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# Maximum modelling One-dimensional Flow in Shatt Al-Hillah in the Middle of Iraq: Acase Study

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## ABSTRACT

Floods rank high among recurring natural disasters, causing widespread global economic losses and endangering human lives. Therefore, predicting floods is crucial. Shatt AlHillah is vital for water supplies, including industrial, agricultural, and domestic uses, in three Iraqi provinces: Babylon, Diwaniya, and Muthanna, sourced from the Euphrates River. This study aims to assess the discharge capacity of shatt alhillah under current conditions and predict potential flood causing discharges.

A one-dimensional model, version 6.0.1Hec_ras, was developed to simulate possible flood scenarios. The model was calibrated, revealing a Manning's roughness coefficient of n=0.023. HEC-RAS Validation of simulated flood outcomes was done by Root Mean Square Error (RMSE) Equation Between simulated and observed data, where the coefficient of RMSE for calibrating shatt alhillah was 0.058 in an appropriate range. The maximum current capacity of shatt Al-Hillah is 205$m^3$/s that cannot accommodate the design discharge 303$m^3$/s. However, using several scenarios with discharges greater than 205$m^3$/s, it was found that some sections experience flooding when the discharge increases. Areas prone to flooding increase with higher river discharges, with a discharge of 450$m^3$/s causing flooding in the greatest number of sections.

Key words: Manning's coefficient, discharge, flood.

## 1.Introduction

Floods, often causes by a combination of natural and human forces, present severe consequences, extending beyond physical damage to affect lives, economies, and displacement of populations [1]. While various elements contribute to floods, the overflow of riverbanks stands out as a predominant cause, resulting in significant economic and personal repercussions. Changes in land use and societal activities in flood-prone regions can also influence the frequency of floods [2],[3]. The surge in population, leading to the use of flood-prone areas for residential purposes, poses a significant challenge to water resource engineering in managing and

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predicting flood disasters. In recent decades, the increasing occurrence of flood-related issues has gained paramount significance [4].
The global concern regarding flooding is evident, with data from the Federal Emergency Management Agency (FEMA) ranking flooding as the second most common natural disaster in the United States [5]. The risk of flooding is not confined to a specific region but is a global concern [6],[7],[8]. To address these concerns, various strategies, encompassing both structural and non-structural measures, have been devised, such as water flow control structures and flood risk mapping [9], [10]. However, structural solutions pose environmental and logistical challenges and may not be comprehensive in preventing recurrent flood hazards [11].
Certainly, the characteristics of water flow play a significant role in determining the water surface elevation within rivers and streams, ultimately influencing the occurrence of floods along the riverbanks. It is worth noting that prior research has not extensively delved into the realm of 1-D flood modeling, this is crucial for comprehending how a systematic and structured investigation should be conducted to analyze the flow patterns and their implications on riverbank flooding. Therefore, this study aims to serve as a case example by utilizing the model of 1-D HEC-RAS to simulate potential scenarios flood and assess their impact on the bank of shatt al-hillah in Babylon City.

## 2.THE HEC-RAS MODEL

The Hydrological Engineering Center of the U.S. Army Corps of Engineers created the HEC-RAS, or Hydrological Engineering Center-River examination System, software model to do an extensive examination of river systems. Its user-friendly graphical interface makes interactive data input and report generating easier. With its capacity to model a wide range of hydraulic situations, including both steady and unsteady flow, riverbank stability, and water quality analysis, this program is highly adaptable. HEC-RAS supports one-dimensional (1D) and one-dimensional unstable flow routing in the context of hydrodynamic.

Incorporating a simulated flood area into the hydrodynamic flow model is essential for one-dimensional flow modeling. To run a flood model effectively in HEC-RAS, three primary types of data are required: boundary conditions, flow data, and geometric data. Once these data are input, the software generates a plan file that visually presents the simulation results.
The HEC-RAS 6.0.1 software was used to simulate a one-dimensional unsteady-state gradually varied flow of the study area under different conditions. The software presented by United State Army Corps of Engineers that is used to analyze the river system. Data of 350 cross-sections were provided by the [Iraqi Ministry of Water Resources, DWRD] for the mainstream of Shatt al hillah used in the hydraulic model. The boundary condition is the constant discharge at the upstream and the normal depth at the downstream.
The geometric file contains a digital elevation model that provides elevation information for the research region in the particular context of 1D flood simulation. Additionally, it includes information on the lengths between the cross-sections of the rivers and streams that are part of the research region. The DEM file or a site survey may be used to determine these distances. Furthermore, the geometric file has to include data on the cross-sections' Manning's roughness inside the research region.When simulating unsteady flow, the flow file should include information on the river's flow hydograph, and when modeling steady flow, it should record the

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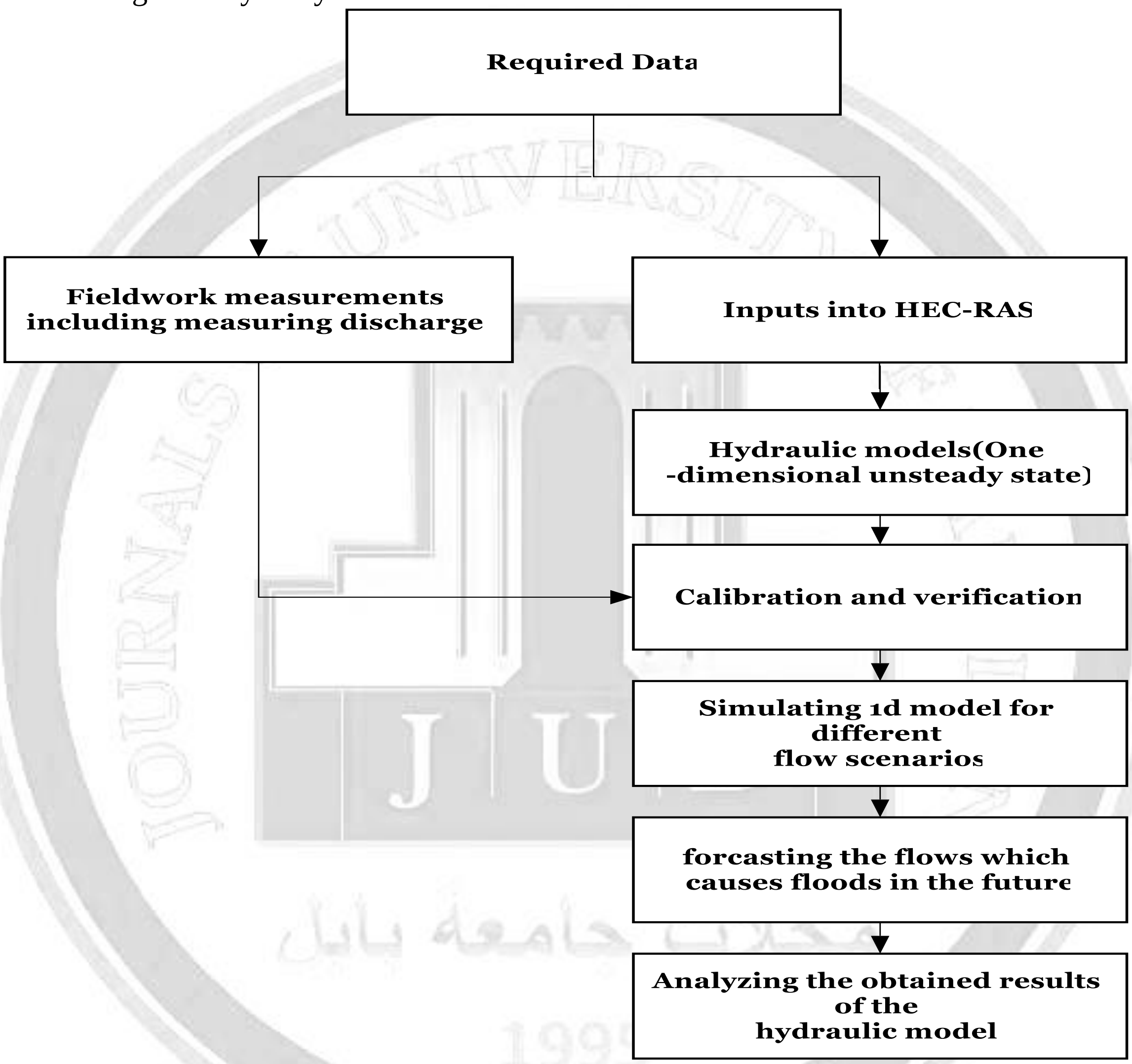
flow volume for a particular event. Configuring the flow parameters at the research area's upstream and downstream limits is essential for the Boundary Condition file. For downstream situations, this entails defining metrics like flow depth, normal depth status, and known flow hydrograph. The flow discharge hydrograph or the flow depth hydrograph can be used as the upstream boundary condition. Figure 1 illustrates the process of generating and setting up outcomes using a 1D hydrodynamic model within HEC-RAS.




**(Figure1)Flowchart Depicting the Process of Establishing a One-dimensional Hydraulic Model within HEC-RAS.**

## 3.Study Area and Data Description

The selected undertaking pertains to Shatt Al-Hillah project. This prominent branch originates from the left bank of the Euphrates River, immediately upstream of the recently constructed Hindiya Barrage. Its extensive extent spans approximately 97 kilometers, commencing from its source at kilometer 00.000, designated as the head regulator, and culminating at the Daghara head regulator, positioned at kilometer 97.000. Positioned roughly 100 kilometers to the south of Baghdad, the city of Hillah is traversed by the Shatt Al-Hillah, resulting in the city's division into two distinct segments (refer to Figure 2). Notably, the entirety of Hillah city's water requisites are contingent upon this watercourse**.**

The normal discharge rate of Shatt Al-Hillah for the period (2004-2022) ranges between 130 to 200 $m^3/s$ and water surface level It is hoped to develop and expand Shatt Al-Hillah to be able to pass a maximum discharge of 303$m^3/s$(desgin discharge), Study of Strategy for Water and Land Resources in Iraq, 2014.

The soil of the study area was characterized as transportable soil formed as a result of the accumulation of various sediments attracted by river water. To the sediments attracted by the winds from areas outside the region, and this requires the soil of the study area to be studied by stratigraphy.

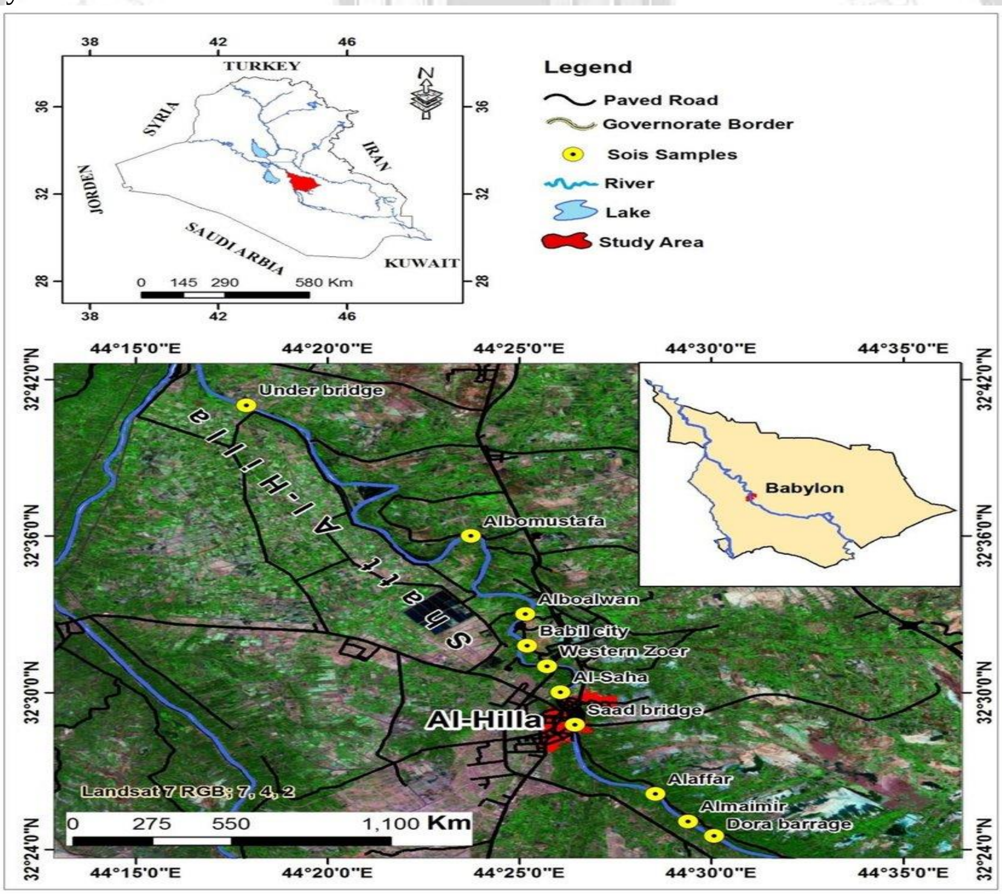



**Figure (2) Shatt Al-Hillah within the Studied Area**

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## 4.THE CALIBRATION AND VALIDATION

The calibration procedure is essential for ascertaining the optimal Manning's coefficient 'n' value along the main river channel in the designated study region. The value of Manning's 'n' is subject to variation across different sections of the river, contingent upon factors such as channel and floodplain conditions. These factors encompass surface roughness, vegetation, stage and discharge, as well as channel irregularity. The coefficient of Manning's 'n' might be notably high during periods of elevated water levels if the banks are characterized by a coarse and vegetated texture. However, typically, this coefficient diminishes as discharge gradually increases, as outlined by Te Chow (1988).

Within the current research endeavor, Manning's coefficient values were assigned to individual cross-sections based on empirical field investigations or prior studies pertinent to the study area, specifically focusing on the Shatt al-Hillah region. after to numerous iterations of the HEC-RAS simulation model, discernible disparities between the observed and computed water surface profiles were identified.

Manning's coefficient was calibrated using flow and matching depth data collected between September 2014 and September 2015.the water year 2014 was taken as amodel becuse it has the highest discharges.

The HEC-RAS model's dynamic flow analysis reveals that the 'n' values range from 0.020 to 0.030 for Shatt Al-Hillah. The river's stage measurements encountered uncertainties inherent in hydrographic data. In Figure 3 the comparison between simulated and observed stages for different Manning's roughness coefficient (n) values is illustrated, with Shatt Al-Hillah specifically having a value of 0.023. To assess Table 1 the accuracy, a statistical test was applied, utilizing Root Mean Square Error Criteria to compare computed and observed stages. provides the model results for these 'n' values and a designated time step (Δt = 1 month), including calibration outcomes for the statistical test.

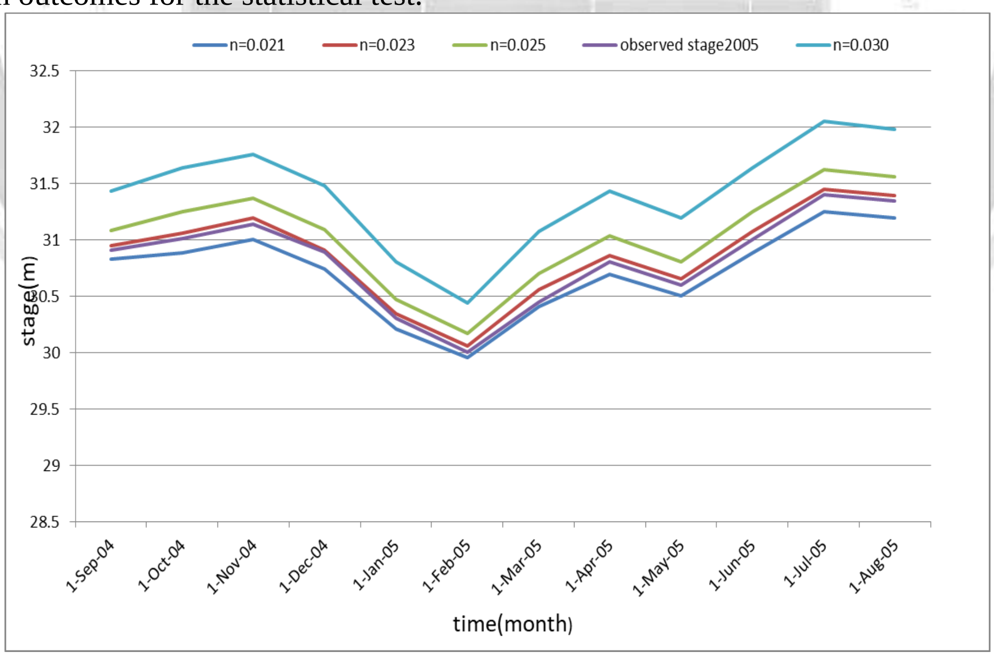


**Figure (3) Comparison between the Calculated and Observed Stage Hydrographs for Shatt Al-Hillah during the Water Year 2005 Across Varying Manning's Roughness Coefficients.**

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**Table 1 The calibration Results of Statistical test for the Shatt Al-Hillah Cross-section**

| The values of 'n' | R.M.S.E. values |
|---|---|
| 0.020 | 0.205 |
| 0.021 | 0.115 |
| 0.023 | 0.058 |
| 0.025 | 0.214 |
| 0.028 | 0.407 |
| 0.030 | 0.593 |

### 5. Resuls and Disicstions of Flood Scenarios Using the 1-Dimensional HEC-RAS Model

The maps of the flood are essential for managing flood risk because they reduce damage and loss from floods, particularly in areas with a high flood risk. Five different scenarios were used to simulate some designed flood events following the model calibration and the validation. These scenarios check flood boundary line for each flow event and assume that the study area will experience various flows. The simulation flow events that were used at the upstream boundary of the study area are listed in Table (2). based on previous information for the research region's typical flow range, This study employed these occurrences of fluid dynamics. Several possible scenarios were made to reach a discharge of 1500 $m^3$/s, so that the discharge reached 1620 according to the 1988 flood report issued by the Ministry of Agriculture (unpublished report).

**Table (2) -The Senarios of Flow Event**

| Senarioes Number | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| The Flow ($m^3$ /sec) | 250 | 400 | 600 | 800 | 1500 |

The effects of variations in the Shatt Alhillah discharge along the riverbanks were identified by producing 1-D flood map for the research area. From Figure (4) to Figure (8), the 1-D maps of flood for each flow event listed in the Table (2) which displayed for three cross sections in the shatt alhillah in hillah city: Section (A-A) was taken in station 40+000 km, Section (B-B) in taken in station 45+000 km, and taken in station 50+000 km. From the Hec-Ras outputs, found the velocities vary between (0.002 –1) m/s.

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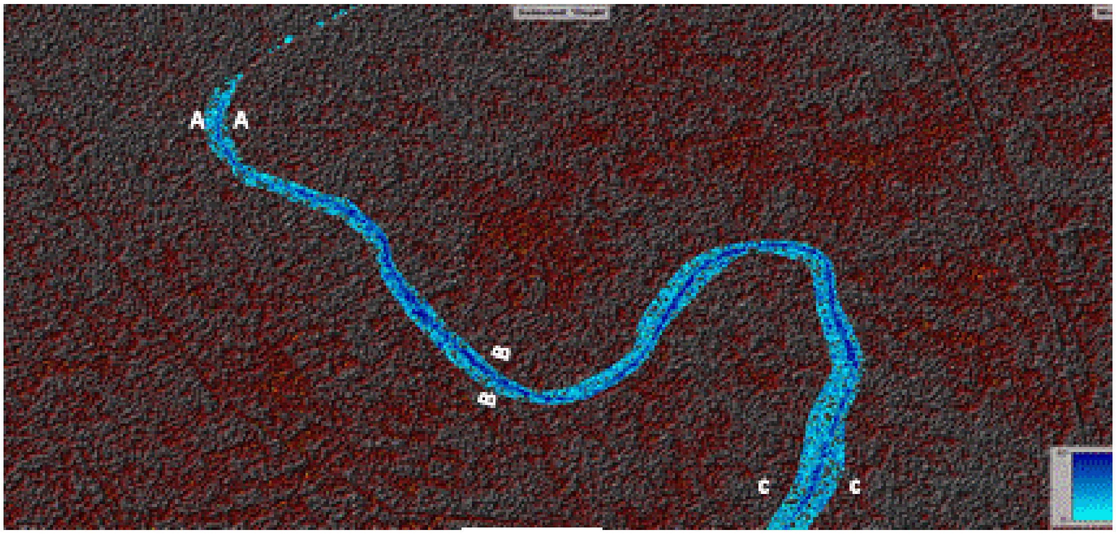


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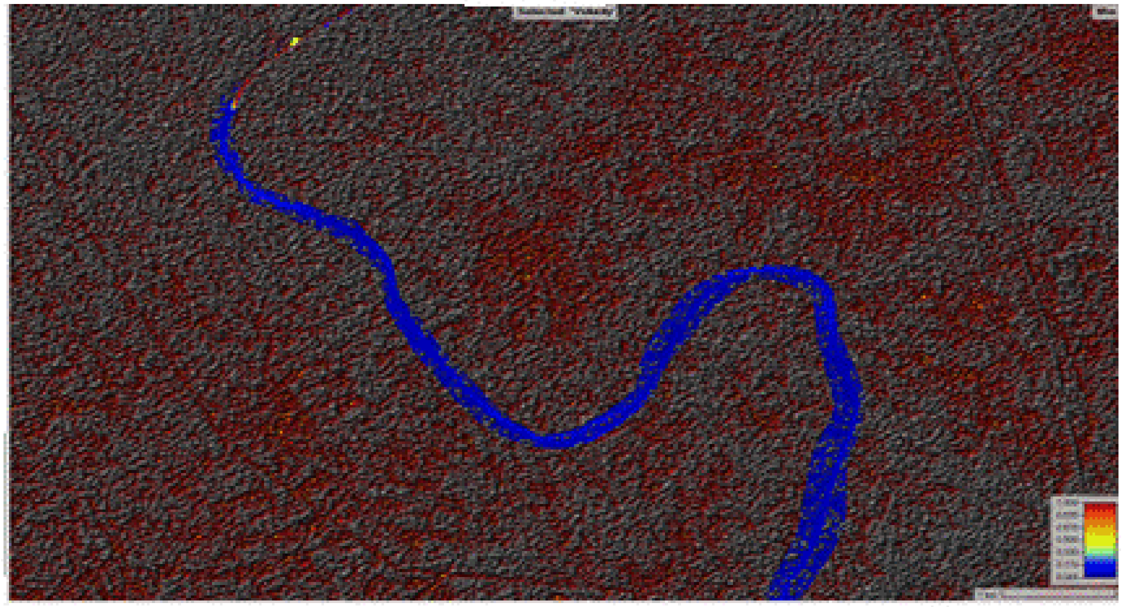

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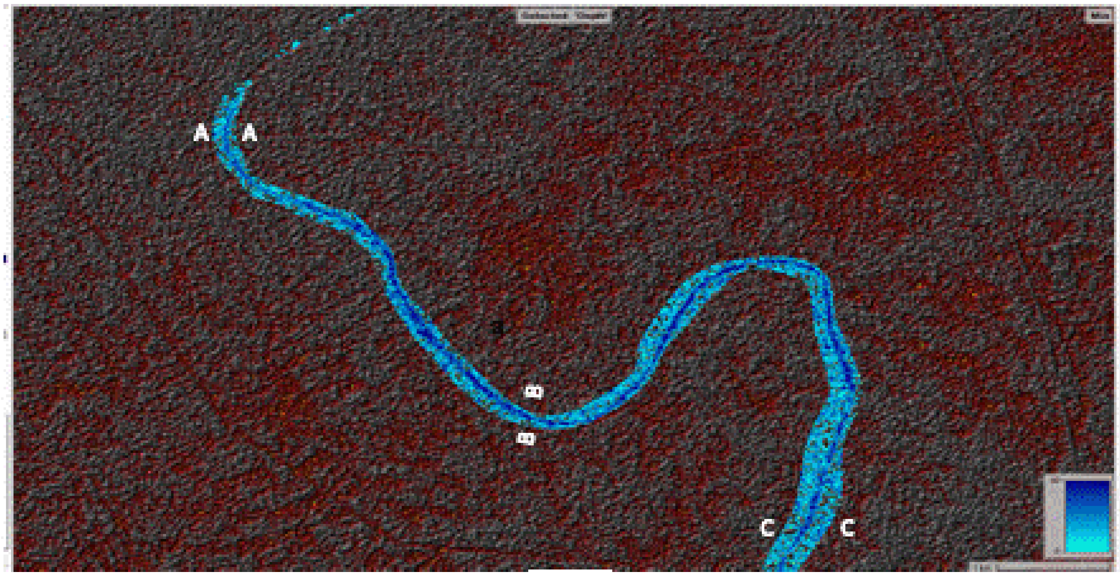
Figure (4) The Ras Map for the First Scenario Flow = 250 m3/sec: (a) with depth of flow; (b) with Velocity

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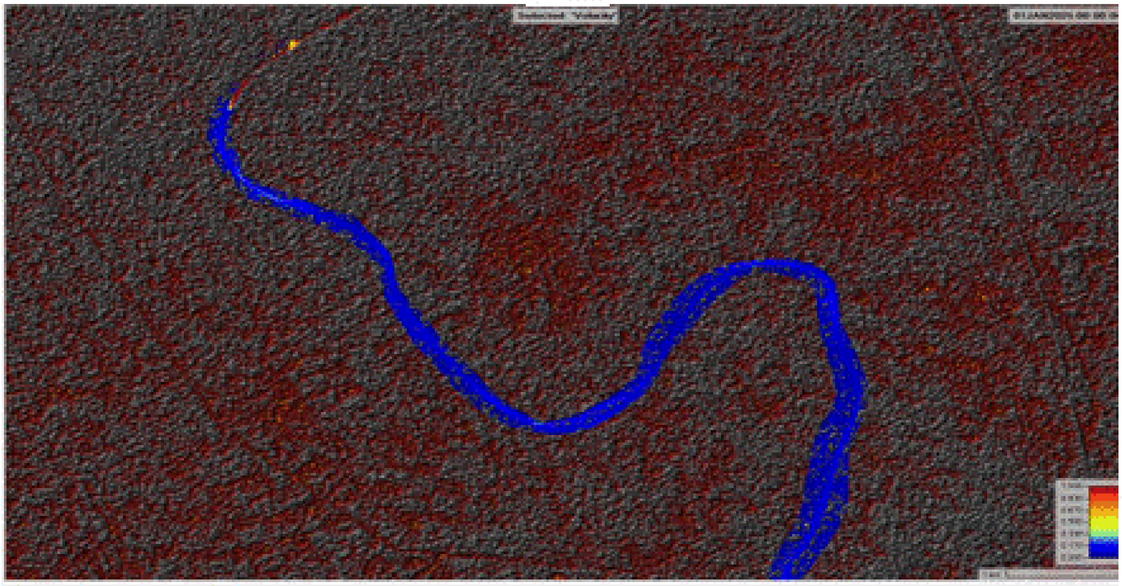

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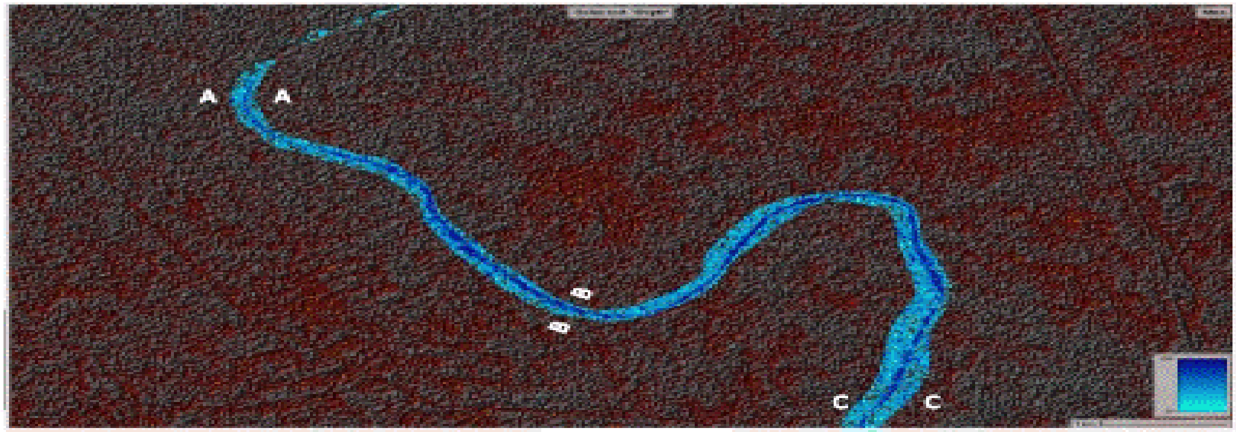
Figure (5) The Ras Map for the secend Scenario Flow = 400m$^3$/Sec: (a) with Depth of Flow (b)with Velocity

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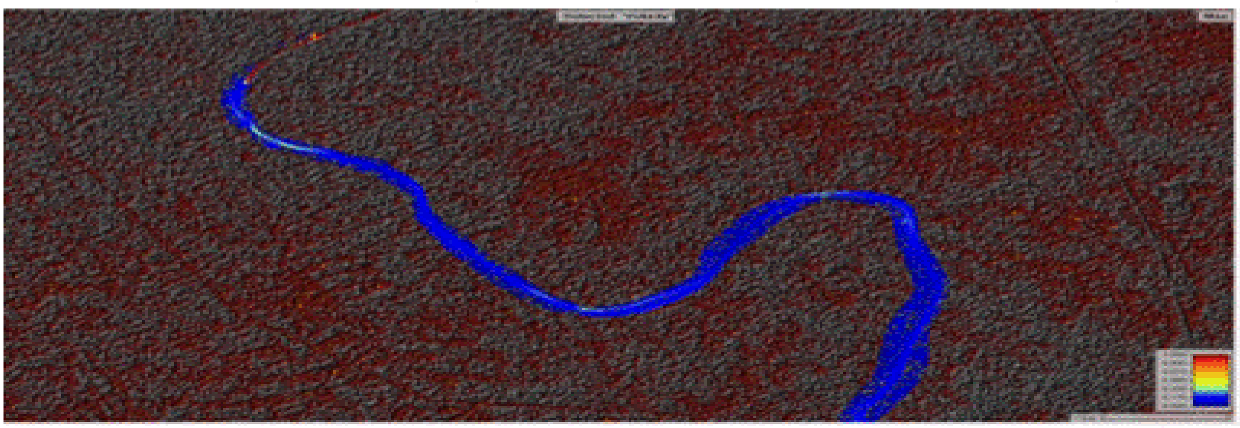

b

Figure (6) The Ras Map for the third Senario Flow = 600m$^3$/Sec:(a) with Depth of Flow (b)with Velocity

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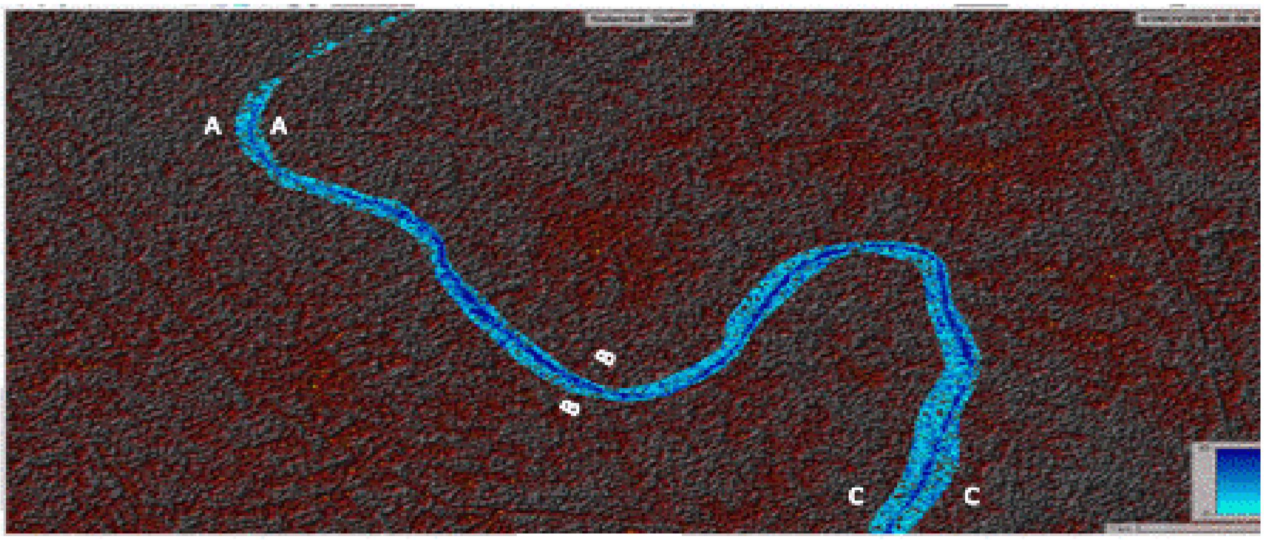


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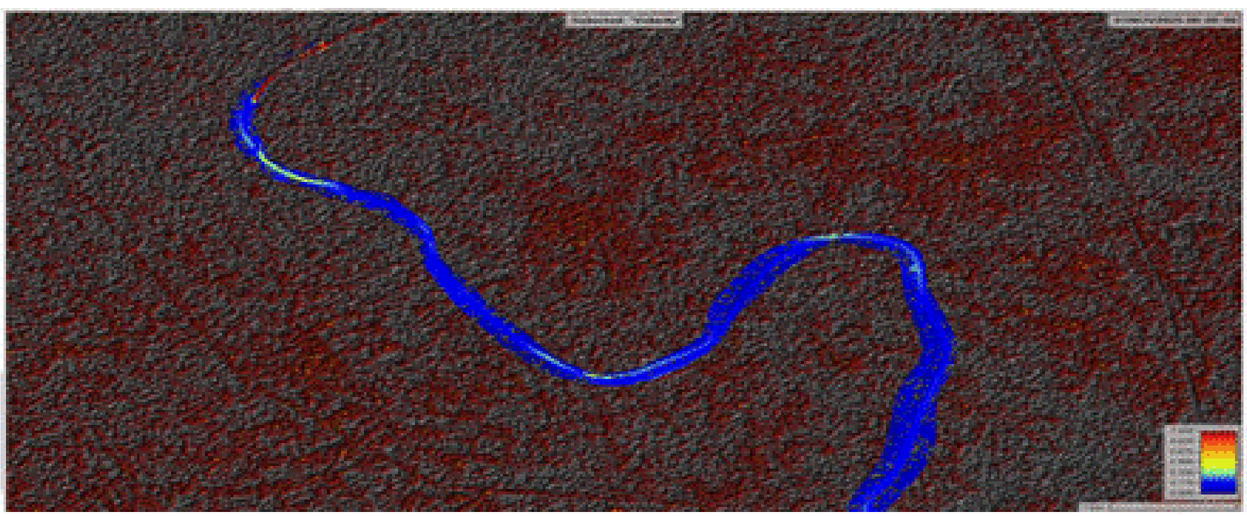

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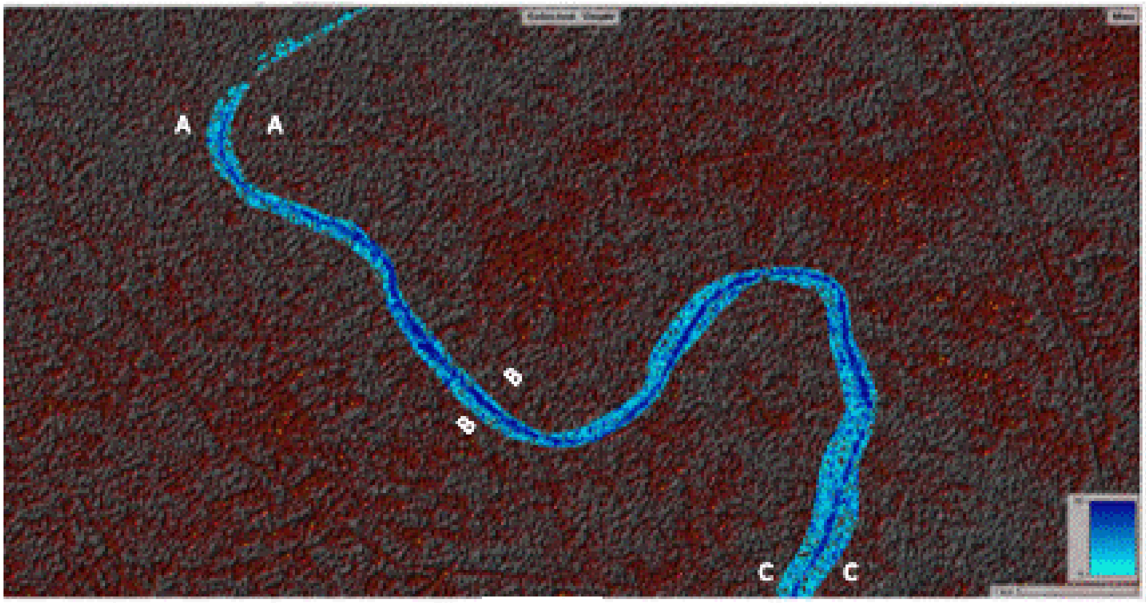
Figure (7) The Ras Maps for the Senario No.4 Flow = 800m$^3$/Sec:(a) with Depth of Flow (b)with Velocity

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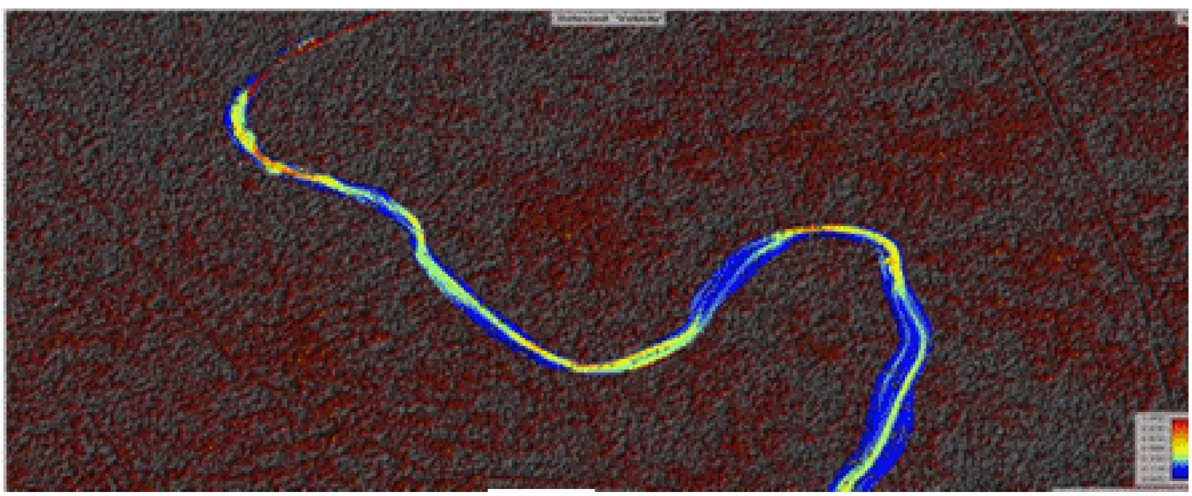

b

Figure (8) -The Ras Maps for the Senario No.5 Flow = 1500m$^3$/Sec:(a) with Depth of Flow (b)with Velocity

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Furthermore, Figure (9) to Figure (11) indicate the water surface elevation for each cross section during the various flow events that pass through the research region.

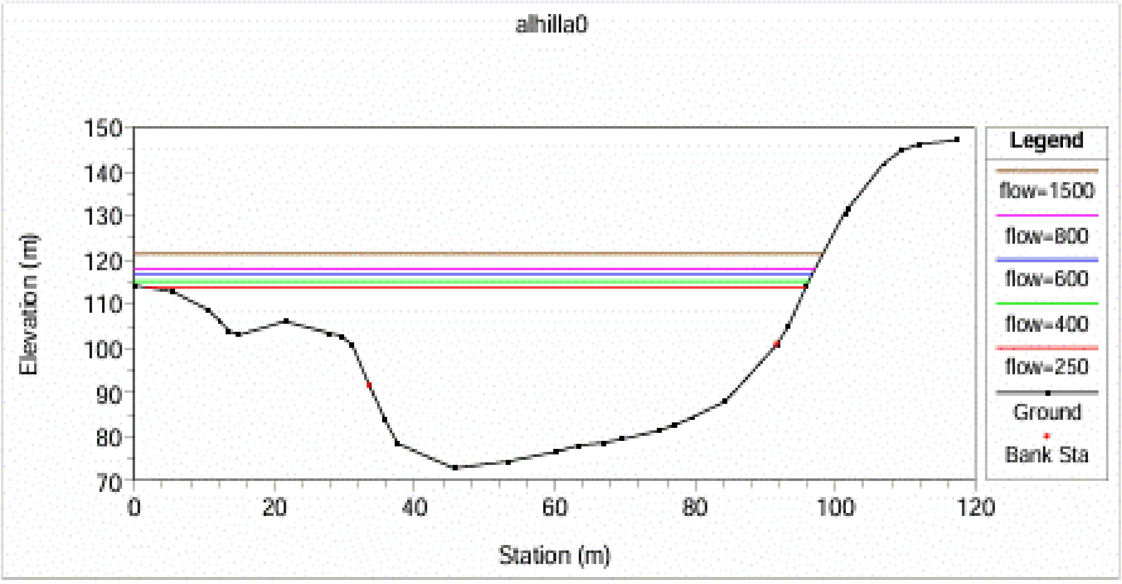
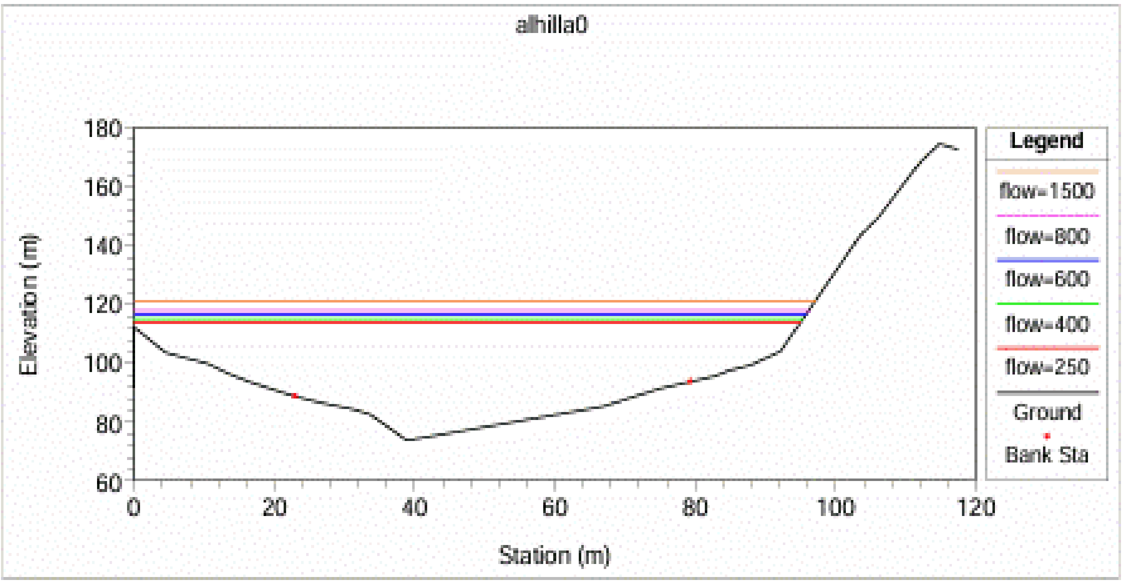



Figure (9)Cross-section A-A at Various Flow Condit




Figur(10) Cross-section B-B at Various Flow Conditions

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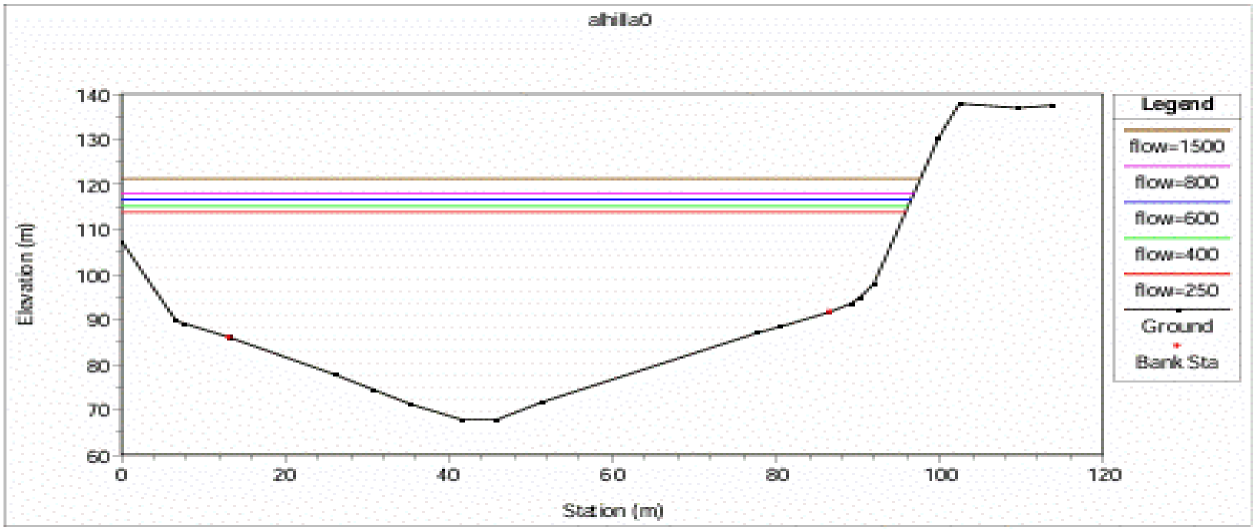


Figure (11) Cross-section C-C at Various Flow Conditions

It is obvious from all flood scenarios that the magnitude of the flooded areas grows with the increase in the amount of discharge flowing through the river. This increase is more noticeable and evident in the left portion of the riverbanks due to lower ground levels than the right riverbank, which is dominated by the river's high elevation in most parts. All sections overflow because the maximum discharge that Shatt al-Hillah can bear is 205m$^3$/sec.

## 6.Conclusions

The study focused on addressing flood risk through the establishment of a 1-D flood model, using the banks of shatt alhillah as a case study. Employing the Hydrological Engineering Center-River Analysis System (HEC-RAS), the model quantified the potential flood-prone area under various flow events along the study area. Calibration and validation of the 1-D model were conducted using field-measured data, ensuring its accuracy. Subsequently, the model of validated was applied in different flow scenarios to assess the extent of the flooding area. The findings revealed a higher flood risk in the western part of the riverbanks, attributed to the lower ground level on the west riverbank. This risk intensified with increased river discharge. Beyond contributing to enhanced safety and reduced flood risk, the study serves as a foundation for further investigations, including the integration of these findings with assessments of flood wave travel and arrival times in areas.

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# التنبؤ بتصريفات الفيضانات المستقبلية ذات التدفق أحادي البعد دراسة حالة: شط الحلة

فائز حسين المرعب بنين محمد هلال

*قسم الهندسة المدنية /كلية الهندسة/جامعة بابل بابل*

**الخلاصة**

وتحتل الفيضانات مرتبة عالية بين الكوارث الطبيعية المتكررة، مما يتسبب في خسائر اقتصادية عالمية واسعة النطاق ويعرض حياة البشر للخطر. ولذلك، فإن التنبؤ بالفيضانات أمر بالغ الأهمية. يعتبر شط الحلة حيويا لإمدادات المياه، بما في ذلك الاستخدامات الصناعية والزراعية و المدنيه لثلاث محافظات عراقيةهي بابل والديوانية والمثنى ومصدرها نهر الفرات. تهدف هذه الدراسة إلى تقييم قدرة تصريف شط الحلة في ظل الظروف الحالية والتنبؤ بالتصريفات المحتملة التي قد تسبب الفيضانات..

تم تطوير نموذج أحادي البعد، الإصدار Hec_ras6.0.1، لمحاكاة سيناريوهات الفيضانات المحتملة. تمت معايرة النموذج ومعرفة عن معامل الخشونة بقيمة n=0.023. تم التحقق من صحة نتائج الفيضانات المحاكاة بواسطة HEC–RAS عن طريق معادلة الجذر المتوسط للخطأ (RMSE) بين البيانات المحاكاة والمرصودة، حيث كان معامل RMSE لمعايرة شط الحلة 0.058 في نطاق مناسب. تبلغ القدرة الحالية القصوى لشط الحلة 205 م$^3$/ثا ولا يمكنه استيعاب التصريف التصميمي 303 م$^3$/ثا. ومع ذلك وباستخدام عدة سيناريوهات مع تصريفات أكبر من 205 م$^3$ / ثانية، وجد أن بعض الأقسام تتعرض للفيضانات عند زيادة التصريف. وتزداد المناطق المعرضة للفيضانات مع ارتفاع التصريف النهري وعندما يصل التصريف إلى 450 م$^3$/ثانية يتسبب في حدوث فيضانات في أكبر عدد من الأقسام.

**الكلمات الدالة:** الفيضان، التصريف، معامل الخشونة.