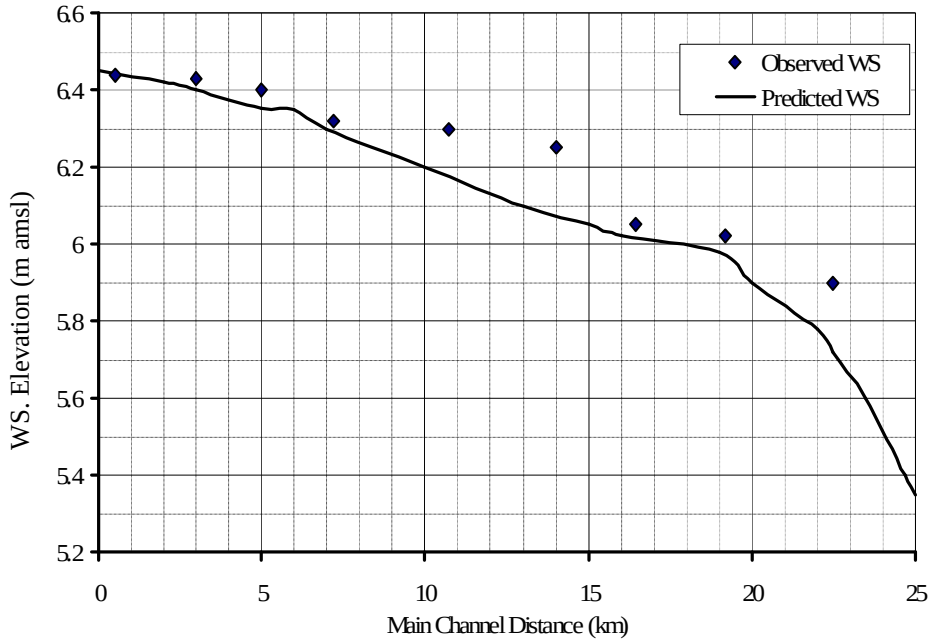

Figure (3) Comparison between the models predicted stage values using the calibrated data and the measured stage values along Al Husa'chi River.

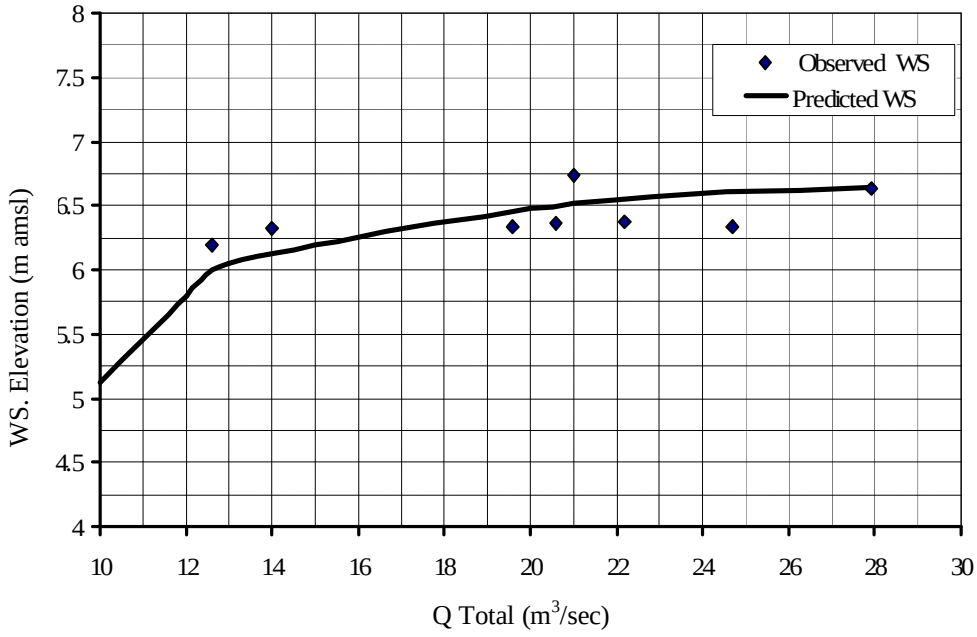

Figure (4) Comparison between the measured and the model predicted rating curve at Al Husa'chi Bridge, station 1.

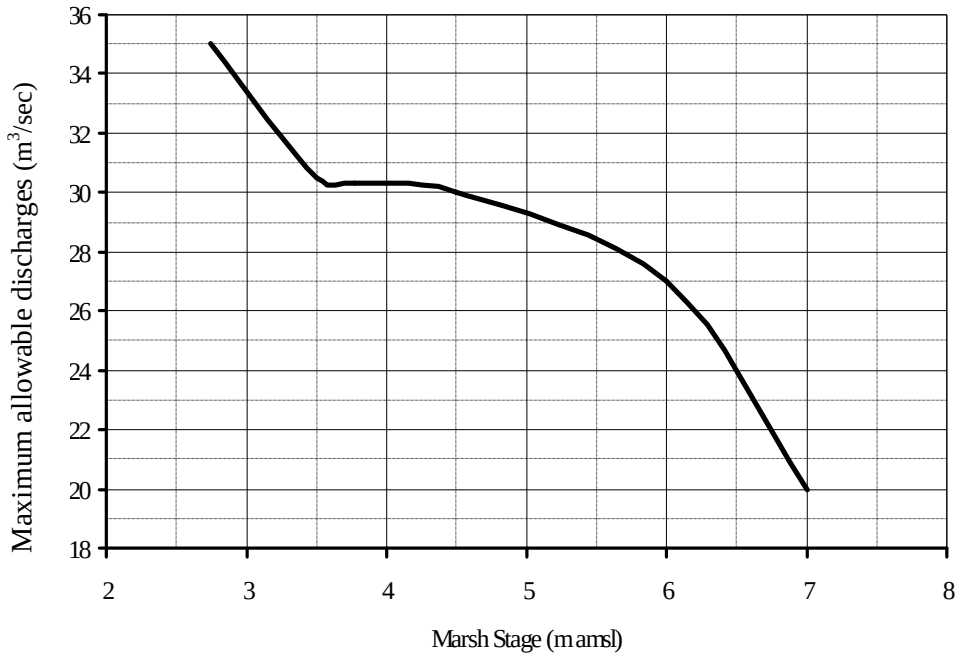

Figure (5) The relation between Al Huwayza Marsh water surface elevations and the maximum allowable discharges of Al Husa'chi River at the first flooded section.