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ISTANBUL GEDİK NIVERSITY
INSTITUTE OF GRADUATE STUDIES

EFFECT OF USE OF GROYNES ON THE BEHAVIOR OF FLOW AND SEDIMENT IN THE RIVER (EUPHRATES RIVER IN IRAQ AS A CASE STUDY)

MASTER THESIS

Ruaa Naser Hussein HUSSEIN

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Thesis Advisor: Assoc. Prof. Dr. Redvan GHASMLOUNIA

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Yüksek Lisans Tez Onay Belgesi

Enstitümüz, Civil Management Department İngilizce Tezli Yüksek Lisans Programı (211291008) numaralı öğrencisi Ruaa Naser Hussein HUSSEIN'in "Effect of Use of Groynes on the Behavior of Flow and Sediment in the River (Euphrates River in Iraq as a Case Study)" adlı tez çalışması Enstitümüz Yönetim Kurulunun 08/06/2023 tarihinde oluşturulan jüri tarafından *Oy Birliği* ile Yüksek Lisans tezi olarak *Kabul* edilmiştir.

<u>Öğretim Üyesi Adı Soyadı</u>

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1) Tez Danışmanı: Doç. Dr. Redvan GHASEMLOUNIA

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DECLARATION

I Ruaa Naser Hussein HUSSEIN as a result of this declare that this thesis titled “Effect of Use of Groynes on the Behavior of Flow and Sediment in the River (Euphrates River in Iraq as a Case Study)” is original work I did for the award of the master's degree in the faculty of Civil Engineering Program I also declare that this thesis or any part of it has not been submitted and presented for any other degree or research paper in any other university or institution. (08/06/2023)

Ruaa Naser Hussein HUSSEIN

DEDICATION

To

My wounded homeland and the blood of the martyrs that bleed over it « My Iraq»

To

whom I miss his applause for the joy of my achievement at this moment, but I never missed his prayers, whose fruits I reap every moment. To whom I have raised my head over time to be proud of, and I will remain **« My Dad»**

TO

Affectionate... that I can't find words that can give her right, to the source of love, altruism, and generosity **« My Mom»**

May God prolong her life and grant her health and wellness

To

To those who helped and supported me and those on whom I relied «**My brothers & sisters**»

To

all those who supported me and gave me advice and help **«Relatives and Friends»**

I dedicate to you my humble research

PREFACE

Praise be to God, Lord of the worlds, and thanks and praise be to God Almighty for blessing me with patience and strength.

I extend my sincere thanks and great gratitude to my colleagues at Istanbul Gedik University and the postgraduate staff in the Department of Civil Engineering.

I thank Dr Redvan Ghasemlounia, the supervisor of this research, for the support and assistance he provided me throughout the research period. And thanks to everyone who urged me and instilled in me the will and to all of us who gave me a helping hand throughout the research period.

June 2023 Ruaa Naser Hussain HUSSAIN

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ABBREVIATIONS

SSIIM	: Sediment Simulation In Intakes with Multiblock Option
CFD	: Computational Fluid Dynamics
ANSYS	: Analysis Systems
SST	: Shear Stress Transport
TKE	: Turbulence Kinetic Energy
ASCII	: American Standard Code for Information Interchange
ADCP	: Acoustic Doppler Current Profile
GPS	: Geographic position system
ADP	: Acoustic Doppler Profile
B	: Width of River
D	: Depth of Water
ASTM	: American Society for Testing and Materials
Q_s	: Suspended Sediments Discharge (kg/s)
C	: Suspended Sediment Concentration (mg/l or ppm)
Q	: Water Discharge (m^3/s)
L	: Left
M	: Mid
R	: Right
NTUN	: Norwegian University of Science and Technology
i j and k	: The grid Indications in SSIIM's Grid
ppm	: Concentration Unit Particles Per Million

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EFFECT OF USE OF GROYNES ON THE BEHAVIOR OF FLOW AND SEDIMENT IN THE RIVER (EUPHRATES RIVER IN IRAQ AS A CASE STUDY)

ABSTRACT

This thesis focuses on the side of sediment's effect and its problems with erosion and accumulation. In this study, Because of the flattening of the soil surface in Iraq, the formation pattern of rivers is mostly tortuous within a few distances. So that this study depended on one of the Computational Fluid Dynamic (CFD) programs called SSIIM was used. Where a systematic plan was developed to carry out the research, which included data collection, analysis, classification, and fieldwork which included sampling, measuring velocity, dimensions of the study area, and river discharges. As for the laboratory works, it included sieve analysis of the soil, calculating sediment concentrations, and finding the field density of the soil.

A comparison was made between the amount of sediment for several sections, and the results were compared with the results of the model. Section No. 2 was selected as the flow entry section into the area, and section 13 was selected as a control section, and the results were compared between the model and the field results.

The sediment transport study in the river has yielded valuable insights into the distribution of sediment in different scenarios.

The results indicate that scenario 4 demonstrated the highest percentage, capturing 41% of the total annual trapped sediment in cubic meters. This finding suggests that scenario 4 holds promise for designing and implementing groynes in the region, supporting our initial hypothesis.

The results of the sediment transport study have identified scenario 4 as the most favorable for designing groynes in the region. The varying percentages across the scenarios emphasize the need for continuous evaluation and modification of design parameters to optimize sediment trapping efficiency. By addressing factors such as groyne location, alignment, spacing, and flow dynamics, it is possible to enhance sediment control measures and contribute to the sustainable management of the river system.

Keywords: *Embankment use in rivers, Preventing erosion in rivers, Iraq Euphrates River*

SET KULLANIMININ NEHİRDEKİ AKIŞ VE TORTU DAVRANIŞI ÜZERİNDEKİ ETKİSİ (IRAK'TA FIRAT NEHRİ ÖRNEĞİ)

ÖZET

Bu tez, tortunun etkisi ve erozyon ve birikim ile ilgili sorunlarına odaklanmaktadır. Bu çalışmada, Irak'ta toprak yüzeyinin düzleşmesi nedeniyle, nehirlerin oluşum paterni çoğunlukla birkaç mesafe içinde kıvrımlıdır. Bu nedenle bu çalışmada SSIIM adı verilen Hesaplamalı Akışkanlar Dinamiği (CFD) programlarından biri kullanılmıştır. Araştırmayı yürütmek için veri toplama, analiz, sınıflandırma ve örnekleme, hız ölçümü, çalışma alanının boyutları ve nehir deşarjlarını içeren saha çalışmasını içeren sistematik bir planın geliştirildiği yer. Laboratuar çalışmalarında ise toprağın elek analizi, sediman konsantrasyonlarının hesaplanması ve toprağın tarla yoğunluğunun bulunması yer almıştır.

Birkaç kesit için sediman miktarları arasında karşılaştırma yapılmış ve sonuçlar modelin sonuçları ile karşılaştırılmıştır. Alana akış giriş bölümü olarak 2 No.lu Bölüm, kontrol bölümü olarak da 13. Bölüm seçilmiş ve sonuçlar model ile arazi sonuçları arasında karşılaştırılmıştır.

Nehirdeki tortu taşıma çalışması, farklı senaryolarda tortu dağılımına ilişkin değerli bilgiler sağlamıştır.

Sonuçlar, senaryo 4'ün en yüksek yüzdeyi gösterdiğini ve metreküp cinsinden toplam yıllık hapsolmuş tortunun %41'ini yakaladığını göstermektedir. Bu bulgu, senaryo 4'ün bölgedeki koruganların tasarlanması ve uygulanması için umut verici olduğunu ve ilk hipotezimizi desteklediğini göstermektedir.

Sediment taşıma çalışmasının sonuçları, senaryo 4'ü bölgedeki oyukların tasarımı için en uygun senaryo olarak belirlemiştir. Senaryolar arasında değişen yüzdeler, tortu tutma verimliliğini optimize etmek için tasarım parametrelerinin sürekli olarak değerlendirilmesi ve değiştirilmesi ihtiyacını vurgulamaktadır. Groyne konumu, hizalama, aralık ve akış dinamikleri gibi faktörleri ele alarak, tortu kontrol önlemlerini geliştirmek ve nehir sisteminin sürdürülebilir yönetimine katkıda bulunmak mümkündür.

Anahtar kelimeler: *Akarsularda set kullanımı, Akarsular erozyonu önleme, Irak Fırat Nehri*

1 INTRODUCTION

The river is an ever-changing environment and it is in constant motion and a carrier of water, sediment and nutrients from the catchment area. Rivers in Iraq are of a dynamic nature and the rivers follow a zigzag pattern. Because of the erosion of the banks due to the frequent interruptions of the navigation system, rapid sedimentation at low flow is very common, and there is a loss of neighboring lands and sedimentation in the opposite lands.

There are various techniques to protect the banks of rivers from erosion, such as cement, soil, stone, vegetation cover, etc. However, groynes was used because it is effective in protecting and stabilizing the beach to reduce flows, as well as they can provide common benefits for recreation and tourism by contributing to the expansion of the beach.

A groynes can be defined simply as a solid hydraulic structure built perpendicular to the river bank, which cuts off the flow of water and limits the movement of sediments. It is made of either wood, concrete or stone.

In this research, the sphere was used to solve the erosion problems of a meandering river, and a number of scenarios were used to use the sphere. The shape of the sphere, length, number, permeability, and spacing are the important factors in the design. There are many numerical and experimental researches on laboratory channels conducted on laboratory experiments, few of which were conducted on rivers. For a better and detailed understanding of the behavior and hydrodynamics of flow analysis software can be used.

Modeling and analysis in CFD have become a common solution for simulation on computers, as the difficulty in applying the laws of physics directly to real-life scenarios in order to make analytical predictions has increased.

1.1 The objective of Study

This study aims to calculate the quantities of sediment and silt in the river. In this study, four different scenarios have been built for the distribution of groynes in the river, and through research, the best scenario has been determined to sequester (trapped) the largest amount of sediment.

The best scenario that reserved the largest amount of silt was the fourth scenario. This study provided a complete picture of what is expected from the annual sediment quantities, which amounted to (1,20 x 10^5) tons, or the equivalent of (4,46 x 10^7) cubic meters.

The correct prediction of sediment quantities gives strength to the hydraulic engineer and the departments of river management specialized in river dredging by determining the costs of sediment removal in a way that is close to reality. The door is still open for other studies to delve deeply into the subject of spheroids.

1.2 Methodology of The Study

This study starts from:

1- **Data collection**: This study included collecting data from many sources, some of which were available and some of which were difficult to obtain. It included obtaining hydrological data and the quantities of discharges from the Department of Dams and Reservoirs Management in Iraq, as well as from previous studies, in-kind observations, and coordinates.

2- **Field work:** The field work included collecting samples from the study area (the Euphrates River in the city of Musayyib), taking measurements of the river (such as speed, coordinates, dimensions, and depths).

3- **Laboratory work:** It included sieve analysis, soil density calculation, and suspended sediment concentration calculation.

4- **Creating and operating the model:** The manufacture of the model included creating a network for it, entering the necessary data to operate it, making simulations and obtaining the results.

5- **Decision making**: In this step, the results obtained were relied upon.

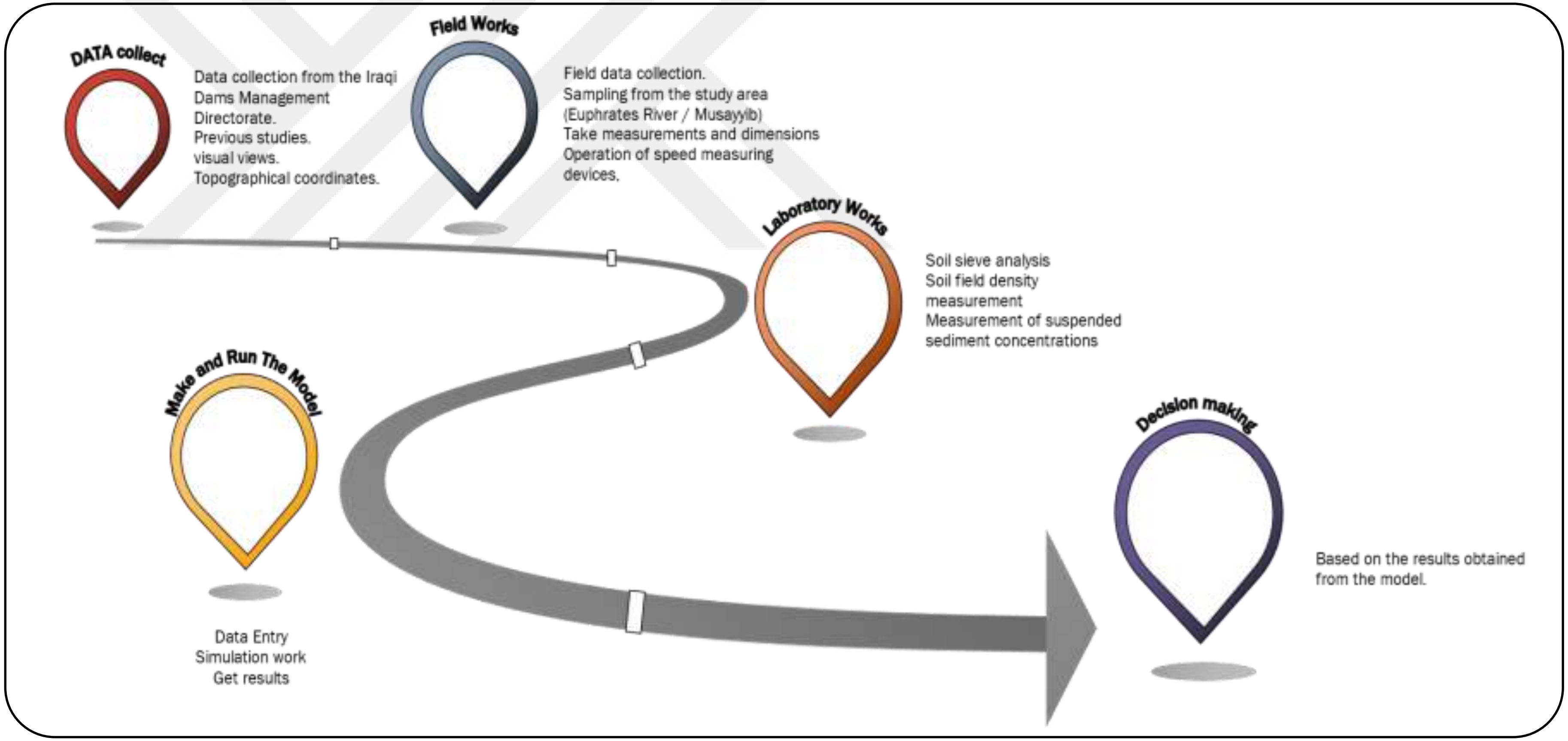


Figure 1.1: The Diagram of the Methodology of the Study

2. LITERATURE REVIEW

One of the major global public issues, at least in some nations, is river bank erosion. Long-term effects on human life are caused by river bank erosion. As they become penniless, the victims are forced to relocate. On the other hand, river ecology is also impacted by the changing flow of rivers (natural or man-made), which is caused by bank erosion. (Das, T.K., et al; 2014).

The most typical constructions used to address issues with bank erosion are groynes. They serve as training exercises for controlling rivers. They have traditionally been described as hydraulic structures that extend outward or perpendicularly from the bank stream into the streamline. They provide a variety of functions, including preventing bank erosion, slowing flow velocity along river banks due to their roughness, preserving navigation channels, and regulating flow into or out of bends in meandering channels. (Ibrahim, M.M., 2012).

Several earlier studies and investigations addressed the grooves and offered data that aided in the advancement and growth of scientific study. Because it gives us a general concept of our issue, it helps us save time and effort.

There is a wealth of information connected to grooves from earlier studies, which also present many of the questions we have about this topic. In the lines below, we reviewed part of it.

K. W. Tomlinson & Price, W.A. describing tests carried out in a wave basin to study the influence of canyons on a beach that was stable for a given wave climate and a given supply of coastal material. The main finding was that on the part of the beach between the HW and LW levels, the gullies did not produce any build-up. The only seaward accumulation occurred from impermeable gullies. Separate grooves made a little impact both onshore and offshore. (Price, W.A., et al; 1969).

In terms of physical, economic and environmental efficiency, the researcher (Wim S. Uijttewaal, 2005,) has replaced standard gullies found in major rivers in Europe with alternative designs. The experiments were conducted in a physical model of a planned river tide, scaled down to a quarter of its actual size, to examine the effects of the different forms of thegroyne on flow in a groyne field. Four different types of striated grooves, including standard reference grooves, headed grooves that have a gentle slope and extend into the main channel, permeable grooves formed by pile rows, and hybrid grooves composed of an impermeable groin lowered with a pile row on top, All tested. Using particle tracking velocimetry, flow velocities were calculated. The experiment was set up so that the cross-sectional area of the groyne ray covers the same amount of area under each condition. The strength of vortex precipitation and recirculation in the groyne field varied depending on the shape of the bent head and the depth of immersion. To understand physical processes such as eddy generation and dislocation near the groyne head, experiment with Altering clear that altering the permeability and slope of the femoral head can alter the upstream and downstream turbulence characteristics of the femur. In addition, it has been found that under submerged conditions, the flow becomes complex and is locally dominated by 3D effects, which makes it difficult to predict using medium-depth numerical models or 3D models with coarse resolution in the vertical direction. We would like to point out here that the researcher did not study what the results would be in the case of the groynes being semi-submersible. The model was applied within fixed and unchanging dimensions. (Uijttewaal, W.S., 2005).

(Joong Kan, Hongkou Yeo, Sungjung Kim & Un Ji, 2011,) report the findings of an experimental investigation of the flow properties around groin structures with different shapes and permeabilities. Considered are the triangular-shaped groins, the permeable pile, and the impermeable rectangular. The highest velocities were determined using an acoustic Doppler velocimeter, while the velocity fields were seen using large-scale particle image velocimetry. For the impermeable rectangular groin, a broad range of the recirculation zones and an enhanced velocity at the groin tip were seen. The velocity at the groin tip, the vortex intensity, and the size of the recirculation zone all tended to decrease as the gaps between the piles grew for the permeable pile groin. In addition, the triangular groin also created longer, narrower recirculation zones than the identical-sized permeable pile groin. (Kang, J., Yeo, et al;2011).

To better understand the dynamics of the flow near groynes, (Mohamed F. M. Yossef1 and Huib J. de Vriende, 2011) conducted experiments in a flat-bottomed stream to achieve a straight, striped river with gullies on one side of the geometric scale of the flume was 140 and was based on the average measurements of the Dutch River Waal. We looked at emergent and submerged groynes. The measurements show the variations in turbulence between the submerged and emerged groyne stages; they also shed light on the flow pattern near groynes, the size and extent of the mixing layer at various flow stages, and the dynamic behaviour of the velocity along the mixing layer between the main channel and the groyne fields. The flow near groynes' turbulence properties is parameterized and displayed. In the mixing layer's centre and at places around its edges, the large-scale u and v velocity fluctuations are in phase, respectively (Yossef, M.F., et al; 2011).

(Zhang and Nakagawa, 2016) studied the sorting of sediment at a nearby scour and around a group of groynes. His experiment was carried out in a lab flume that had a constant bed slope. In his research, impermeable straight groynes were employed. The groynes measure 10 centimetres in length, 1 centimetre in width, and 20 centimetres apart. Two different types of homogeneous silica sands with a mean diameter of d50=1.03mm were used to create a 20 cm thick moveable bed. Experiments were carried out in two cases—submerged and non-submerged groynes—under identical discharge. The outcomes demonstrated that groynes had an impact on the retention of small sediment particles. The fine particles' placements and the submergence levels e affected their patterns. Within the scouring hole, the silt at the bottom is coarser than that at the top, and the localized scouring zones have been 5 coarsened. Additionally, in both submerged and non-submerged scenarios, the scales and sizes of the mean grain of the two fine sediment zones vary. Finally, the enormous scoring hole and the fine sediment downstream of the first groyne were significantly impacted. (Zhang, H.,2016).

Using ANSYS Fluent, Kumar and Malik (2016) conducted a numerical 3D simulation to examine the flow around several groynes. As seen in Figure II.2, the flow around five different single groynes was investigated using the FD analysis. The model simulates the flow in a rectangular channel with zero slope groynes situated 2 meters upstream of the channel. Around the lone groyne, the flow was induced. There were two distinct discharges used. The findings demonstrated that, compared to other groynes, the variation of the vortex at the groyne's foundation, known as SG45, is more compact and potent. Using ANSYS Fluent, Kumar and Malik (2016) conducted a numerical 3D simulation to examine the flow around several groynes. As seen in Figure II.1, the flow around five different single groynes was investigated using the FD analysis. The model simulates the flow in a rectangular channel with zero slope groynes situated 2 meters upstream of the channel. Around the lone groyne, the flow was induced. There were two distinct discharges used. The findings demonstrated that, compared to other groynes, the variation of the vortex at the groyne's foundation, known as SG45, is more compact and potent. (Malik, A., 2016).

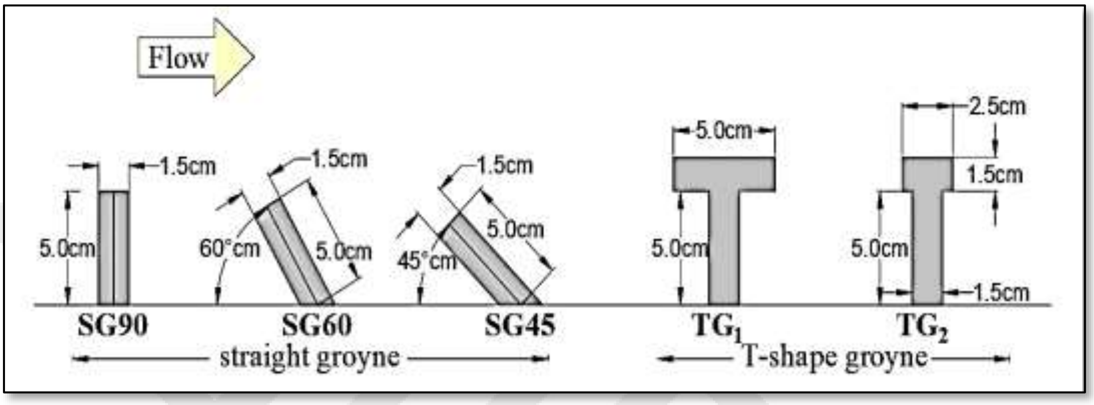


Figure 2.1: The Five Shapes of Groynes Used

Source: (Malik, A., 2016).

Numerical and experimental hydraulic modelling of flow around spur dikes was performed by Ahmed et al. in 2017. The simulation of the flow around straight groynes using CFD software was validated using the model of the experiment. experiments performed with a flume that has a fixed zero slope. a 20 cm thick, very gritty sand utilized as the bed with a mean diameter of 1.46 mm. Groynes in the T and L forms with 2 cm thick walls and ratios of 20, 30, and 40% of the flume width were used. All of the trials used non-submerged groynes conditions. Two portions, 0.5 and 1 meters from the last groyne were used to measure the validation data. They have groyne numbers of 1, 2, and 3 as well as angles of inclination with the upstream that are 45°, 90°, and 135°. This work used a simulation of the theoretical k-turbulence model, which exhibits good agreement with the data. The results demonstrated that varying lengths of groynes within each bank with the same rate of constriction were required to realign the line of the thalweg. The main requirement for improving the river environment is the provision of low velocity, which can occur between a succession of groynes that are all aligned with the flow direction and have an area that is at least twice as long as each groyne. Finally, each scenario assigns the best conception of 7 using groynes for river repair using raising water levels, moving the thalweg's alignment, and shielding piers and pump intakes from scour. (Ahmed, M., et al; 2017)

In a rectangular channel with a constant bed slope, Marak and Saikia (2018) conducted an experimental study of velocity distributions due to permeable and impermeable spur dikes. Figure II illustrates the usage of two distinct types of straight spur dikes, permeable and impermeable, with dimensions of 10 cm in length and 5 cm in width. A meter has been placed between the channel intake and the spur dike. Additionally, it was positioned at three different angles: 60°, 90°, and 120°, respectively. A non-submerged spur-dike, two Froude numbers, three different angles, and a spur-dike were used to stimulate the experiments. The findings demonstrate that when there was spur-dike flow in an open channel, the Froude number was higher than 1. As a result, the flow is When compared to spur-dikes set at other angles, an impermeable spur-dike that is placed at 90 degrees has a significant influence. Contrary to a permeable spur dike, it is costly. (Marak, D.R., et al; 2018).

Figure 2.2: The Experimental Model of a Spur Dike That Is both Permeable and Impervious

Source: (Mark and Saikia, 2018)

To increase the power output of instream turbines, Canilho and Fael (2018) examined the velocity field of a meandering trapezoidal channel that had been shortened by spur-dikes. Three examples with straight spur-dikes in varying orientations equal to 45°, 90°, and 135° were simulated using CFD software, ANSYS Fluent. The simulation's outcomes were contrasted with those of comparable scenarios without spur-dikes. The outcomes of spur-dikes protecting the bank by lowering the side-dike velocities were as anticipated. This created a space at Groyne opposite where turbines or other power generation equipment might be put.

Furthermore, compared to a typical situation without spur-dikes, it can provide up to 85% more power. (Canilho, H. et al; 2018).

To better understand the flow, erosion, and sedimentation patterns around various groynes under various hydraulic and geometrical circumstances, Choufu et al. 2019 carried out a numerical investigation. FLOW-3D software was used to simulate numerical modelling for the flow around several impermeable straight groynes that were not submerged. Groynes coordinated at an angle of 45° from large to small were found to reduce scour depth by up to 55%, and groynes coordinated at an angle of 135° from small to large were found to reduce scour depth by up to 72%. Furthermore, it was found that, in comparison to other simulations, simulations with an orientation closer to 90o required longer times to reach equilibrium. (Choufu, L., et al; 2019).

In their 2019 study, Dutta and Kalita looked at the effectiveness of straight-head and threaded groynes in river training structures. With and without two different types of groynes, flow around the bend of an open channel and the contour of a fictitious curve as illustrated in Figure II.3 were both simulated using a numerical model, MIKE21C modelling software. To determine where scouring and deposition occur, open channel flow without groynes was first simulated. Seven groynes were subsequently set up at the scouring spot. To safeguard the outside of the channel's curvature, comparing the performances of straight-head and T-head groynes is necessary. It has been discovered that due to the curvature of the rivers, T-head groynes are more practical than straight-head groynes.

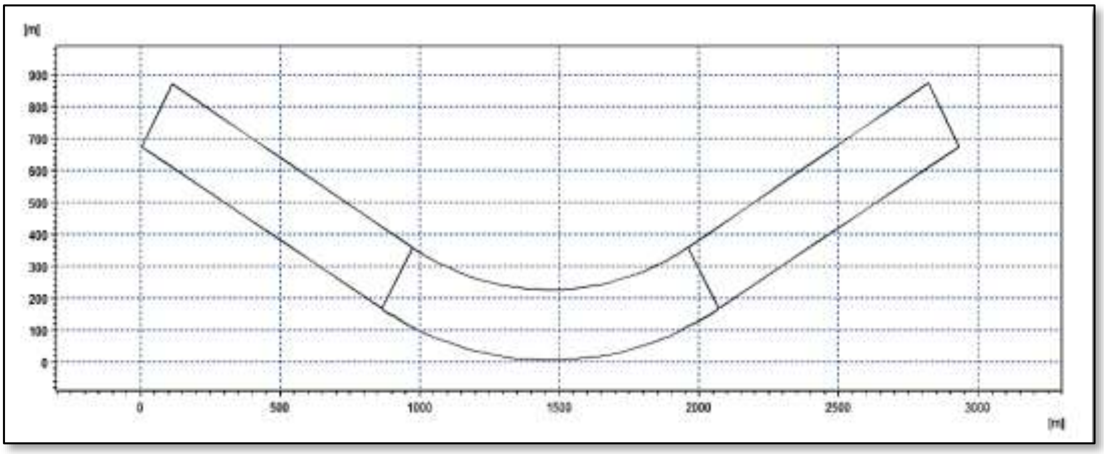


Figure 2.3: Depicts a Top Perspective of an Imagined Curve in the Open Channel

Source: (Stitic, A., et al; 2019)

A meandering channel reaction to several permeable and impermeable constructions under various sinuosity was assessed by Karki et al in 2019. The flow around groynes with and without groynes was simulated using the numerical modelling program TELEMAC-2D. The characteristics examined included two deflection angles, two curvature radii, and permeable and impermeable groynes. The outcomes demonstrated that banks are best protected against scouring with groynes in the channel with the maximum deflection. Furthermore, in the region far from the outer banks, the deflection of 15-shear stress and high-velocity increased. Although permeable groynes only allow for minimal bed growth, they increased the near-bank flow velocity, which increased the risk of bank erosion (Karki, S.,2019).

The function of groyne spacing in efficiently reducing wall shear stress in open-channel flow was investigated by Koutrouveli et al. in 2018. For the case of a straight single groyne, the ANSYS Fluent, Shear Stress Transport, SST, k-, model was utilized and validated against experimental data. The length of the groyne was equal to one-sixth of the channel width, and the experimental flume was employed with a constant bed slope. Different designs were investigated for a steady-state simulation of open channel flow involving several non-submerged groynes. The outcomes demonstrated that the numerical model accurately anticipated the flow circulation in the corner between the channel sidewall and the groyne downstream. This is because the SST k-separation models of f have good predictive power. The setup with a spacing of six lengths of groyne was more efficient for 11 groynes nilsequences with regular spacing between them. A new arrangement that reduces the groyne spacing by half in the first four groyne fields and maintains it for the remaining six groyne lengths has proven to be more effective for the parameters range under consideration. Based on these findings, a series of groynes were designed for the new configuration, with the initial four groynes being spaced more closely apart than the suffix groynes. The shear stress at the sidewall of an open channel within the groyne zone reduces while it increases at the bed as a result (Koutrouveli, T.I., et al; 2019).

(Liang Choufu, Saeed Abbasi, Hanif Pourshahbaz, Poorya Taghvaei Samkele Tfwala, 2019,) his study uses numerical analysis to examine the impact of changing the direction and spatial configuration of groynes (from large to small and vice versa) on flow patterns, bed erosion, and sedimentation. The groynes under study were parallel, not submerged, and impermeable. In FLOW-3D, numerical simulations were run. When comparing numerical results to experimental results, a nested mesh arrangement along with the Van-Rijn formula on sediment movement produced more precise results. Groynes placed from large to small at an angle of 45° and from small to large at an angle of 135° reduced the scour depth by up to 55% and 72%, respectively. Furthermore, it was shown that, in comparison to other simulations, those with orientations closer to 90 degrees (Chou, L., Abbasi, et al; 2019).

Nayyer et al. 2019 investigated the effects of a sequence of spur dikes using both numerical and experimental methods. The numerical model with a bottom slope of zero was tested using an experimental flume. The flow characteristics around three combinational series with different groyne shapes—straight I, L, and T-head—were simulated using FLOW-3D software, turbulence models, k-, RNG, and LES. A TLI combination series of groynes were tested in the lab to confirm the accuracy of the numerical model. Under a steady discharge, the hydraulic properties of the flow surrounding them were seen. The findings demonstrated that the flatbed was generated near the site of maximal scour depth and deposition with high flow velocity, shear stress, pressure, and turbulence kinetic energy, or TKE. The designed series is very good in reducing velocity, bed shear stress, pressure, and TKE near spur dikes. Eventually, the utilization of spur dikes with various geometry results in a reduction in scouring (Nayyer, S., et al; 2019).

3. THE PRINCIPLES OF GROYNES

3.1 Definitions

Groynes. They are solid hydraulic structures built vertically from the shore of a river or a waterway, which impede the movement and flow of water and also limit the movement of sediments.

It is usually made of hard, water-resistant materials such as stone, concrete, or even water-resistant wood.

The main purpose and functionality of grooves are to avoid (prevent) shore erosion caused by high flow movement, as this is the main process of grooves.

Groynes, also known by names such as the groin, spur dike, retard and van, are hydraulic structures constructed from gabions; it's designed to extend from the outer bank of a channel to the main flow (Osman, M. A., et al; 2008). The angle between the hydraulic structures of these groynes and the bank is selected depending on the things for which the groynes were constructed (Alauddin, et al; 2011).

3.2 Classification of Groynes

Groynes can be classified into several types, depending on the materials of groynes Permeability properties or Height of Groynes and the purpose of groynes, below aresome examples of these types:

- The materials used in its creation.

1. Wood groynes
2. Rubble-mound groynes
3. Rock groynes
4. Sheet pile groynes
5. Sandbag groynes
6. Concrete groynes

 A- Example for the wood groynes	 B- Example for the Rubble-mound groynes
 C- Example for the Rock groynes	 D- Example for the Sheet pile groynes
 E- Example for the Sandbag groynes	 F- Example for the Concrete groynes

Figure 3.1: Examples of Groynes of Different Materials

Source: (The Constructor, 2022)

- Permeability properties.
  a. Permeable groynes
  b. Impermeable groynes

 A- Example for the Permeable groynes groynes	 B- Example for the impermeable groynes groynes

Figure 3.2: Examples of Groynes of Different Permeability

Source: (Wikipedia, the free encyclopedia,2022

- Height of Groynes.
  a. Submerged groynes.
  b. Non-submerged groynes

A- Example for the Submerged groynes

B- Example for Non-submerged groynes

Figure 3.3: Examples of groynes of different height

Source: (Biria, 2015)

- The purpose of Groynes

Groy have multiple functions. Here are what groins can do:

a. Attracting groynes

b. Repelling groynes

c. Deflecting groynes

d. Sediment groynes

A- Example for the Submerged groynes

B- Example for Sediment groynes

Figure 3.4: Examples of groynes with different functions

Source: (Irrigation Engineering, 2022)

3.3 Theory of Groynes

3.3.1 Flow around groynes

In the flow around the groynes, some variables and factors affect the flow and its patterns. These patterns and the nature of the flow differ with the difference in the width, depth and length of the groyne ,the width of the channel also affects the nature of the flow. Whether the groynes are submerged or non-submerged also participates in the formation of a special pattern for each case.

The flow around the groynes some variables and factors affect the flow and its patterns. These patterns and the nature of the flow vary with the difference in width, depth, length and location of the groynes. The width of the channel, which affects the nature and type of eddies, cannot be ignored. (McCoy, et al; 2008).

Submersible groins have a different flow pattern than non-submersible groins. It is highly noted that there are patterns that form in the case of single groins in the form of a series of groins.

It should be noted that the angle of the groins with the flow line of the river affects the distribution of velocity in the section in the vertical and horizontal directions. See the figure (Fig. 3.5). The angle of the groynes greatly affects the amount of sediment that is deposited near or far from the groynes.

The viscosity and temperature of the water have a lesser effect on the flow patterns around the grooves3. (Alauddin, M. 2011)

3.3.2 Emerged groynes (non-submerged groynes)

The groynes fields are not truly a part of a river's flow-conveying cross-section when the groynes are not submerged. As a result, the discharge in the main channel is not immediately influenced by the flow pattern in a groin field. Lowering the water does influence the flow pattern, however reducing the mainstream velocity has little impact on the flow pattern itself (Uijttewaal et al., 2001). Additionally, a groin field's geometry, position (inner bend, outer bend, straight part), and/or groyne orientation can all affect how water flows through it. (Przedwojski, B. 1995). In Fig. 3-5, a flow pattern around a single groyne is seen.

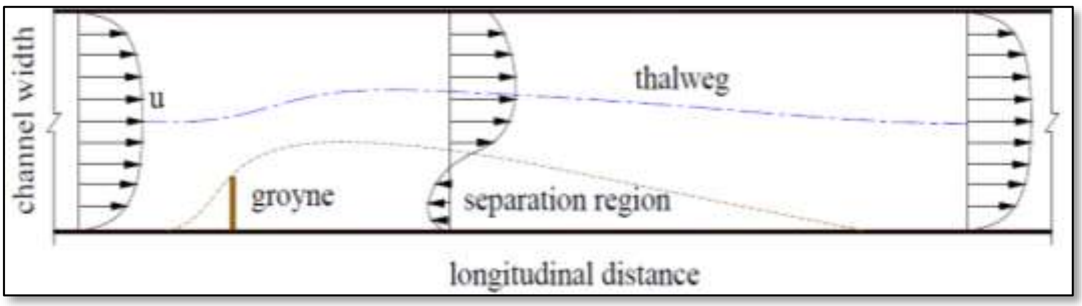


Figure 3.5: Flow Thalweg And Separation Around A Single Groyne

Source: (Przedwojski, B. 1995)

The size and number of eddies that form in the stagnant flow region are determined by the length-to-breadth ratio of the groyne field (Sukhodolov,1999; Revy, P., et al., 2000). A single eddy results from an aspect ratio that is nearly unity. Two stationary eddies can exist in a greater aspect ratio: a larger main eddy in the downstream portion of the groyne field and a smaller secondary eddy close to the upstream groyne. The flow enters the lengthy groyne field, which has a length-to-width ratio of about six. While the main flow field begins to encroach into the groyne field further downstream, the two eddies stay in a mostly steady posture. In every instance, there is sporadic eddy shedding. Even in the event of a steady discharge, the flow field is unstable. The instantaneous flow field and the time-averaged flow field so diverge significantly.

The flow pattern between emerged groynes is primarily two-dimensional farther from the groyne's tip. The mass and momentum exchange mechanism between the groyne field and the main channel is mostly governed by small-scale three-dimensional turbulence. Due to the shallowness of the water, strong, large-scale three-dimensional formations cannot form. The flow is strongly three-dimensional close to the groyne's tip (Krebs et al., 1999).

3.3.4 Underwater groynes (submerged groynes)

The fact that groynes are typically used in emergent settings may explain why there aren't many studies on them when they're submerged. An additional factor could be the problem's complexity and three-dimensionality, which call for sophisticated measurement tools and/or potent three-dimensional computational approaches. The case of submerged groynes has been studied by a few researchers (e.g., Aya et al., 1997; Peng et al., 1997; Krebs et al., 1999; Tominaga et al., 2001). Between the upstream and downstream sides of the groynes, the water level has dramatically decreased, according to Aya et al. (1997). Inferentially, the slope of the water between two adjacent groynes is lower than the slope in the main channel region.

There are considerable differences in the flow field between the cases of a single groyne and a set of groynes. The flow pattern near a single groyne or multi (series) is discussed in this thesis. we refer to e.g. Ishi et al. (1983), Tingsanchali and Maheswarn (1990), Chen and Ikeda (1997), and Ouillon and Darius (1997). (Yossef, M. F. (2002).

3.3.5 Flow Near the Single Groyne

The flow field near a single groyne and that near a group of groynes differ significantly from one another. The primary flow zone, return flow zone, shear layer, and reattachment point are the four main zones that make up the flow pattern in the vicinity of a single groyne (Yossef, 2002). Between the groyne's tip and the bank of the opposite channel is where the major flow zone is located. The narrowing of the channel here causes the flow velocity to accelerate. The downstream side of the groyne is where the return flow zone is situated. The primary flow zone and the return zone have different flow velocities, which causes a shear between the two zones. The separation streamline and shear layer are similar. The junction between the channel boundary and the separation streamline is referred to as

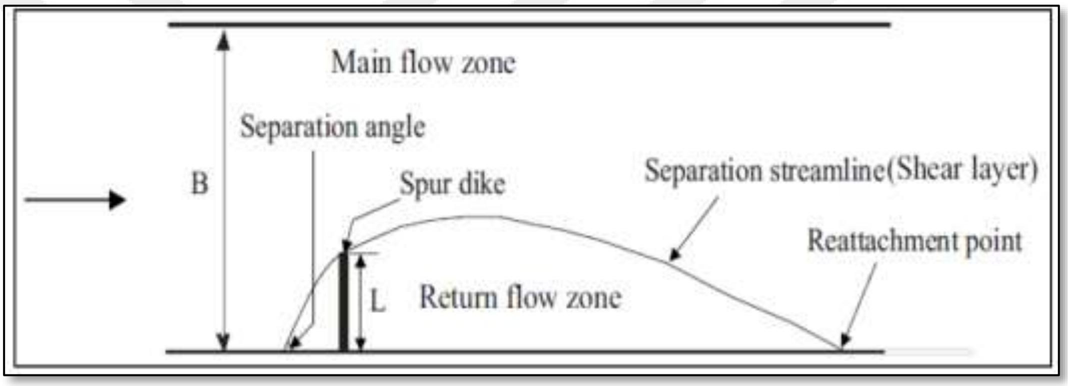


Figure 3.6: Groynes Primary Flow Zones Are Depicted in a Schematic Plan View of the Groyne

Source: (Kafle, M. R. 2013)

3.4 Patterns of Flow Around Series Groynes

According to Alauddin (2011) and Daniel and Heever (2013), the flow conditions, flow resistance, and the number of groynes all significantly impact the backwater effect. The shape, length, and spacing of the groynes, as well as the features of the river and the sediment load, can all affect the flow patterns around series groynes. However, in many instances, certain broad trends in flow can be seen.

The river channel is generally lined with a series of groynes that form pools and riffles. The groynes are used to redirect the flow of water, causing eddies and turbulence that aid in reducing the flow's velocity and dissipating water energy. In turn, this enables silt to build deposits in the pools and settle out of the water column, which can aid in stabilizing the channel shape.

Here are some Examples of flow patterns around series groynes:

1. Parallel flow: When the groynes are far apart, the water may flow relatively directly and parallel to the groynes between them. This may produce shallow riffles and deep pools.

2. Meandering flow: When groynes are placed closer together, the water may meander between them, causing eddies and turbulence as it flows around the groynes. As a result, the silt may be distributed along the channel more evenly.

3. Diagonal flow: If groynes are oriented upstream, water may flow between them at an angle, resulting in a diagonal flow pattern. Fish and other aquatic creatures may benefit from a more complicated series of pools and riffles as a result of this.

3.5 Factors Influencing the Choice and Design of Groynes

The selection and layout of groynes in a river system are influenced by a variety of elements, such as the river's unique characteristics, the groynes' intended functions, and the river system's social and environmental context. The following are some of the key variables that affect the selection and layout of groynes (van Rijn, L. C. 2018).

1. River morphology: When designing groynes, it is important to consider the features of the river, including its breadth, depth, slope, and sediment load. The groynes should be created to produce the necessary flow patterns and sediment deposition while also fitting the specific shape of the river.
2. Goals: The main goals of groyne installation in a river might be very different, such as minimizing bank erosion, stabilizing the river channel, managing sediment flow, providing recreational options, or improving fish habitat. The specific goals will determine the type and design of groynes.
3. Silt characteristics: The type, size, and quantity of river silt are important factors in groyne design. The groynes should be constructed to meet the unique properties of the sediment and avoid the buildup of sediment in undesirable locations.

4. Hydrology: The design of groynes can be impacted by river flow, including velocity, depth, and frequency of floods. In order to avoid damage or failure during floods or heavy flows, the groynes should be built to handle the expected flow conditions.
5. Environmental and social context: The environmental and social context of the river system, including the existence of endangered species, cultural values, recreational use, and public access, might impact the choice and design of groynes. The groynes should be designed to minimize negative impacts on the environment and social context, and promote sustainable use of the river system.
6. Available resources: The resources available for the installation and maintenance of groynes, including funding, labor, and equipment, can also influence the choice and design of groynes. The groynes should be built to fit within the available resources and promote efficient use of resources.

3.6 The CFD Modeling Techniques

Recent technological advancements have made CFD (Computational Fluid Dynamics) calculations useful for engineering applications. It would be helpful to have some guidance on how to portray different types of hydraulic structures. Four major problem categories are examined in this text:

- Vegetation/stones in rivers
- Intakes
- Local scour
- Spillways

When looking at the issues examined in physical laboratory models, a study of spillways is one of the most prevalent. It is crucial to accurately calculate the coefficient of discharge from the perspective of dam safety. Separate analyses are required for each spillway since the geometry affects the capacity of the spillway. Hydraulic research has a unique focus on sediment transmission. A distinctive flow pattern develops around a structure placed in a river, such as a bridge pier. If the construction is situated in a river with an erodible bed, it can be exposed to local scour.

3.7 SSIIM Model

SSIIM stands for Sediment Simulation in Intakes with Multiblock. environmental, hydraulic, and sedimentation engineering applications. The first main objective of the program was to mimic silt transport in conventional river/channel geometries. It has proven difficult to do research on fine sediments using physical models. Later, more hydraulic engineering topics like turbidity currents, stage-discharge relationships in rivers, head loss in tunnels, and spillway simulation were added to the program's scope of application. The main goal of the program is to simulate sediment movement across rivers, reservoirs, and around hydraulic structures.

The primary advantage of SSIIM over other CFD programs is its ability to mimic sediment flow with a moving bed with a complex form. This includes a variety of sorting techniques, bed load and suspended load, bed forms, and slope bed effects for various sediment process sizes. The most recent modules for wetting and drying in the unstructured grid enable complex geomorphologic modeling. (Nils Reidar B. Olsen,2010)

3.8 The General Model

In rivers, channels, and reservoirs, the SSIIM program calculates the water velocities and sediment movement. The k-turbulence model is used to solve the Navier-Stokes equations on a three-dimensional, nearly universal non-orthogonal grid. For various sediment sizes, the velocities are utilized to solve the convection-diffusion equations. This reveals the pattern of sediment deposition and trap effectiveness. Together with the movement of the free water surface, the changing state of the bed over time may be calculated.

SSIIM is split into three sections, similar to previous multi-dimension numerical models: a pre-processor, a solver, and a post-processor. The computational grid is one of the tools the pre-processor includes to produce input data. Along with a discharge editor, there is also an interactive visual grid editor with elliptic and transfinite interpolation. Based on data from measured geometry, the grid can be created.

The velocity vectors and scaler variables can be shown in the program's user interface as a two-dimensional view of the three-dimensional grid, a plan view, a cross-section, or a longitudinal profile. (Manual 2013)

Grids with versus. without structures While SSIIM 2 employs an unstructured grid, SSIIM 1.x uses a structured grid. Each cell in a structured 3D grid will have three indexes, making it simple to locate cells on the grid. Once input files with grid indexes are included in the data set, the locations of walls and inflow/outflow surfaces are described there.

The structured grid version will compute more quickly because quicker solvers are available. Some water quality and sediment transport algorithms that are not present in the structured grid version are present in the unstructured grid version. The unstructured version's primary benefits are its ability to simulate complex shapes and its wetting/drying algorithms. Only SSIIM 2 can represent a river's lateral movements. (Manual 2011).

3.9. 8 Input-Output files in The Model

Most of the files are only utilized for certain functions and are not typically necessary. Output files make up some of the files. Many of the input files can be produced by the application. All required input files can be generated by the application in simpler scenarios. The control file and the coordinate file are the two primary input files. Since they are all ASCII files, any common editor can be used to produce them.

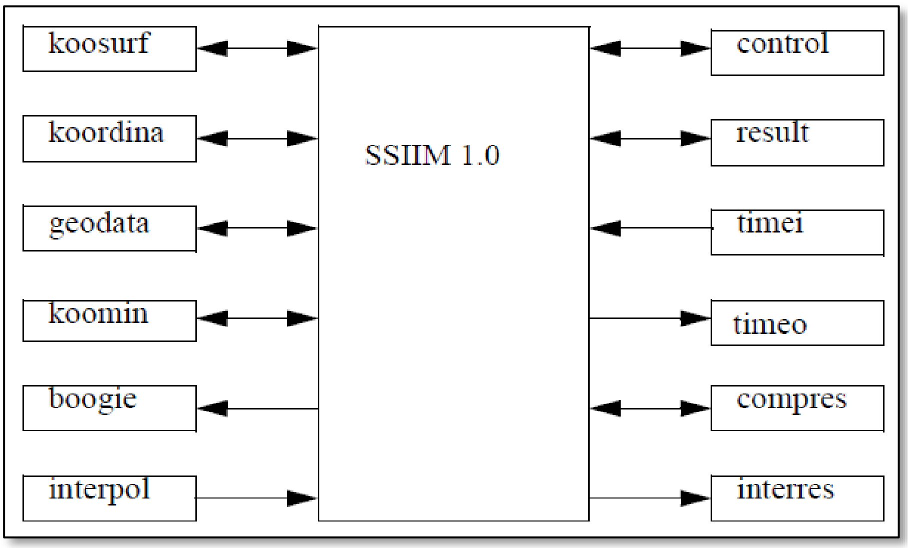


Figure 3.7: SSIIM File Structure for the Main File

Source: (Manual, 2011)

4. FIELD MEASUREMENTS AND LABORATORY WORKS

4.1 General

This chapter includes the collection of data and field measurements required by the process of a numerical study on the impact of the use of groynes in rivers on the flow and distribution of sediment in the river, this information must be collected from the field and worked on in the laboratory to obtain the required properties. This chapter will include all field measurements that include measurements of water drainage, flow speed, concentration and characteristics of suspended sediments, as well as equipment, devices and methods used.

4.2 General Information About the Study Region

The Euphrates River is one of the largest rivers in the world and southwest Asia in particular. It has a length of 2780 km. It originates from Turkish territory through Syria and Iraq and its width ranges from source to mouth between 2000m - 200m. Previously, the Euphrates River went through a state of flooding annually and thus carried out a process of washing the riverbed naturally, which preserves its original section and the behaviour of water flow in it. The figure below shows the location of the Euphrates River in the continent of Asia.

However, due to the establishment of control facilities in the three countries and the impact of global warming and climate change, which led to a decrease in the amounts of water running in it and the formation of many islands and sediments, thus the phenomenon of drifting one side of the river and the dumping of the other side in multiple places of its course.

Figure 4.1: The Location of the Euphrates River

Source: (Google Earth ©)

The study area is located on the Euphrates River, part of Iraq, specifically in the middle of Iraq within the province of (Babylon). Where the Euphrates River goes through meanders (bends)in the Musayib area. See Figure (4.2, 4.3)

Figure 4.2: Map of Iraq and the Region of Study

Source: (Allawi, M. F.et al; 2021)

Figure 4.3: The Region of Study

Source: (Google Earth ©)

4.3 Hydraulic Characteristics of the Study Region

The length of the study region is (2.6) km, and it is located within the coordinates of longitude (32°47'33.59"N), (32°46'40.19" N) and coordinates of latitude (44°17'24.50"E), (44°16'43.69"E).

An annual discharge rate of 300 m^3/sec passes through the study region, see the tables:

Table 4.1: The Amounts of Discharge for Each Month

Year	Month	Discharge m^3/sec	Year	Month	Discharge m^3/sec
2019	January	450	2020	January	430
2019	February	420	2020	February	410
2019	March	410	2020	March	385
2019	April	470	2020	April	450
2019	May	480	2020	May	490
2019	June	800	2020	June	780
2019	July	850	2020	July	810
2019	August	750	2020	August	720
2019	September	680	2020	September	650
2019	October	500	2020	October	520
2019	November	400	2020	November	410
2019	December	600	2020	December	580

Table 4.1: (Cont.) The Amounts of Discharge for Each Month

Year	Month	Discharge m³/sec	Year	Month	Discharge m³/sec
2021	January	470	2022	January	370
2021	February	390	2022	February	365
2021	March	380	2022	March	330
2021	April	400	2022	April	310
2021	May	420	2022	May	275
2021	June	700	2022	June	390
2021	July	750	2022	July	385
2021	August	700	2022	August	345
2021	September	630	2022	September	312
2021	October	480	2022	October	280
2021	November	395	2022	November	290
2021	December	560	2022	December	345

Source: (Department of Dams and Reservoirs, 2023)

The widths of the river in this study region were ranges from (104m) to (280m), the Depths in the river range from (0)to (14m), the slope is 0.001m/m, and the amount of precipitation in the Region annually is (100)mm. See the figure below regarding the amount of precipitation.

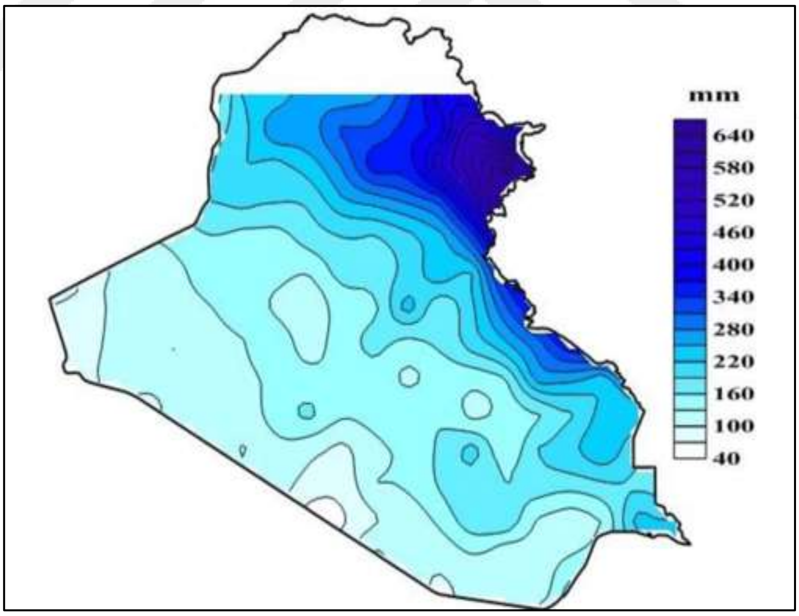


Figure 4.4: The Amount of Precipitation

Source: (Al-Zuhairi, Et Al; 2016)

4.4 Importance of Study Area

This region was chosen for study for several reasons.

- The region is exposed to large amounts of sediment as a result of the increased speed of flow which causes morphological changes in the extension of the river over time.
- The exploitation of water from both sides of the Euphrates River for agricultural and residential purposes and these activities lead to an increase in the amount of sediment and changes over time in the extent of the river's arrival.
- The impact of erosion can be sudden and dramatic; rivers sometimes cause river bank erosion and swallow up agricultural land.

4.5 Field Data Measurements

Field measurements entailed gathering the information required to accomplish the study's goals, which included the following:

1. Locate cross sections and extract their coordinates and geometric properties.
2. Measure ring flow speed and water discharge for each section using a technique of Acoustic Doppler Current Profile (ADCP) .
3. Calculate the bottom level of each section using a water scanner (ECHO SOUNDER).
4. Sapling of suspended sediments

4.5.1 Accounts for the cross-sectional

The length of the region identified for the study (2,600 m) included 14 cross sections, the distance between one section and the other (200 m) and using GPS technology, the coordinates of each section were taken from the left and right banks. The table below showed the all information for the sections with the coordinates for each section.

Table 4.2: The Coordinates of the Sections (Right & Left of the River)

Section No	X Coordinate	Y Coordinate	Section No	X Coordinate	Y Coordinate
1L	44.2876	32.7916	**1R**	44.2899	32.7929
2L	44.2884	32.7902	**2R**	44.2908	32.7913
3L	44.2891	32.7886	**3R**	44.2917	32.7894
4L	44.2898	32.7867	**4R**	44.2922	32.7871
5L	44.2901	32.7849	**5L**	44.2901	32.7849
6L	44.2895	32.7831	**6R**	44.2904	32.7825
7L	44.2875	32.7822	**7R**	44.2883	32.7814
8L	44.2858	32.7816	**8R**	44.2869	32.7807
9L	44.2836	32.7807	**9R**	44.2849	32.7795
10L	44.282	32.7798	**10R**	44.2835	32.7784
11L	44.2802	32.7789	**11R**	44.2823	32.7773
12L	44.2787	32.7777	**12R**	44.2809	32.7762
13L	44.2773	32.7764	**13L**	44.2773	32.7764
14L	44.276	32.7751	**14R**	44.2782	32.7736

4.5.2 Utilizing ADCP Technology

ADCP measures water currents with sound using the principle of sound waves called (The Doppler effect). ADCP works by transmitting sounds at constant frequencies in the water. While it bounces off the particles suspended in the water and is reflected again from the device, these reflected frequencies are captured and interpreted through software. The frequency increases if the particle is close to its core, but the frequency decreases if it is farther away. The difference in frequency between the waves the analyzer sends and the waves it receives is called (Doppler shift). The distance can be determined by the transducer and then the velocity profile of the entire water column can be produced at many depths (Terray, et al; 1999).

Divide the stream or river into multiple horizontal slides (rows)and measure the current from top to bottom to perform current profiling (columns) Each slide (row of cells) represents the flow of water at a specific speed. Due to friction, cells nearest to the bottom tend to move more slowly than cells in the middle of the depth. Additionally, cells on each row’s left and right ends move more slowly than cells in the middle. The velocity of all the water in the river can be determined by moving the ADP from one bank to the other.

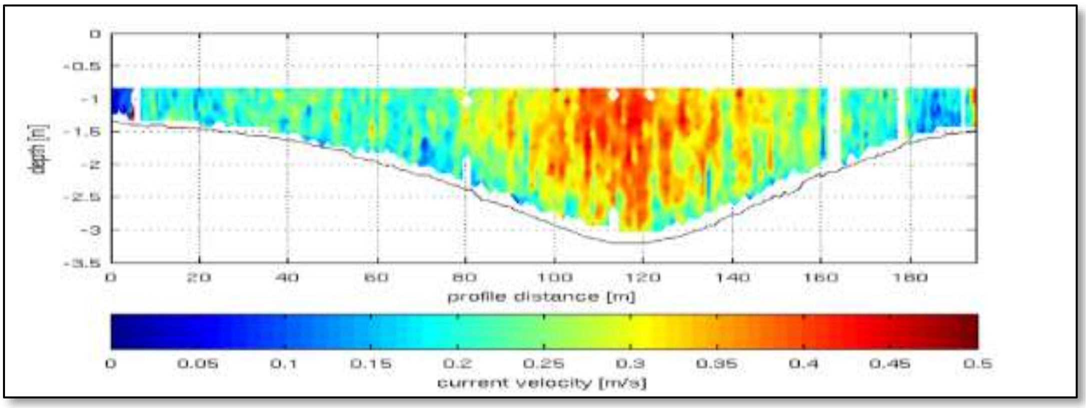


Figure 4.5: Shows the Production of Cross-Sectional Water Velocity (Top), & Circulation Profile (Bottom), Using ADCP Cross-Section Sections

Bottom-mounted ADCPs require an anchor to keep them in place, batteries, and an internal data recorder. Instruments mounted on ships require a powered ship, a computer on board to receive the data, and a GPS system to subtract the ship's motions from the present data. Data must be stored and processed on a computer because ADCPs lack an external read-out. There are software tools available that can handle ADCP data. (Atle Lohrmann, 2023)

An ADCP instrument is often mounted to a boat or permanent platform and moved from one side of the river to the other to monitor water discharge. The U.S. Geological Survey's (USGS) methodology is used to measure discharge. (Mueller, et al; 2009).

This approach is referred to as the "middle section method" and is the same approach that (Son Tek Flow Tracker). This method entails measuring the mean velocity, depth, and cross-sectional area at several points along the cross-section that are known to the (stations).

The entire cross-section of a river cannot be measured by river surveyor systems. The (unmeasured) portions are depicted in Figure and below (4.6).

1. (Edges), which the River Surveyor system can profile, are the regions close to the beginning and end of the river's banks and indicate the minimum ADP and vessel depth requirements.
2. (Top), which denoted the depth of the mounting (i.e., transducer depth).

3. (Bottom), which showed the last cell's possibility for data contamination (e.g., the cell is partially or fully touching the river bed).

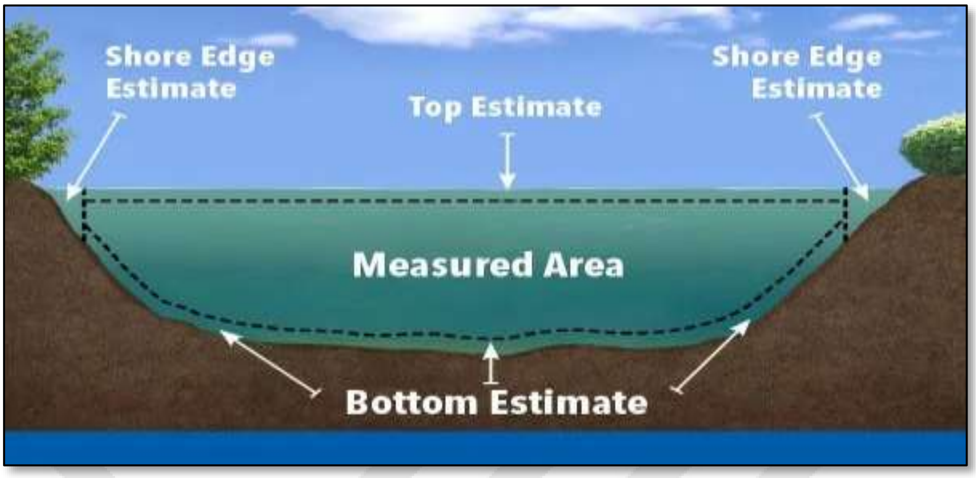


Figure 4.6: Cross-Sectional View of the Measured & Unmeasured Areas of An ADCP Transect

Source: (Isaac Jones, 2022)

4.5.3 Measurements of hydraulic and geometric data

Figure 4.7: Researcher While Working In the Field

Data was collected from the field (study area) after dividing it into 14 sections using ADCP device top width and the water level at different distances from the width of the section, the flow velocity, and the total area of each section well as the discharge. Figures depict SonTek river tracker surveyor type SR M9 (4.7, 4.8). After contacting the ADCP device, the application from version 4.1 starts collecting data; these measures are displayed in Table (4.3). The information from the sections was displayed using SonTek software as a velocity contour graph in Figure (4.9). The discharge report's discharge summary and other data were displayed as shown in

Figure (4.10). The cross sections of the study region are shown in Figure (4.11, 1) from Section No. 1 to Section No. 14.

Figure 4.8: The River Surveyor ADCP

Table 4.3: Hydraulic & Geometric Data

Section No.	Top width (m)	Depth of Water@¼ Width (m)	Depth of Water@½ Width (m)	Depth of Water@¾ Width (m)	Average Depth (m)	Average velocity (m/sec)	Total area (m^2)	Discharge Rate (m^3/sec)
Section 1 (0+000)	258	6.2	3	5.4	4.87	0.49	675	333.45
Section 2 (0+200)	260	3.85	2.525	4.9	3.76	0.49	720	333.45
Section 3 (0+400)	260	4.56	5.86	5.26	5.23	0.46	830	333.45
Section 4 (0+600)	225	6.2	6.28	5.9	6.13	0.40	1,082	333.45
Section 5 (0+800)	175	3.17	4.02	5.2	4.13	0.31	560	333.45
Section 6 (1+000)	104	6.5	4	4	4.83	0.60	264	333.45
Section 7 (1+200)	125	5.5	4.7	3.25	4.48	0.49	675	333.45
Section 8 (1+400)	137	5.15	4.6	5.15	4.97	0.49	480	333.45
Section 9 (1+600)	167	4.82	5.92	5.6	5.45	0.69	560	333.45
Section 10 (1+800)	245	4.65	4.65	4.35	4.55	0.60	597	333.45
Section 11 (2+000)	280	4.35	3.25	4.5	4.03	0.56	900	333.45
Section 12 (2+200)	280	5.75	4	3.95	4.57	0.37	841	333.45
Section 13 (2+400)	254	5.93	3.43	3.83	4.40	0.40	618	333.45
Section 14 (2+600)	270	5.4	3.4	5.2	4.67	0.54	757	333.45

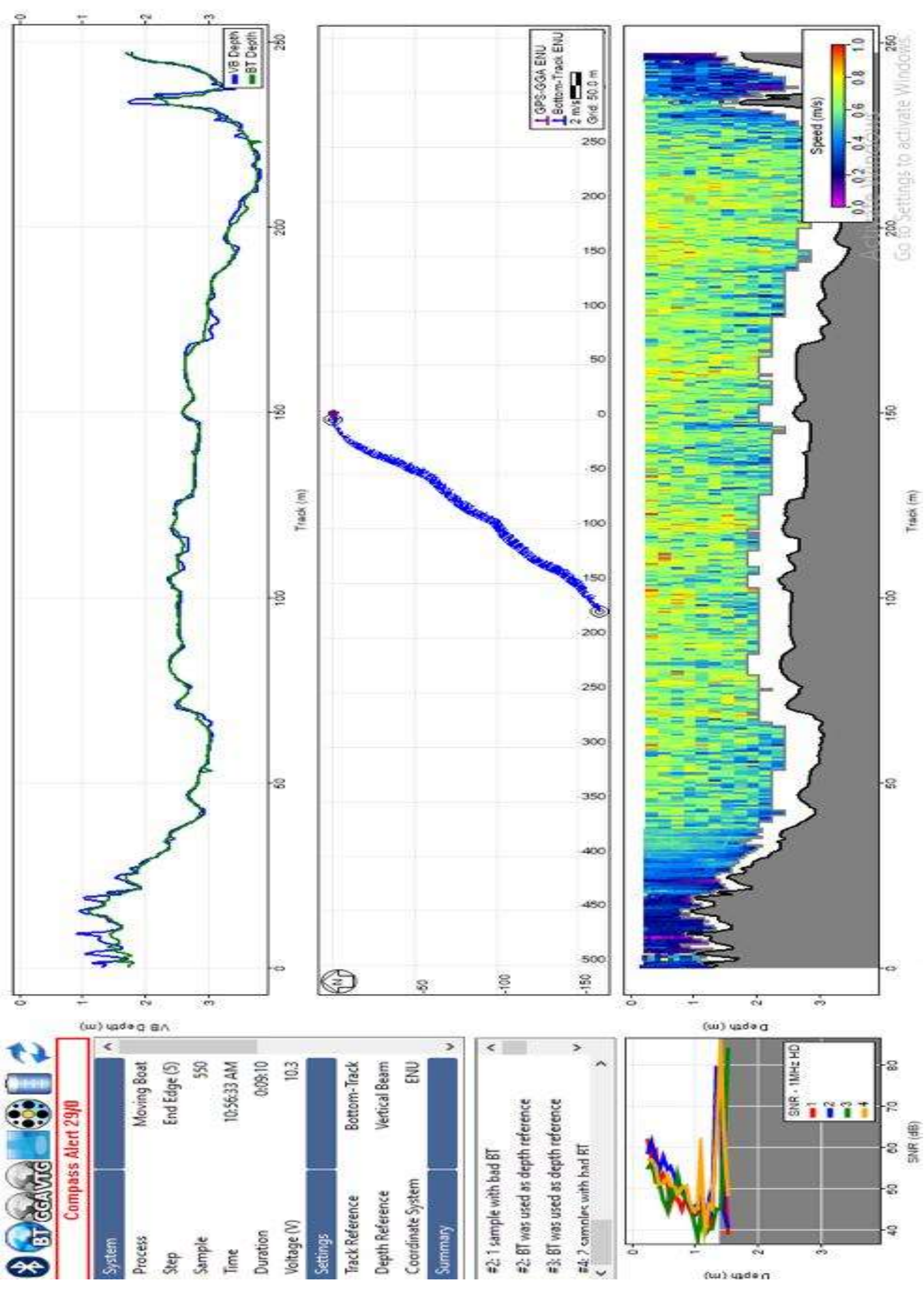


Figure 4.9: Velocity Contour Graph for One of the Gross-Sections of the Study Region

Discharge Measurement Summary

Data Measured: Sunday, October 23 2022

Site Information	
Site Name	furat mseab
Station Number	
Location	

Measurement Information	
Party	
Boat/Motor	
Meas. Number	

System Information	
System Type	RS-M9
Serial Number	6752
Firmware Version	4.10
Software Version	4.1

System Setup	
Transducer Depth (m)	0.09
Screening Distance (m)	0.00
Salinity (ppt)	0.0
Magnetic Declination (deg)	0.0

Units	
Distance	m
Velocity	m/s
Area	m2
Discharge	m3/s
Temperature	degC

Discharge Calculation Settings			
Track Reference	Bottom-Track	Left Method	Sloped Bank
Depth Reference	Vertical Beam	Right Method	Sloped Bank
Coordinate System	ENU	Top Fit Type	Power Fit
		Bottom Fit Type	Power Fit
		Start Gauge Height (m)	0.00
		End Gauge Height (m)	0.00

Discharge Results	
Width (m)	251.879
Area (m2)	654.484
Mean Speed (m/s)	0.510
Total Q (m3/s)	333.549
Maximum Measured Depth	4.089
Maximum Measured Speed	1.013

Measurement Results

Tr		Time			Distance				Mean Vel		Discharge							%
#		Time	Duration	Temp.	Track	DMG	Width	Area	Boat	Water	Left	Right	Top	Middle	Bottom	Total	MBTotal	Measured
1	R	7:51:51 AM	0:08:27	31.8	261.04	250.12	256.116	666.642	0.515	0.502	0.22	0.00	33.06	251.11	50.44	334.834	--	75.0
2	L	8:00:21 AM	0:09:50	31.5	254.79	241.64	247.642	642.327	0.432	0.517	-0.31	-0.02	32.58	253.30	46.71	332.265	--	76.1
			Mean	31.7	257.91	245.88	251.879	654.484	0.473	0.510	-0.04	-0.01	32.62	252.21	48.58	333.549	0.000	75.5
			Std Dev	0.2	3.13	4.24	4.237	12.157	0.042	0.008	0.27	0.01	0.24	1.09	1.86	1.285	0.000	0.5
			COV	0.0	0.012	0.017	0.017	0.019	0.088	0.015	-6.156	-1.000	0.007	0.004	0.038	0.004	0.000	0.007

Exposure Time: 0:18:17

Tr1=20220724075151r.rivr; Tr2=20220724080028r.rivr;

Comments

Tr1=20220724075151r.rivr - ; Tr2=20220724080028r.rivr - ;

Compass Calibration

Passed Calibration
Error from calibration: 0.17 deg
Mean Magnitude: 8194.85

Pitch: -20/40
Roll: -50/10

System Test

System Test: PASS

Parameters and settings marked with a * are not constant for all files.

Report generated using SonTek RiverSurveyor Live v4.1

Figure 4.10: Discharge Summary Report for One of Gross- Sections

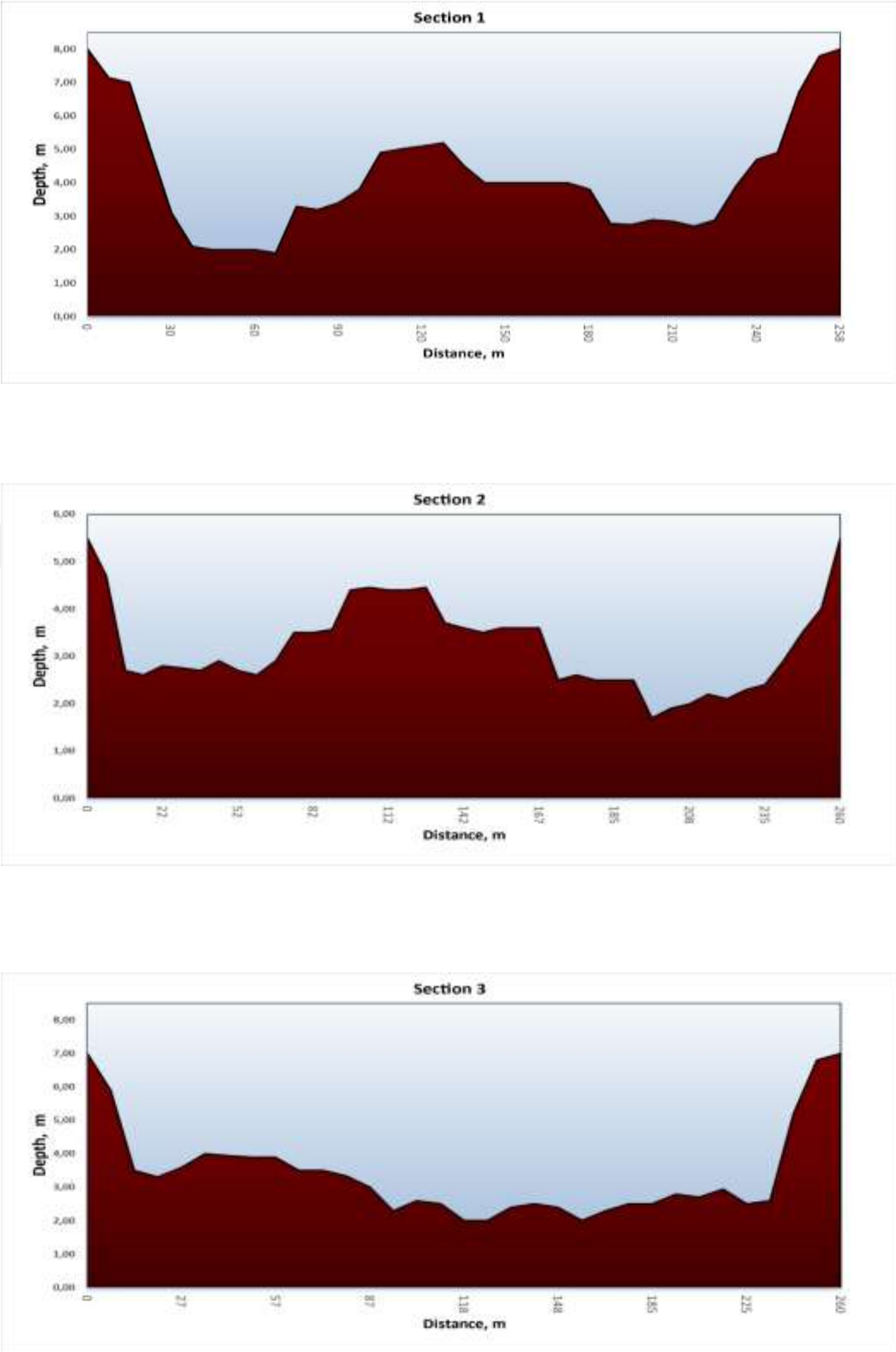
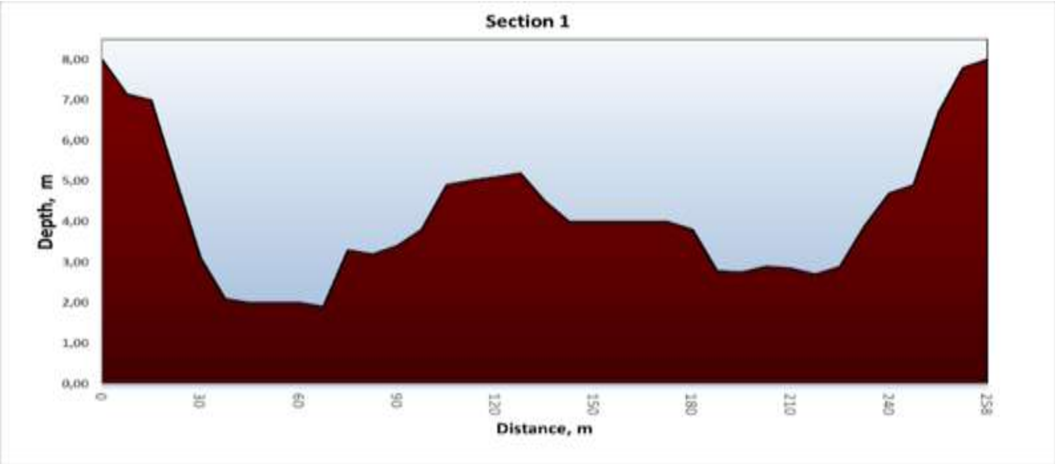
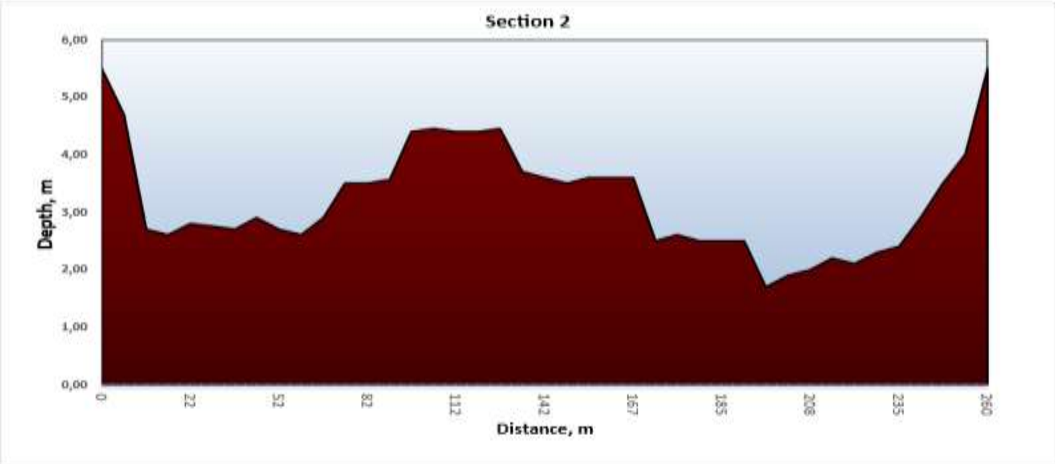


Figure 4.11: Cross-Sections





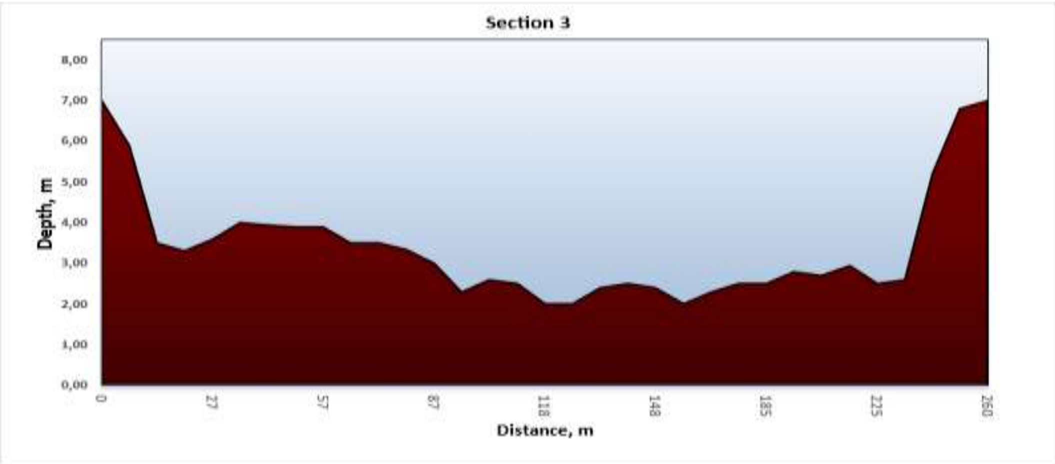
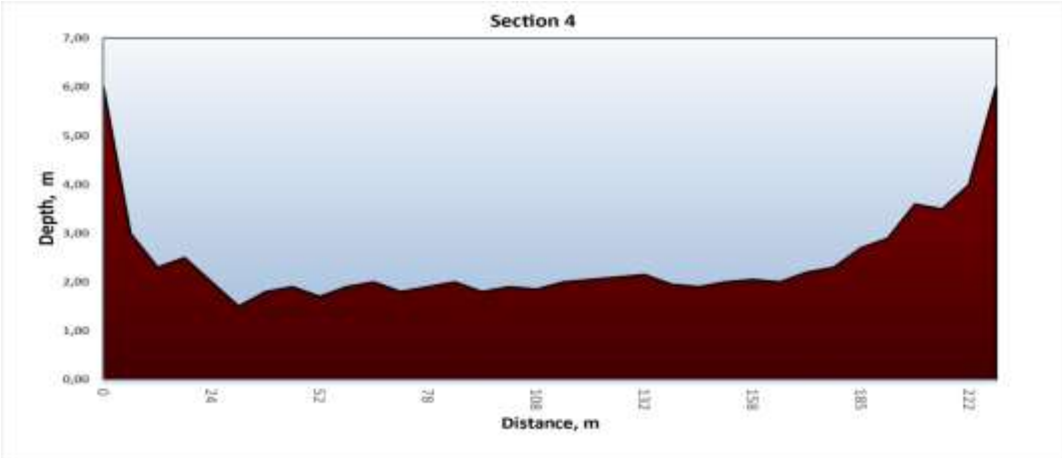
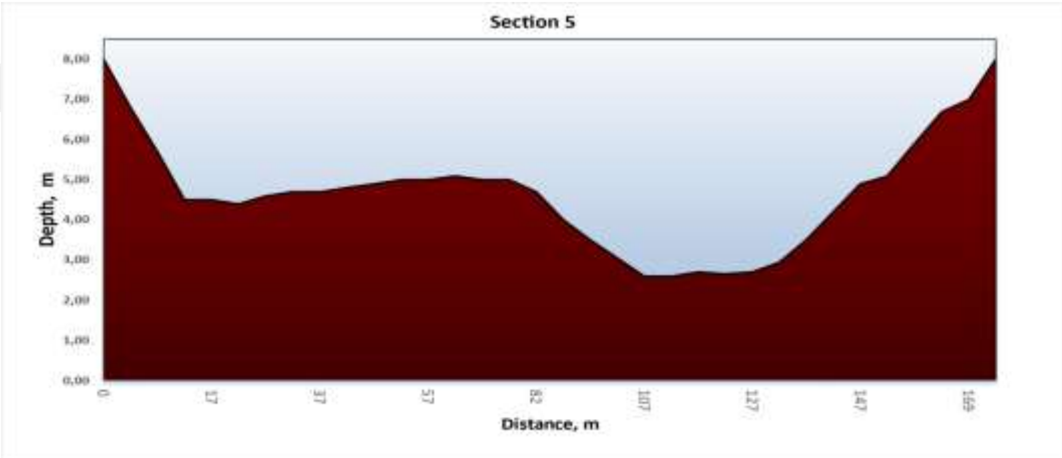


Figure 4.11: (Cont.) Cross-Sections





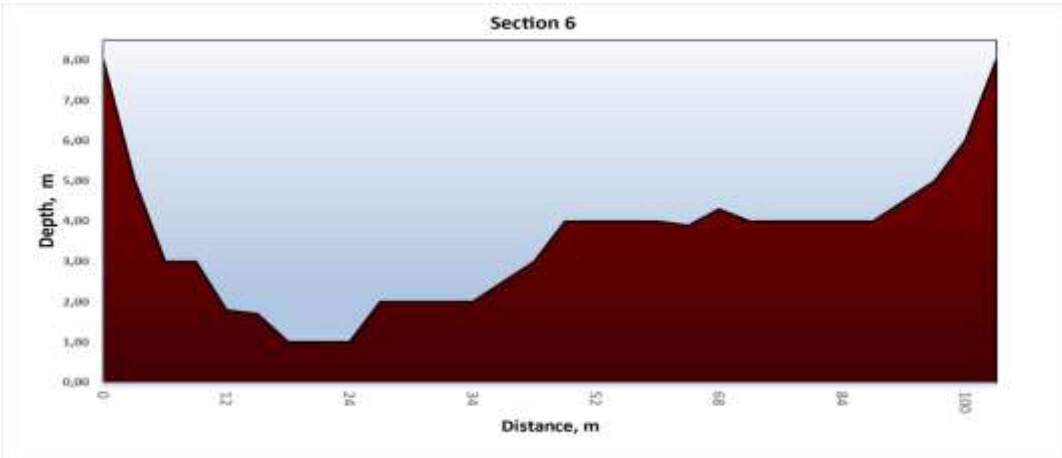
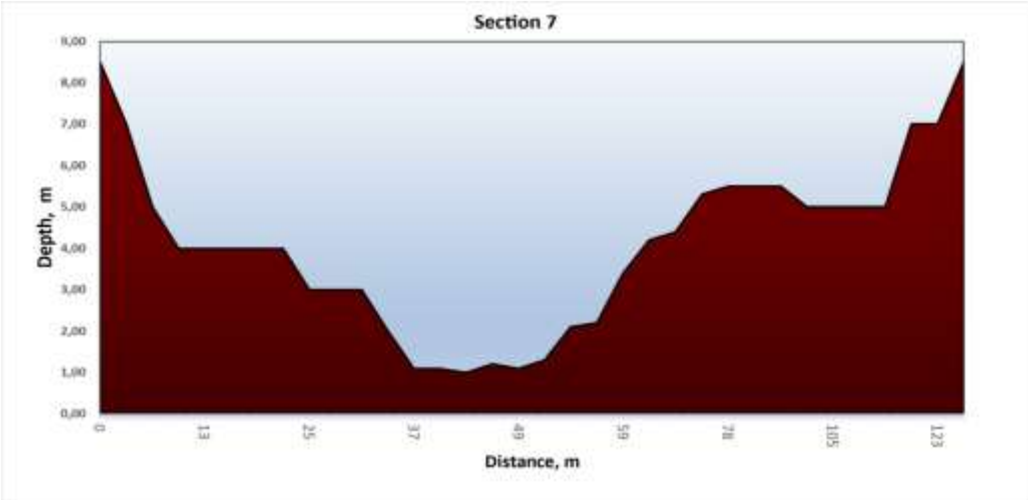
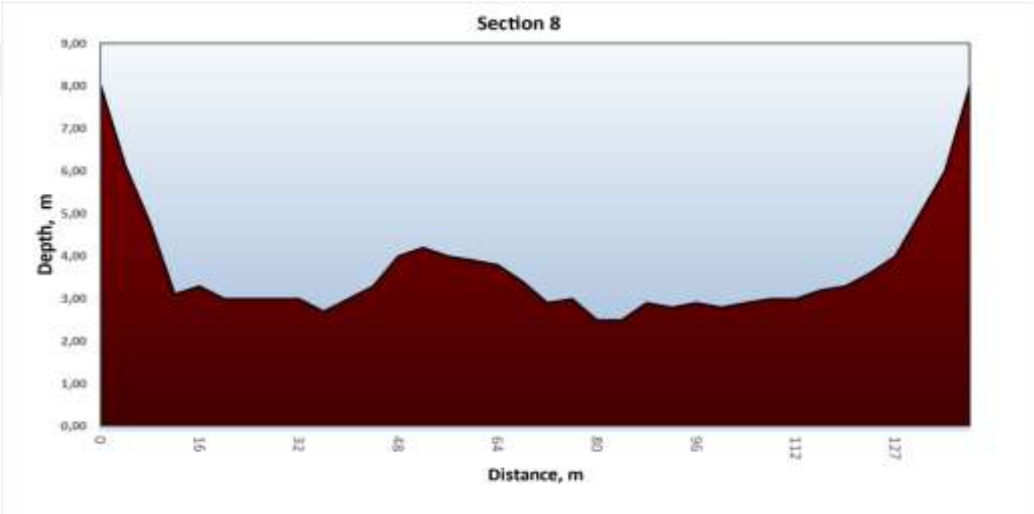


Figure 4.11: (Cont.) Cross-Sections





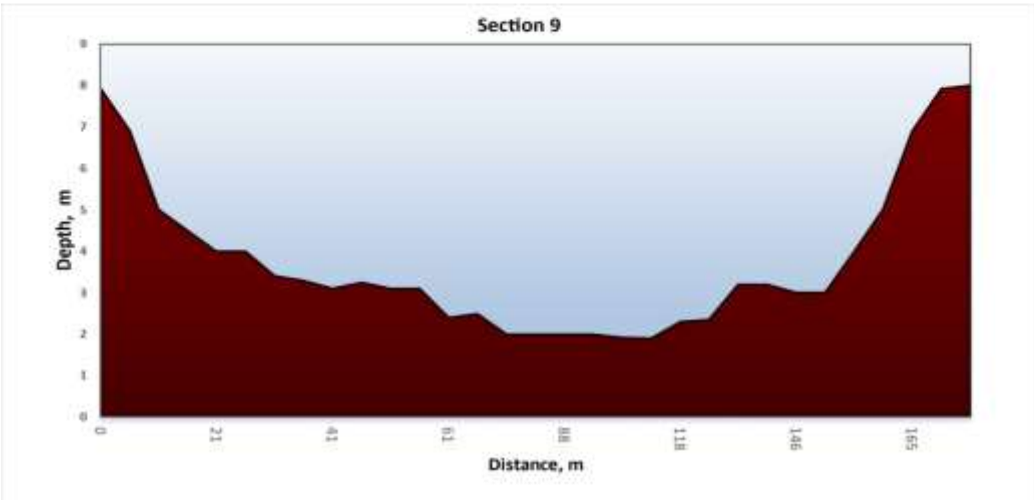
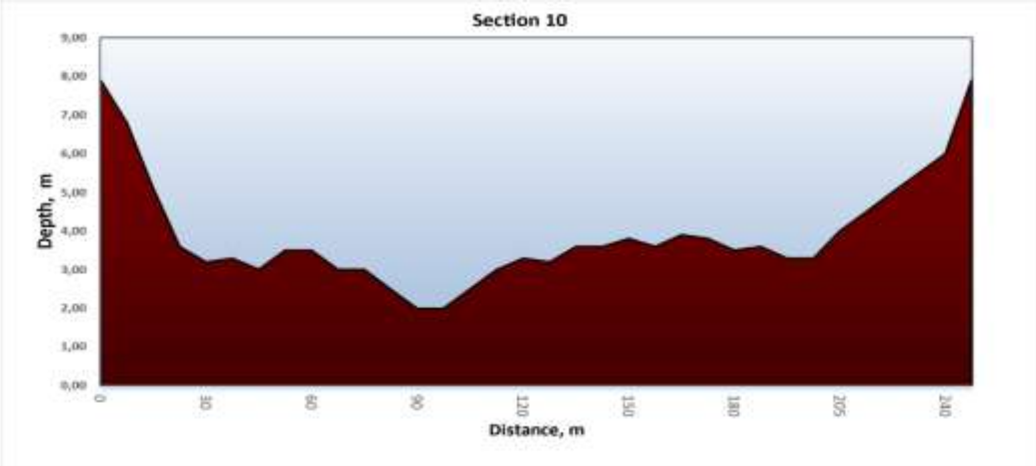
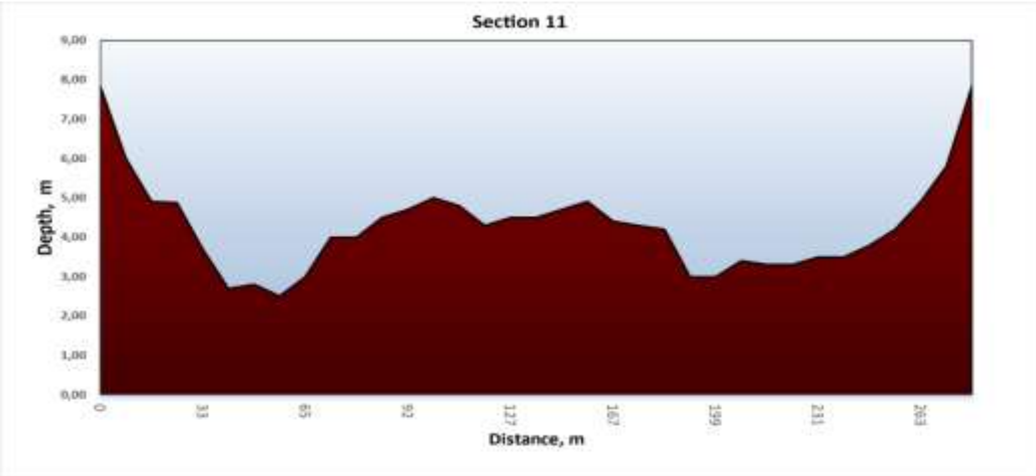


Figure 4.11: (Cont.) Cross-Sections





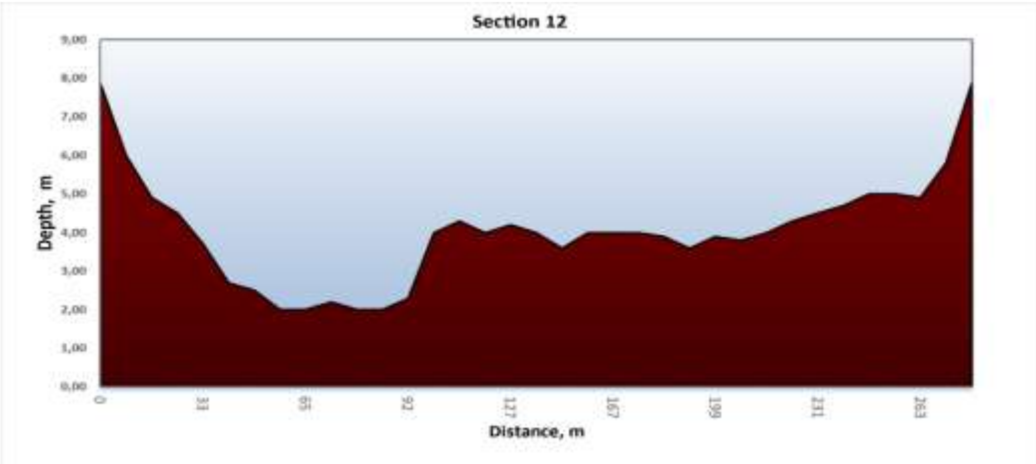
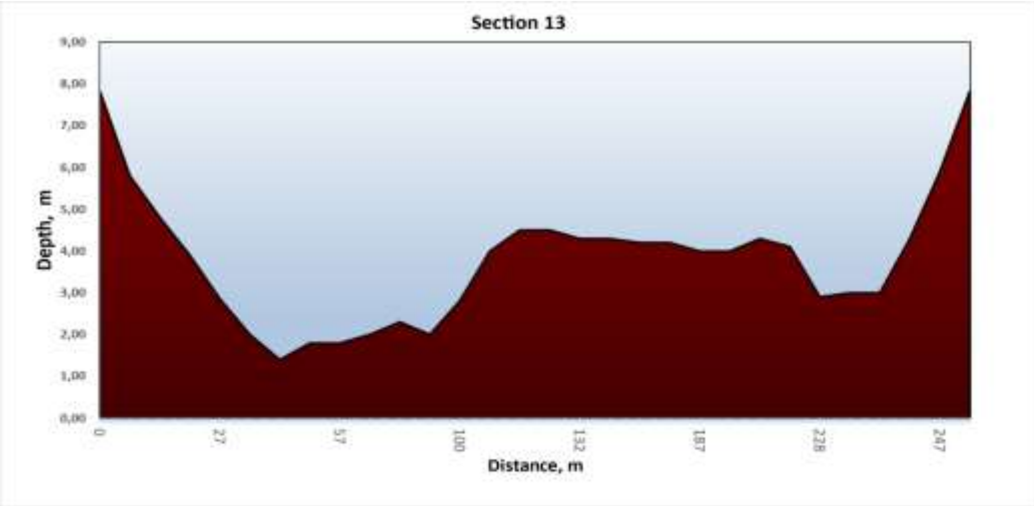


Figure 4.11: (Cont.) Cross-Sections



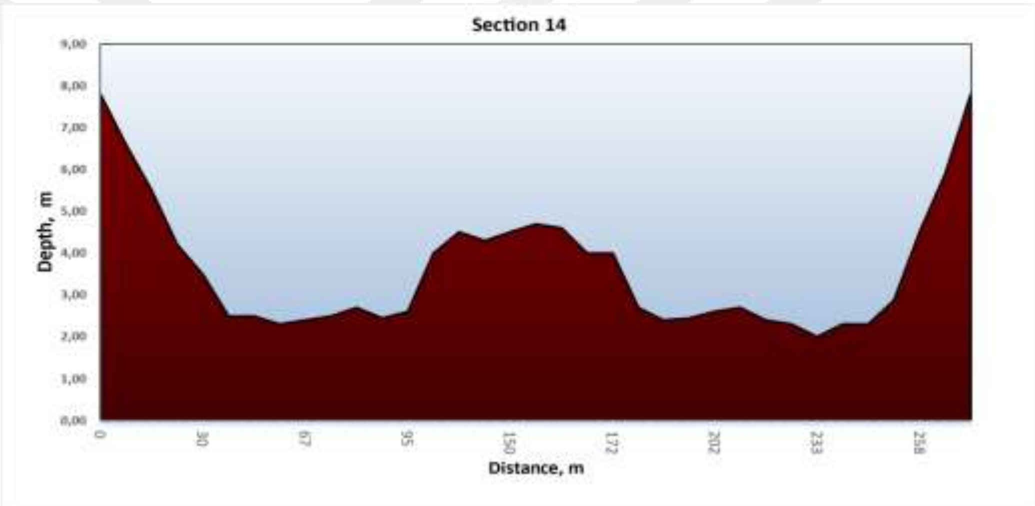


Figure 4.11: (Cont.) Cross-Sections

4.5.4 Water discharge and velocity measurements

According to the method described in section (4.3.2) and using the ADCP device, the discharge was calculated for fourteen sections based on the average speed and the total area for each section, and then the rate of discharge for these sections was calculated and it was mentioned in the table (4.2). Figure (4.12), below shows the measurement of river discharge

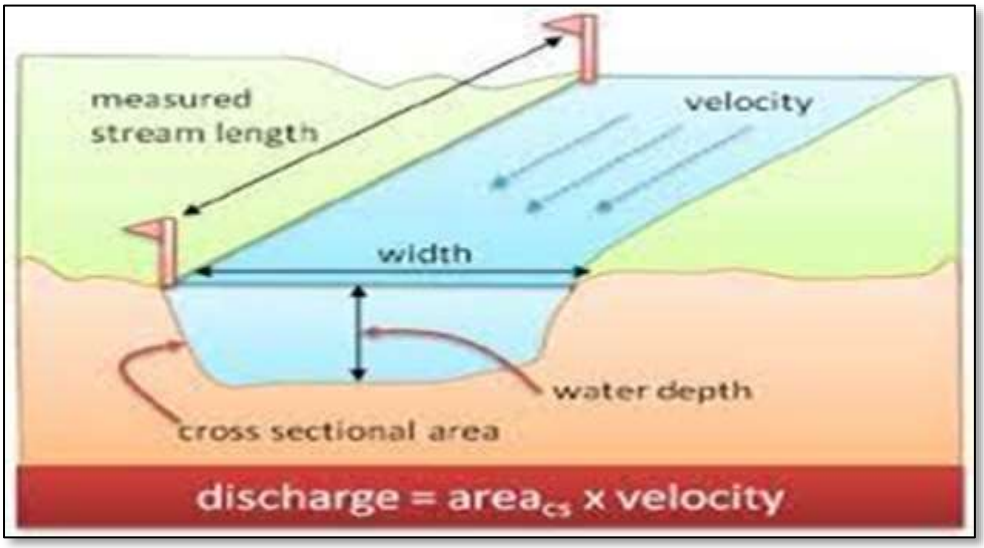


Figure 4.12: River Discharge Measurement

Source: (Scheider, S., Et Al; 2011)

4.5.5 Taking suspended load samples

Given high levels of physical and biological effects, fine silt (2mm) is very important in fluvial systems. Fine sediment is removed from the landscape and then moved by rivers and streams while suspended. A variety of human and automated techniques can be used to sample suspended sediment, estimate river loads, and collect samples for further stud Suspended sediment sampling (Clarke Ley, 2014).

litre-One plastic bottle containers serve as the sampling apparatus. Each bottle cap had two holes drilled in it, and copper tubes (8 mm)were placed in each one, spacing them apart by around 3 cm (air exhaust pipe and intake tube). To ensure that no water seeps into the bottle and to stop the tubing from slipping in and out of the bottle cap, the area around the tube is sealed with a sealing substance. These units can all be put in a single station (three bottles are installed on the fencepost). As shown in Figure, the samples' entrances were at various depths based on the depth of the column (4.13). So that sediment samples from various depths in the water column can be taken. Water and sediments enter as the water level rises to the level at which the intake tube was positioned. bottles positioned at areas where samples are collected. This sampler fills up over time.

Each sample is identified by a label that includes the date, time, and location information.

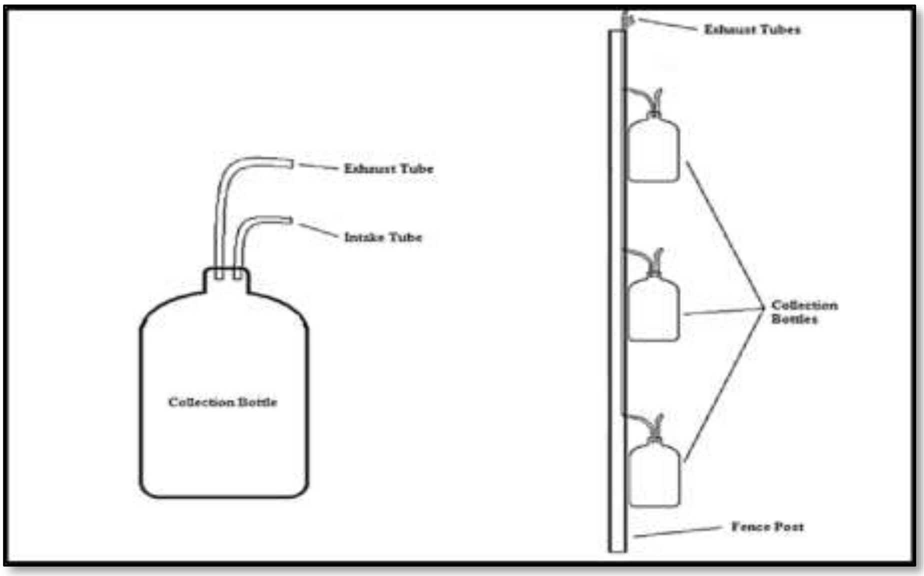


Figure 4.13: Suspended Sediment Sampler

Source: (Ismaeel, A. J., Et Al; 2020)

4.5.6 Number and locations of sampling

Sever al variables, including the level of measurement accuracy required, the shape and size of the cross-section, and other flow characteristics, must be taken into consideration when determining the quantity and locations of vertical sampling necessary for suspended sediments. The following illustrates the most popular techniques for determining the transverse position of sample verticals according to the Interagency Committee on Water Resources:

a. A single mid-stream vertical.

b. A single vertical at the thalweg or deepest point.

c. Verticals Column at the (1/4, 1/12, and 3/4 of the river or stream width.

d. Verticals at (1, 6, and 5.6) times the width of the river or stream.

e. Crossing the stream with four or more verticals at the midpoints of equal-width sections.

There are vertical lines at the centroid of portions with an equal water discharge.

The approach (c), shown in Figure (4.14), uses the sample verticals (1/4, 1/2, and 3/4) of the stream cross-section from the river width. Compared to the single vertical method, this method provides greater details regarding the sediment distribution through thecross-section.

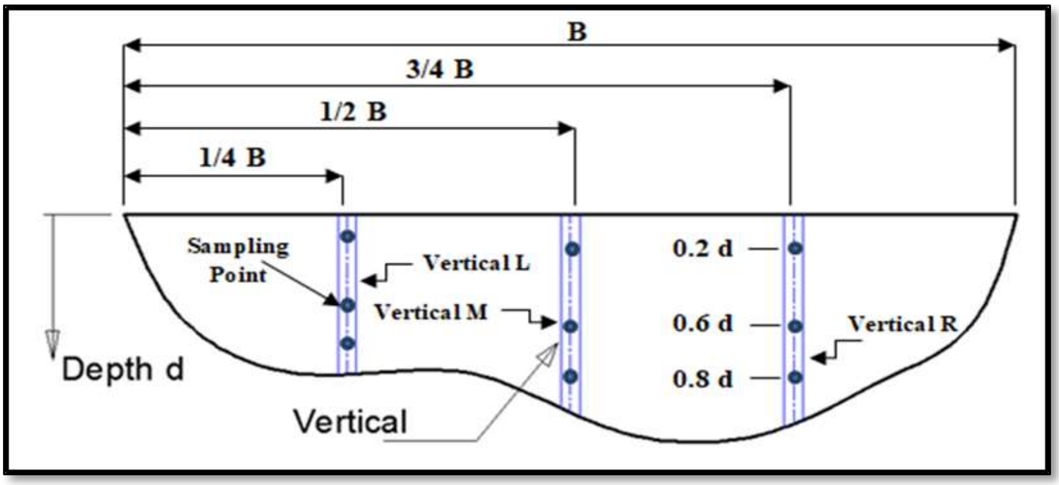


Figure 4.14: Select of Sampling Verticals

Source: (Shamkhi, M., Et Al; 2018)

The sampling verticals for the suspended sediment samples in this investigation were determined using method (c) at (1/4, 1/2, and 3/4)from the width of the river cross-section, as illustrated in Figure (4-14). Samples were taken in two sections of the study area (No. 2 and No. 13), which was more useful and completely appropriate to the extent of the study. Three samples were taken at three depths (0.2, 0.6, 0.8 d), where d represents the depth of water measured from the surface. Thus, the total samples are nine for each section.

4.5.7 Sampling of bed materials

Regarding river bed samples, three samples were taken from each part of the river's width at (1/4, 1/2, and 3/4). After thoroughly mixing the three samples to create a homogeneous sample representing the cross-section, a portion was taken to the lab for examination The device that was used to collect bed samples is known as (Van Veen grab sampler).

4.5.7.1 Van Veen grab sampler

A device for sampling silt in aquatic situations. Usually, it is a stainless-steel clamshell bucket. It might be low-tech and relatively lightweight (5 kg). Even handbags may fit the tiniest version in 1933, dutch engineer johan van veen created the sampling device. (van veen, johan, 1936).

A disadvantage of this sampler is that it has a propensity to disturb the sediment. It works by spreading out like an open pair of scissors while submerged in the water thanks to its two bucket-end levers. In this position, the levers are locked; when they contact the ground, they unlock. They close the two buckets and draw the rope up again and retrieve a sample from the river bed. as in Figure (4.15), which shows this device (Eleftheriou, Anastasios, 2013).

Figure 4.15: Van Veen Grab Device

Source: (Virginia - Va. Beach, 2020)

4.5.7.2 Time series water level measurements

Measurements of the water level are regarded as crucial data in this investigation. As a result, we tried to give these data in separate places within the scope of the research field. This information on water levels was gathered with the assistance of the Babylon Governorate's management of dams and reservoirs. and a measuring ruler from the management of dams and reservoirs took measurements of the water levels. And also, water level information was collected via a hydrological station under their control, as shown in Figure below.

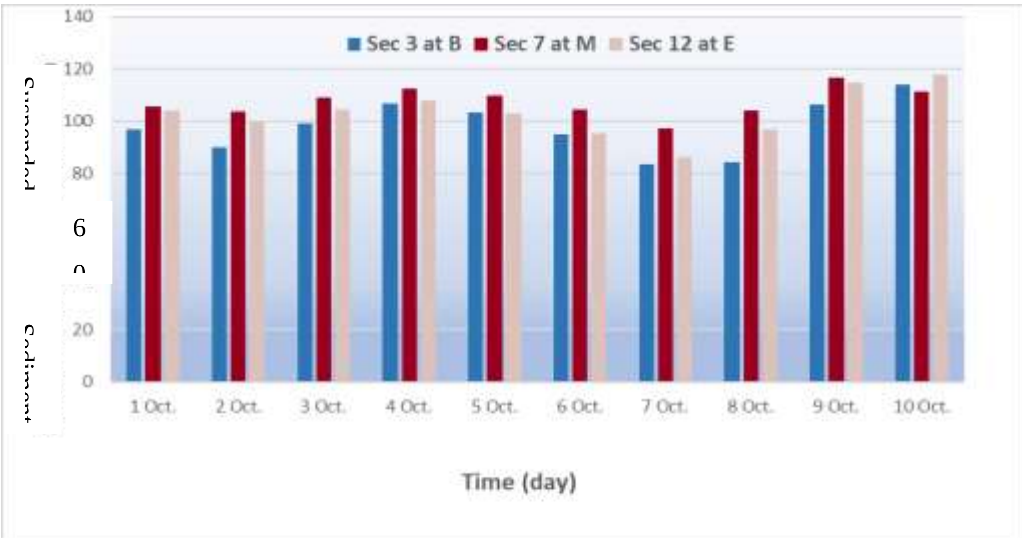


Figure 4.16: Time Time Series Water Level Measurements

4.6 Laboratory Works

The results of the sieve analysis and the hydrometer test of the bed samples and were used to determine the sediment distribution curve for the bed materials. Laboratory work was also used to determine the specific gravity of the bed samples and the concentration of suspended sediments.

4.6.1 Specific Gravity of Bed Materials

The specific gravity of soils can be defined as the ratio of the mass or volume of soil at a specified temperature to the mass of the same volume of distilled water free from gas at the same specified temperature. The pycnometer test is the procedure used to determine the values of the specific gravity of bed materials. This procedure according to (ASTM D854-02) determines the specific gravity of bed sediments materials. The values of the specific gravity of bed materials for all cross sections are listed in Table (4.5). The average value of specific gravity for all sections was (2.69).

Table 4.4: Specific Gravity Of Bed Material

Section No.	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**Average Specific Gravity for All Sections**
Specific gravity	2.70	2.69	2.69	2.70	2.70	2.72	2.70	
Section No.	8	9	10	11	12	13	14	2.69
Specific gravity	2.70	2.69	2.69	2.70	2.70	2.72	2.70	

4.6.2 Hydrometer testing and sieve analysis

The purpose of the grain size analysis test is to estimate the proportion of each size of grain that makes up a soil sample. The test's outcomes can be utilized to create the grain size distribution curve. The soil is categorized and its behaviour is predicted using this information. Which results in the grain gradient curve (Trent Smith, 2014). River bed samples were analyzed according to ASTM D422 D422 (Christopher A. Bareither, et al; 2008). This test employed sieves with dimensions of 2, 0.85, 0.6, 0.425, 0.3, 0.25, 0.21, 0.15, and 0.075 mm. From the largest size to the smallest size, they are stacked one on top of the other. The sediment sample is dried before being put in the first sieve and shaken for ten minutes. The leftover granules are then weighed on each sieve and their weights are recorded, precise silt particles are then Finally, it is determined what proportion (%) of the silt particles are finer.

A hydrometer is used to measure the volume of the sample that passes through sieve No. 200 (0.075 mm). and this test was carried out in accordance with ASTM D422A hydrometer is used to measure the volume of the sample that passes through sieve No. 200 (0.075 mm). and this test was carried out in accordance with ASTM D422 (Gavlak, Ret al; 2003). A dispersant called sodium hexametaphosphate is combined with soil and water before the soil particles are allowed to settle. Stock's law states that larger particles settle more quickly.

The mixture's density then drops, which has an impact on the hydrometer's buoyancy. The particle gradient curves are finished using information from a table that contains information on the density, time, and fall velocity of the particles. by calculating the grain size (mm) versus the per cent passing (%).

The bed material size distribution in sections No.2 & No.13 is shown in Figure (4.16) and Figure (4.17) The researcher explains this while conducting the test in the laboratory. Table (4.6) shows the average bed material size distribution in the study reach.

Table 4.5: The Average Bed Material Size Distribution

Diameter (mm)	Average diameter (mm)	% of fraction
d < 0.007	-----	9
0.007 < d < 0.03	0.0185	5
0.03 < d < 0.1	0.065	20
0.1 < d < 0.15	0.125	26
0.15 < d < 0.3	0.225	30.6
0.3 < d< 2	1.15	9.4
2 < d	-----	0

Figure 4.17: The Researcher While Conducting the Test in the Laboratory

5. THE MODELLING

5.1 Quantifying Silt and Sediment between Groynes

One of the main uses of these scenarios is to quantify the amount of silt and sediment that is being transported downstream between the groynes. This can be done using a variety of methods, including field measurements, sediment sampling, and CFD (computational fluid dynamics) simulations. By studying the flow between the groynes and quantifying the amount of sediment transport, it is possible to optimize the design of groynes and improve their effectiveness in controlling erosion and promoting sediment deposition.

Studying the flow between groynes in detail

Another use of these scenarios is to study the flow between groynes in detail. This can be done using CFD simulations, which can provide detailed insights into the dynamics of sediment transport and the formation of river morphology. By studying the flow between groynes, it is possible to optimize their design and improve their effectiveness in controlling erosion and promoting sediment deposition.

In conclusion, the four scenarios for groynes in a river discussed in this article are useful for quantifying silt and sediment between groynes and studying the flow between them in detail. By optimizing the design of groynes based on these studies, it is possible to improve their effectiveness in controlling erosion and promoting sediment deposition, which is critical for maintaining a healthy river ecosystem.

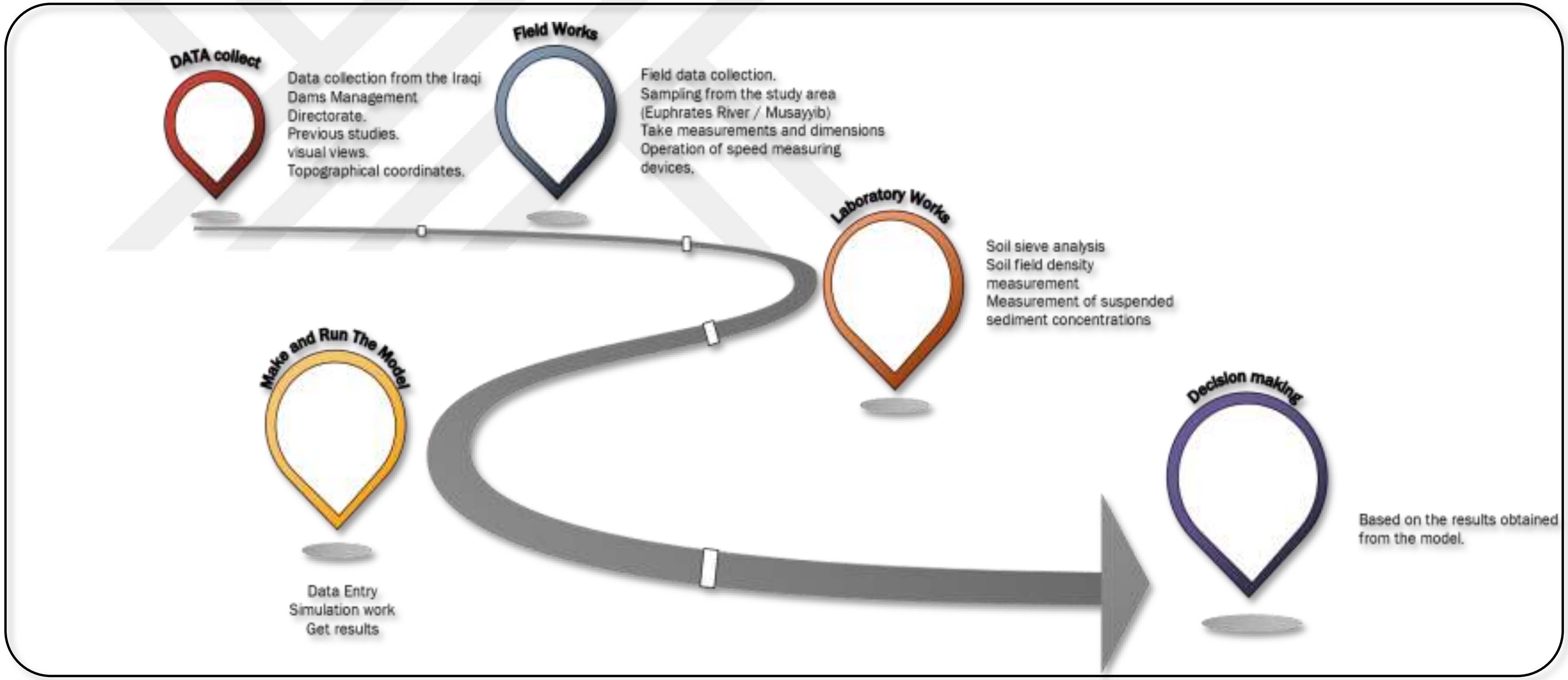


Figure 5.1: The Plan of This Research

Figure 5.2: Date7/2018 Düsseldorf Germany

Source: (GOOGLMAP)

Figure 5.3: Date 4/2019 Düsseldorf Germany

Source: (GOOGLMAP)

5.2 Control Sections

In this search it will be considered two control section at section No. 2 and at section No. 13.

The purpose of selecting control sections in the study area is to calculate the quantities of sediments that have been sequestered in the study area as a result of groynes.

The number of cross sections in this model was 229 (i) and the number of the profile sections was 19 (j), and the numbers of levels in vertical direction was 8 (k).

The Boundary of condition for this model were:

The discharge is 333 m3/s

The initial depth is 7 m,

The density of soil is 2.69 kg/m3

The slope of the region in this area is 0.001

The viscosity of water at 20 c is 0.001 Ns/m2

The sizes of particles in this model were: 0.0435, 0.19, 0.6,0.95 and 1.5 mm.

Table 5.1: Average Bed Material Distribution for Study Reach

Diameter (mm)	Average diameter (mm)	% of fraction
d < 0.007	-----	8
0.007 < d < 0.08	0.0435	13
0.08 < d < 0.3	0.190	67
0.3 < d < 0.9	0.600	7
0.9 < d < 1	0.950	3
1 < d< 2	1.5	2
2 < d	-----	0

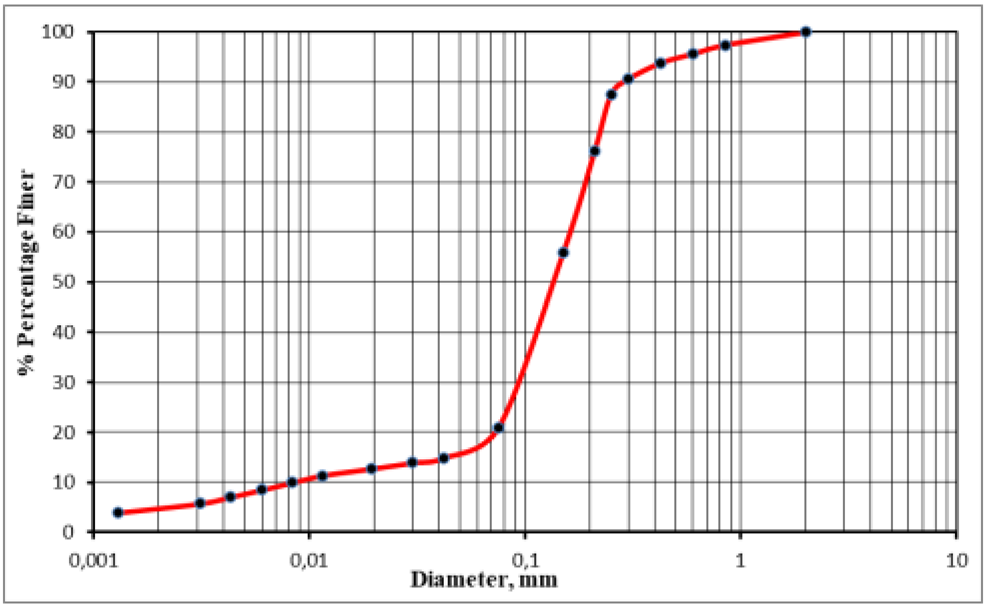


Figure 5.4: Distributions of Sieve Analysis

Calculate of sediment discharge is very important for estimating sediment loads in rivers or streams. The suspended sediments rate (discharge) can be calculated by multiplying the concentration of suspended sediment in the water discharge through the equation below [Abbas; 2022]:

$$Q_s = C \times Q \times 0.001 \qquad \textbf{(5-1)}$$

Where: Q_s= suspended sediments discharge (kg/s), Q= water discharge (m^3/s), and C= suspended sediment concentration (mg/l or ppm).

From the second section of the study area, we find that the suspended sediment rate is 91 parts per million. In order to find the sediment flow rate for the study area, we will use Equation (4). It will be 30.3 kg/s. for the average discharge 333 m^3/sec. These values will be as input values for the model.

Table 5.2: Field Measurements for Concentration of Suspended Sediments and Flow Velocities for the Control Sections (Before The Modelling).

Section	**Width of section (m)**	**Percent from depth**	**Velocity (m/s)**			**Concentration (ppm)**		
			L (1/4B)	**M (1/2B)**	**R (3/4B)**	**L (1/4B)**	**M (1/2B)**	**R (3/4B)**
2	**260**	**0.2d**	0,51	0,52	0,49	90	95	97
		0.6d	0,44	0,60	0,48	100.4	102.0	82
		0.8d	0,46	0,57	0,51	111.0	90.9	123.0
13	**254**	**0.2d**	0,48	0,60	0,48	75.7	71.0	85.2
		0.6d	0,46	0,57	0,49	97.8	84.3	92.5
		0.8d	0,47	0,53	0,48	110.0	103.2	101.5

5.3 The Modeling in SSIIM or CFD

Computational Fluid Dynamics (CFD) is a powerful tool for simulating and analyzing fluid flows in a wide range of applications. In CFD, a grid (also known as a mesh) is used to discretize the fluid domain into small control volumes or cells, where the governing equations of fluid motion are solved numerically. The accuracy and reliability of the CFD simulation heavily depend on the quality of the grid used. In this article, we will discuss the importance of creating a grid in CFD programs, especially with SSIIM program.

SSIIM (Sediment Simulation in Intakes with Multiblock option) is a CFD program developed by the Norwegian University of Science and Technology (NTUN) for simulating surface and subsurface flows in irrigation systems. SSIIM uses a finite difference method to solve the equations of fluid motion and mass transport in the domain. To simulate a complex irrigation system, a high-quality grid is essential.

One of the main advantages of creating a grid in CFD programs is that it allows for accurate representation of the physical domain. The grid discretizes the domain into a finite number of cells, which can be used to calculate the flow variables at each point in the domain. This allows for accurate prediction of the flow behavior, including velocity, pressure, and turbulence intensity.

In SSIIM, creating a grid is especially important because irrigation systems often have complex geometries with irregular boundaries and varying soil properties. A high-quality grid is essential for accurately capturing the flow behaviour in these systems. SSIIM allows for the creation of grids using a variety of methods, including structured, unstructured, and hybrid grids.

Another advantage of creating a grid in CFD programs is that it allows for efficient computation of the flow behaviour. The grid discretizes the domain into small control volumes, which can be solved independently of each other. This allows for efficient parallelization of the computation, which can significantly reduce the computational time required for a simulation. In SSIIM, efficient parallelization is crucial because irrigation systems often have large domains that require long simulation times.

Creating a grid in SSIIM also allows for the simulation of different scenarios and optimization of the irrigation system. By modifying the grid and the boundary conditions, different irrigation scenarios can be simulated and compared to optimize the system's performance. For example, the impact of changing the irrigation schedule or the irrigation method can be simulated to determine the most effective approach.

In conclusion, creating a grid in CFD programs, especially with SSIIM, is essential for accurate and efficient simulation of fluid flows in irrigation systems. A high-quality grid allows for accurate representation of the physical domain, efficient computation of the flow behaviour, and the simulation of different scenarios to optimize the system's performance.

In the figure below Fig (5-5), the grid of the study area. This step is important and at the same time difficult, because the formation of the grid of natural areas and meanders of natural rivers with this program is difficult. This difficulty comes from the fact that the program is intended for specific system shapes.

Control segment 13 will be the equivalent of segment 200 on the model. As for 1/4 of the width of the river, 1/2 of the width of the river, and 3/4 of the width of the river, they will have the J values of 5, 10, and 15, respectively. The value in the depth of river will be k=2 equal to 0.2d and k=6 equal to 0.6d and K=8 equal to 0.8d.

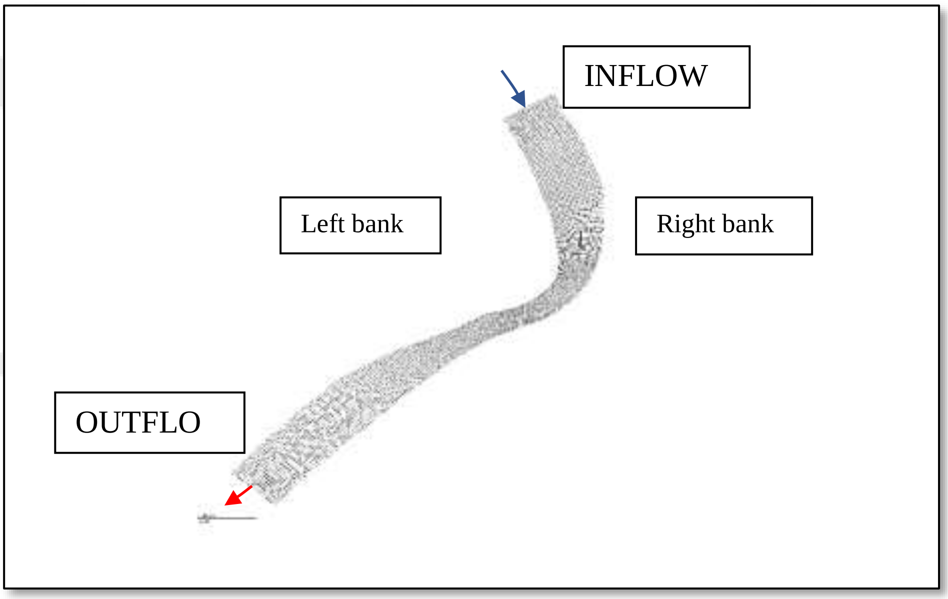


Figure 5.5: The Region of Study in SSIIM (Grid Generated Step)

5.4 The Importance of Matching CFD Models of Fluids with the Study Region

Computational Fluid Dynamics (CFD) is a tool used to model the behaviour of fluids, including water, in various scenarios. It has become an essential tool in the field of river engineering, as it allows researchers to study the complex dynamics of water flow and predict how it will behave under different conditions. However, the success of CFD modelling depends on how well the models match the areas of study for rivers.

One of the most important factors in accurately modelling fluid flow in rivers understands the geometry and topography of the river. Rivers can be characterized by their cross-sectional shape, bed slope, and channel roughness. These factors can have a significant impact on the flow of water, and it is essential to accurately capture them in CFD models.

Another important factor to consider when modelling rivers is the type of flow regime. Rivers can exhibit laminar or turbulent flow, depending on their characteristics. Laminar flow is characterized by smooth, steady flow, while turbulent flow is chaotic and unpredictable. Different modelling approaches are required to capture each type of flow regime accurately.

CFD models must also account for the impact of sediment transport in rivers. Sediment transport is the movement of sediment particles, including sand, gravel, and silt, by water flow. It can significantly impact the hydraulic characteristics of a river, and it is essential to accurately model sediment transport to obtain accurate results.

Finally, CFD models must account for the impact of vegetation on river flow. Vegetation, such as trees and aquatic plants, can significantly impact the flow of water in rivers, especially in shallow or low-flow areas. Modelling the impact of vegetation on river flow accurately can provide valuable insights into the ecology of rivers and help guide management decisions.

In conclusion, accurate CFD modelling of fluid dynamics in rivers is essential for understanding the behaviour of water flow and predicting how it will respond to changes in the environment. To achieve accurate results, CFD models must match the areas of study for rivers, including the river's geometry, topography, flow regime, sediment transport, and vegetation. By incorporating these factors into CFD models, researchers can gain a better understanding of the complex dynamics of rivers and make informed decisions about river management and conservation.

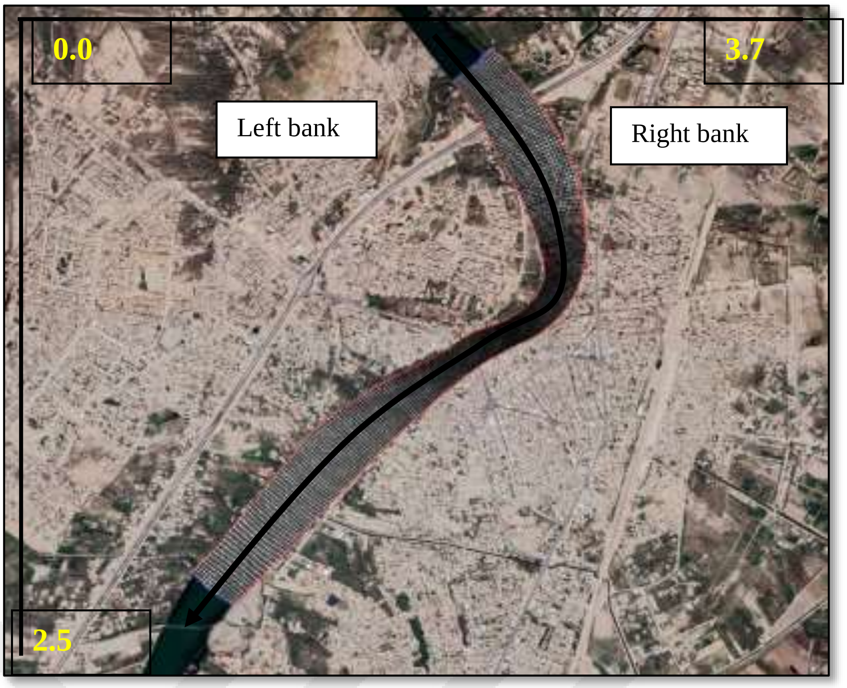


Figure 5.6: The Matching Of SSIIM Model with Region of Study

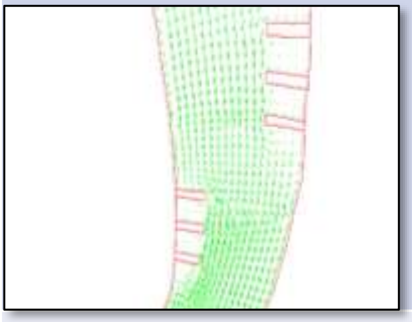
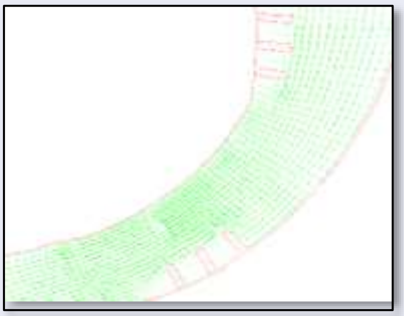
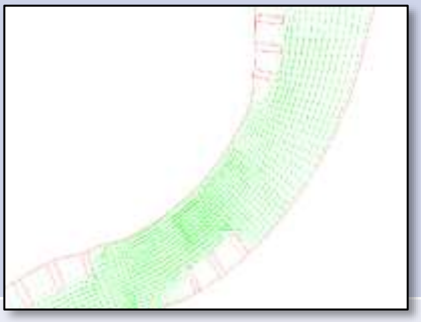
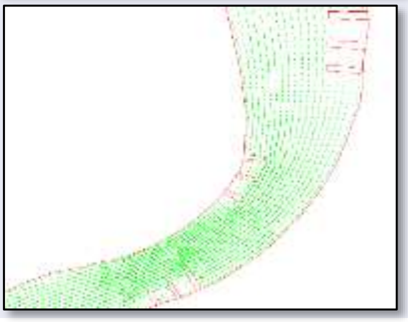
5.5 The Scenarios of the Study

Groynes, also known as spur dikes, are structures that are constructed perpendicular to the flow of a river to control the flow of water and sediment. They are commonly used in river engineering to stabilize riverbanks, prevent erosion, and improve navigability. In this article, we will discuss four scenarios for groynes in a river and their usefulness for quantifying silt and sediment between groynes and studying the flow between them in detail.

The reason for choosing the locations of these groynes is what previous studies indicated that there is a lot of erosion in the banks of these areas due to high speeds or because of the accumulation of sediments in other areas.

It is also noted that the location, shape and length of the groynes were completely dependent on the previously mentioned main design factors.

Table 5.3: The Summary of the All Scenarios

Scenario	Screen Shoot	Remarks
1		Three Groynes On the Right Followed by Three on The Left
2		**Three Groynes On the Left Followed by Three on The Right**
3		Three Groynes On the Left Followed by Three Groynes On Each Side
4		Advancing Three Groynes On Right with Three Groynes On Each Side

5.5.1 Scenario 1: three groynes on the right followed by three on the left

In this scenario, three groynes are constructed on the right side of the river with the distance around 50m and the depth of these groynes was around 1/3 from the width of river, followed by three groynes on the left side and the dimensions of its was same.

This arrangement creates a meandering flow pattern, which can help to control erosion and promote sediment deposition. By studying the flow between the groynes, it is possible to quantify the amount of silt and sediment that is being transported downstream.

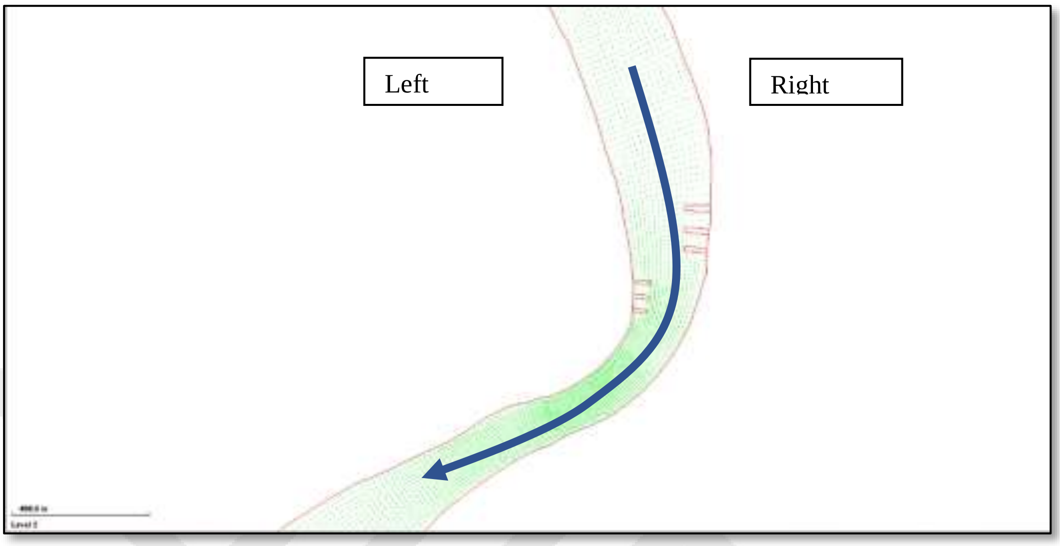


Figure 5.7: Scenario 1: Three Groynes on the Right Followed By Three on the Left

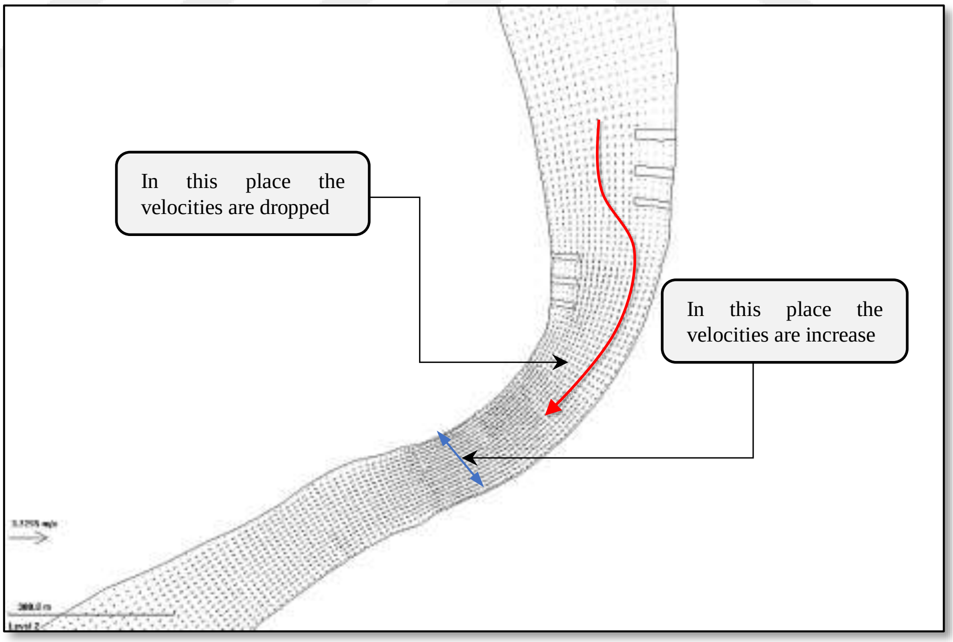


Figure 5.8: The Pattern of Flow In Scenario 1

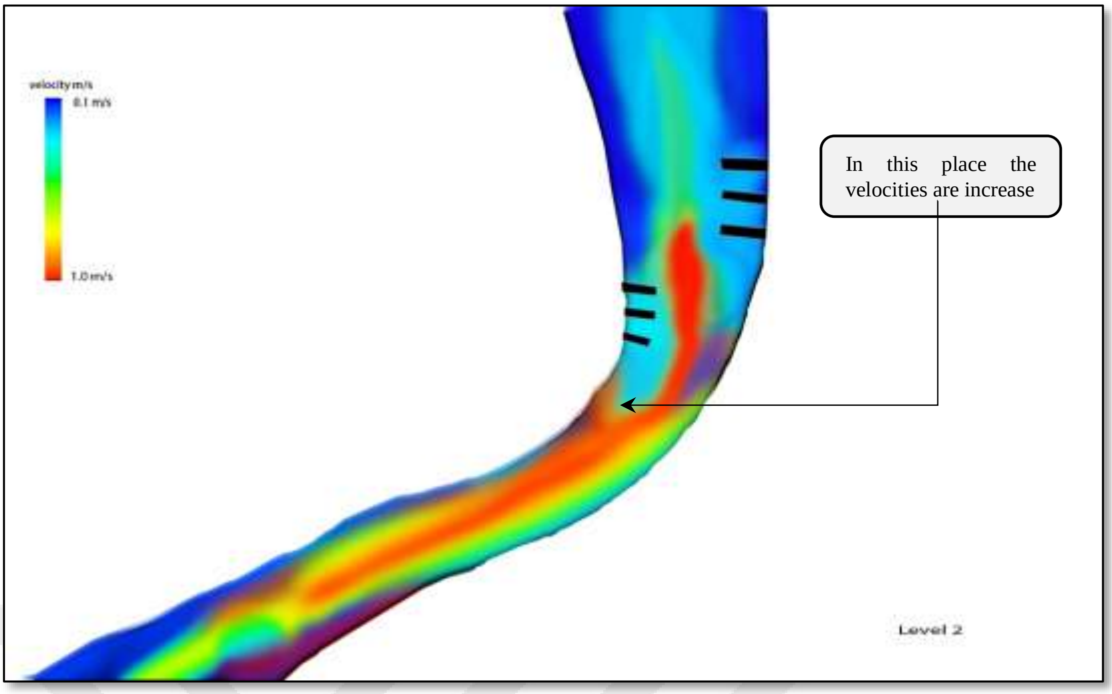


Figure 5.9: The Distribution of Flow as Gradients Colours

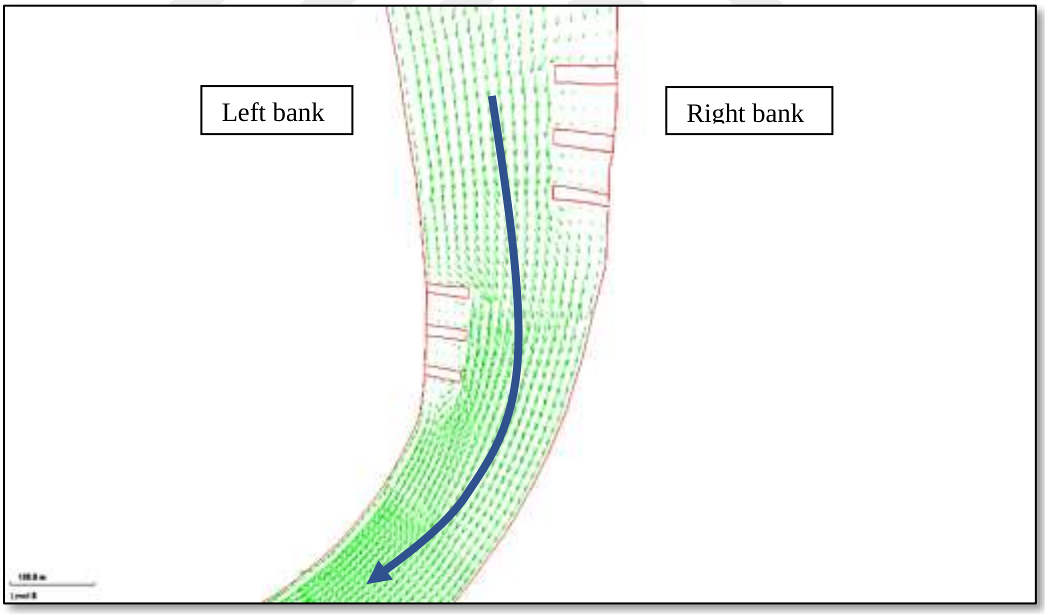


Figure 5.10: The Flow Vectors Pattern in Scenario 1

Table 5.4: Field Measurements for Concentration of Suspended Sediments and Flow Velocities for the Control Sections. After the Scenario 1

Section (i)	Width of section (m)	K	Velocity (m/s)			Concentration (ppm)		
			L	M	R	L	M	R
			J=5	J=10	J=15	J=5	J=10	J=15
200	254	2	4,30E-01	6,80E-01	5,80E-01	9,00E+01	7,55E+01	8,20E+01
		6	4,80E-01	5,50E-01	5,10E-01	8,80E+01	9,50E+01	7,82E+01
		8	4,60E-01	5,80E-01	5,10E-01	9,00E+01	8,82E+01	1,12E+02

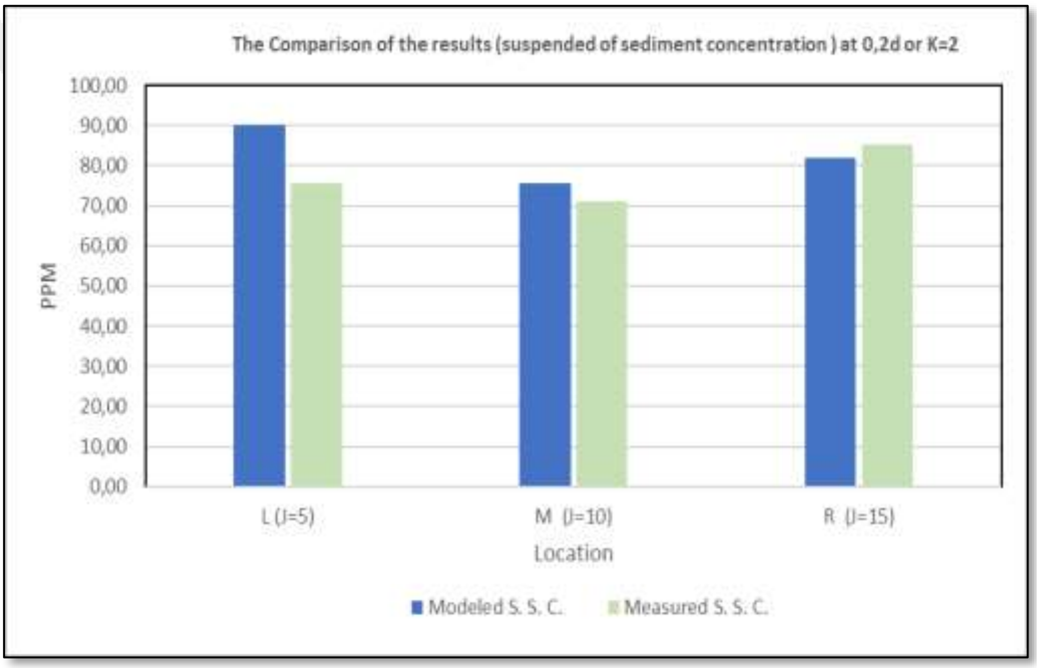


Figure 5.11: The Comparison of the Results (Suspended Sediment Concentration) At 0.2d Or K=2

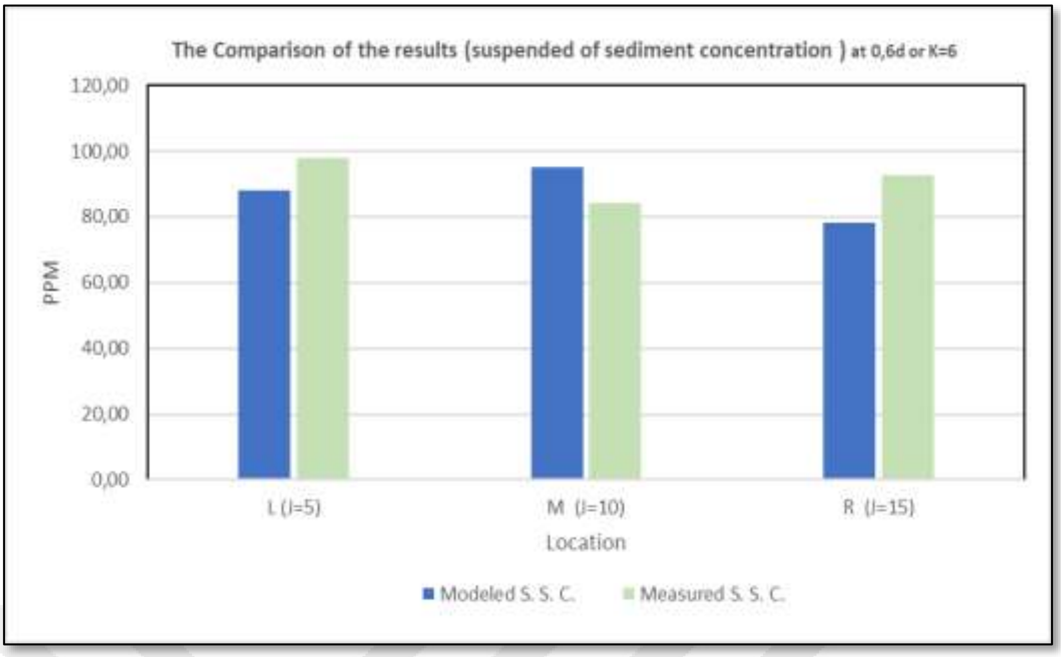


Figure 5.12: The Comparison of the Results (Suspended Sediment Concentration) At 0.6d Or K=6

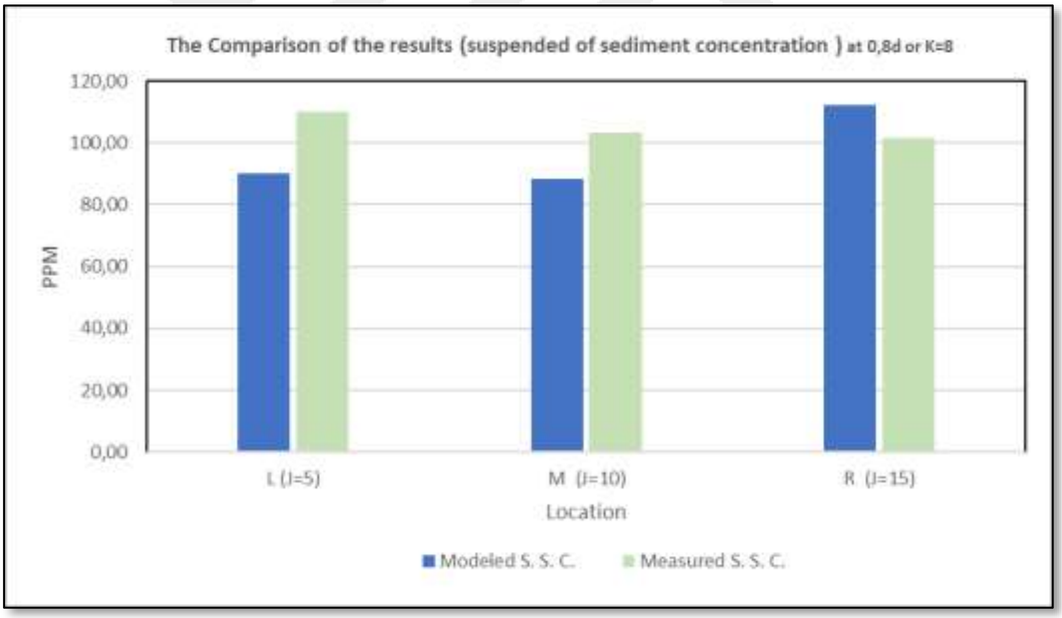


Figure 5.13: The Comparison of the Results (Suspended Sediment Concentration) At 0.8d Or K=8

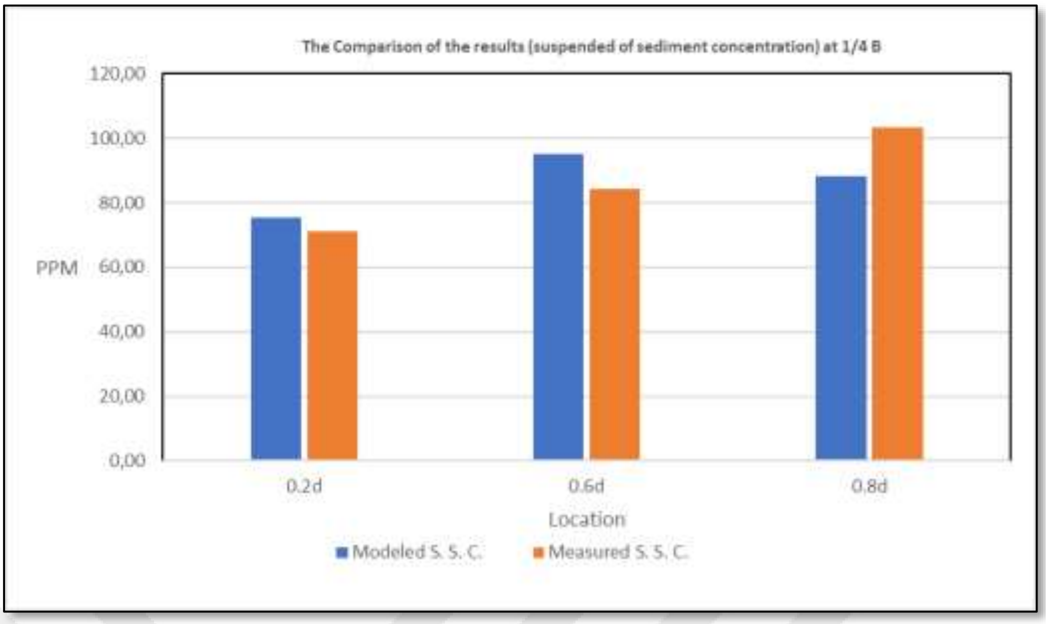


Figure 5.14: The Comparison of the Results (Suspended Sediment Concentration) At 1/4B

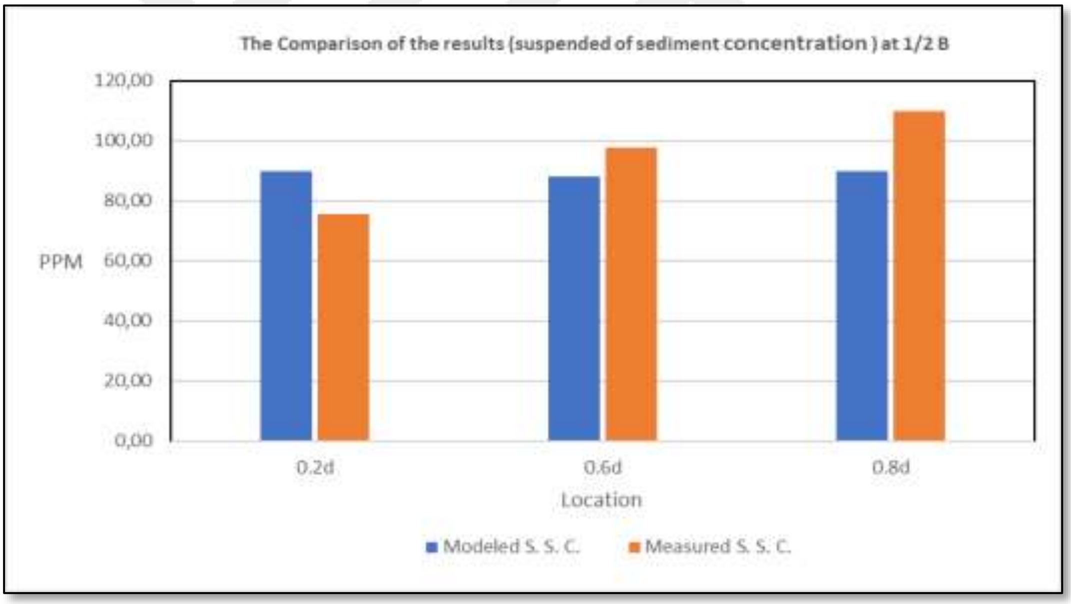


Figure 5.15: The Comparison of the Results (Suspended Sediment Concentration) At 1/2B

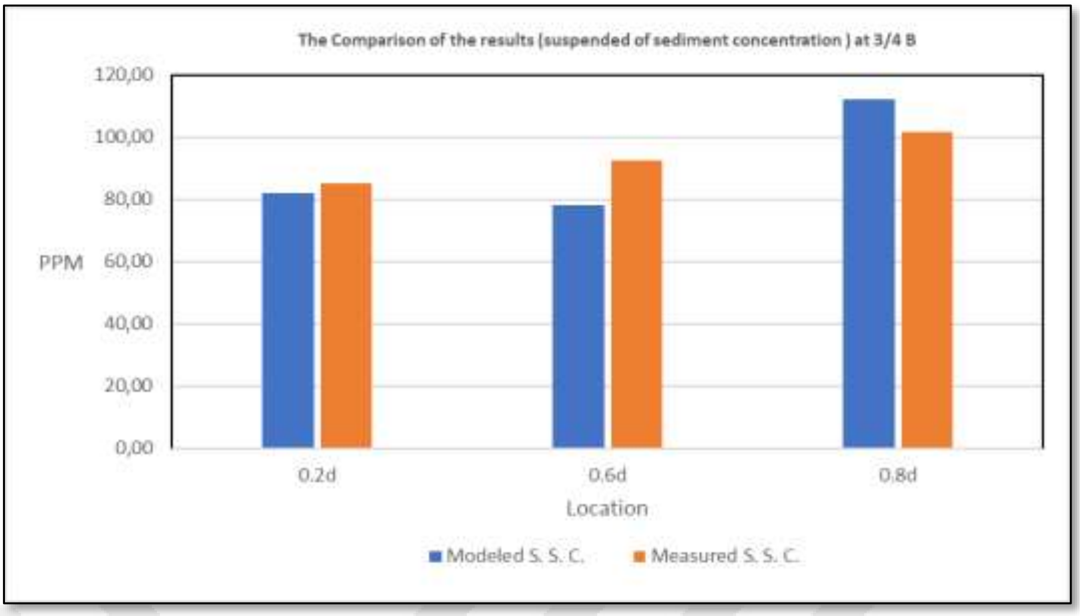


Figure 5.16: The Comparison of the Results (Suspended Sediment Concentration) At 3/4B

5.5.2 Scenario 2: three groynes on the left followed by three on the right

In this scenario, the three groynes on the left are in the foreground, followed by three groynes. On the right side, the groynes are advanced, creating a more complex flow pattern. By studying the flow between the groynes, it is possible to gain insights into the dynamics of sediment transport and the formation of river morphology. This information can be used to optimize the design of groynes and improve their effectiveness in controlling erosion and promoting sediment deposition.

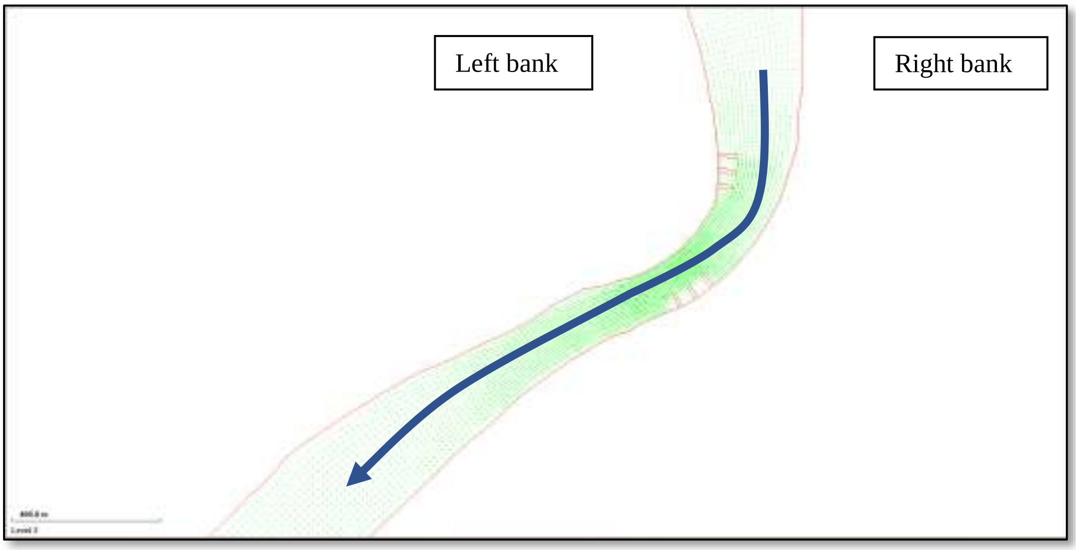


Figure 5.17: Scenario 2, Three Groynes on the Left Followed By Three on the Right

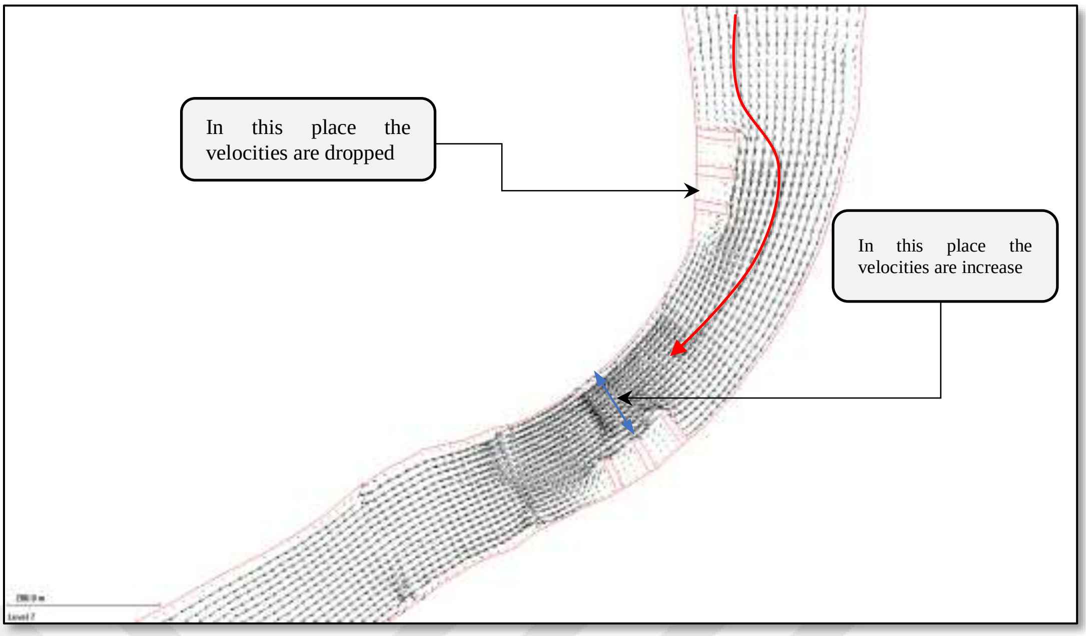


Figure 5.18: The Pattern of Flow in Scenario 2

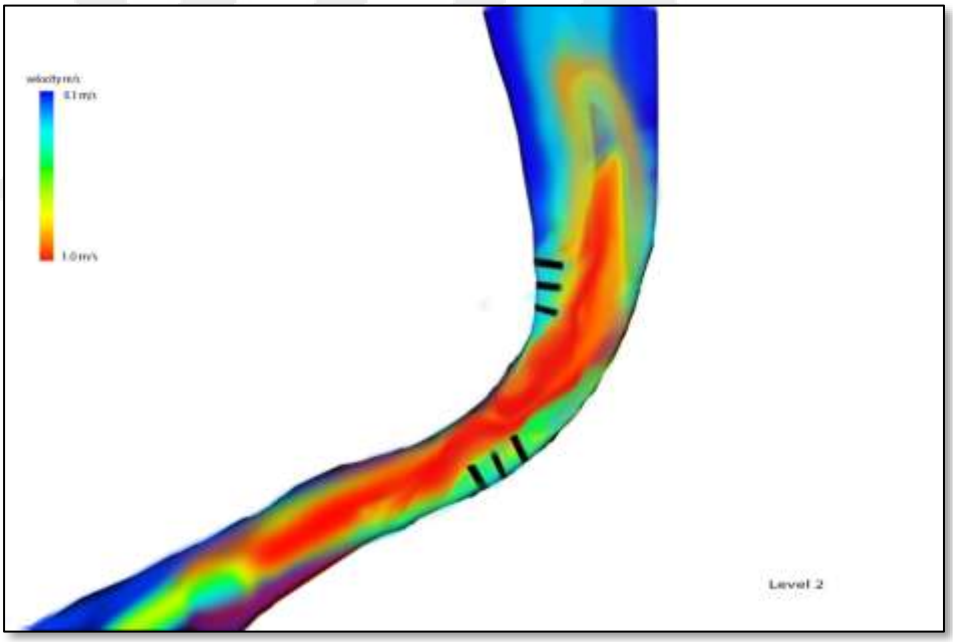


Figure 5.19: The Distribution of Flow as Gradients Colours in Scenario 2

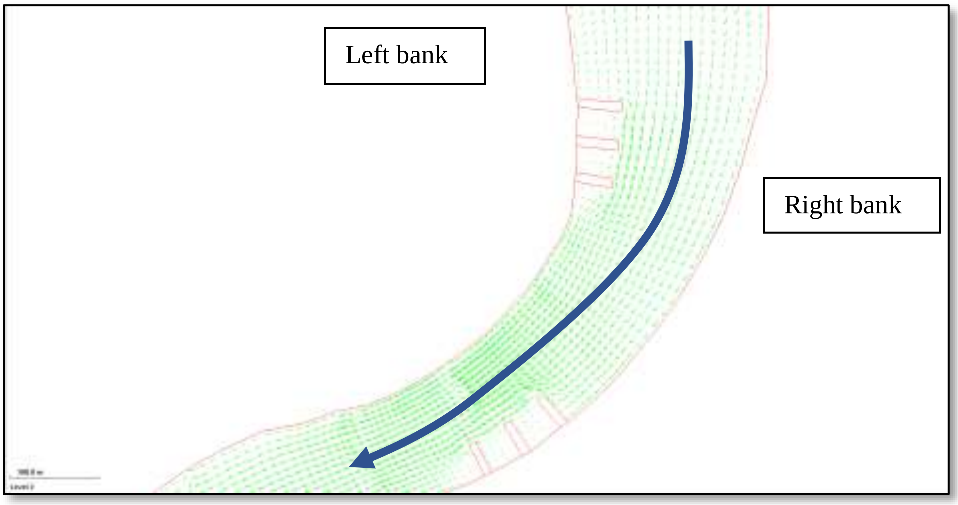


Figure 5.20: The Flow Vectors Pattern in Scenario 2

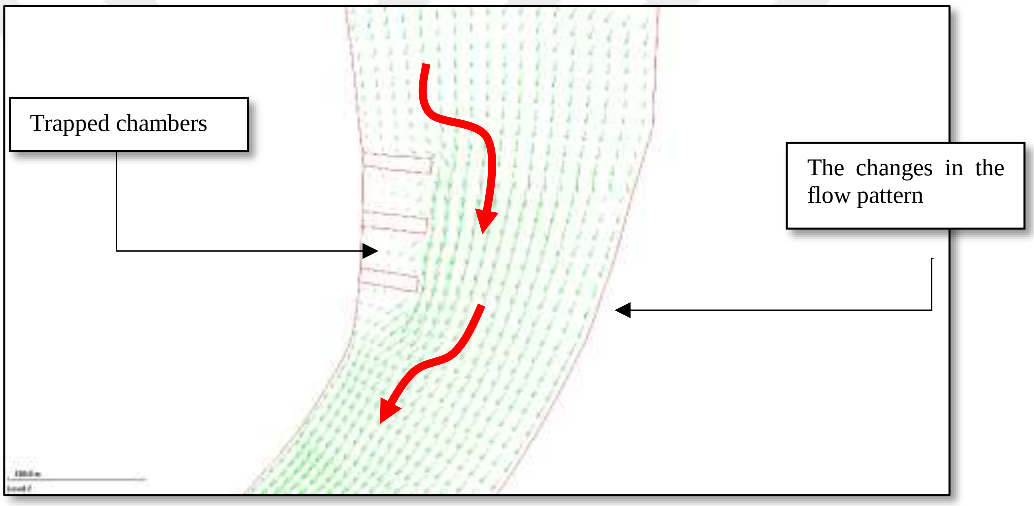


Figure 5.21: Zoom on the Pattern of Velocities in Scenario 2

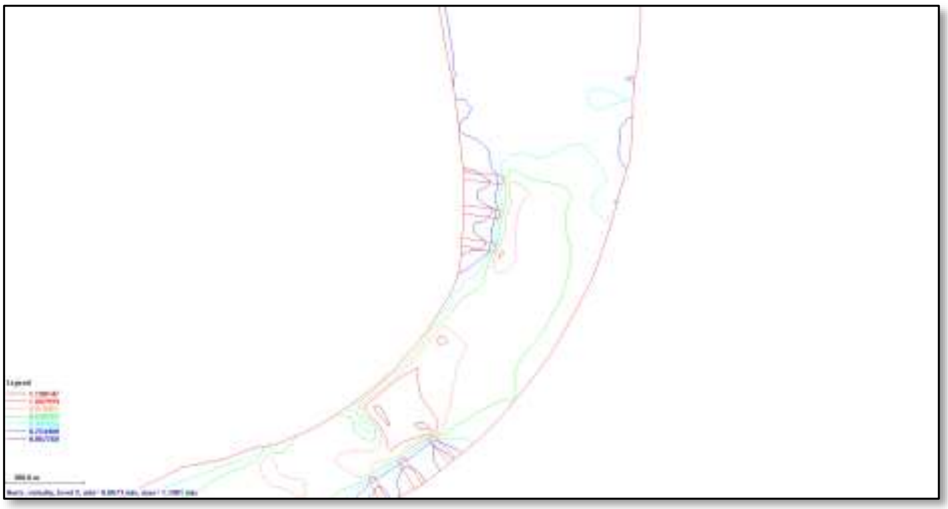


Figure 5.22: The Distributions of Velocities as Colour Lines in Scenario 2

Table 5.5: Field Measurements for Concentration of Suspended Sediments and Flow Velocities for the Control Sections, After the Scenario 2

Section (i)	Width of section (m)	K	Velocity (m/s)			Concentration (ppm)		
			L	M	R	L	M	R
			J=5	J=10	J=15	J=5	J=10	J=15
200	254	2	4,50E-01	7,50E-01	9,80E-01	8,00E+01	8,50E+01	9,00E+01
		6	5,50E-01	5,90E-01	5,20E-01	1,01E+02	9,60E+01	8,20E+01
		8	5,30E-01	6,80E-01	5,70E-01	9,50E+01	9,00E+01	1,01E+02

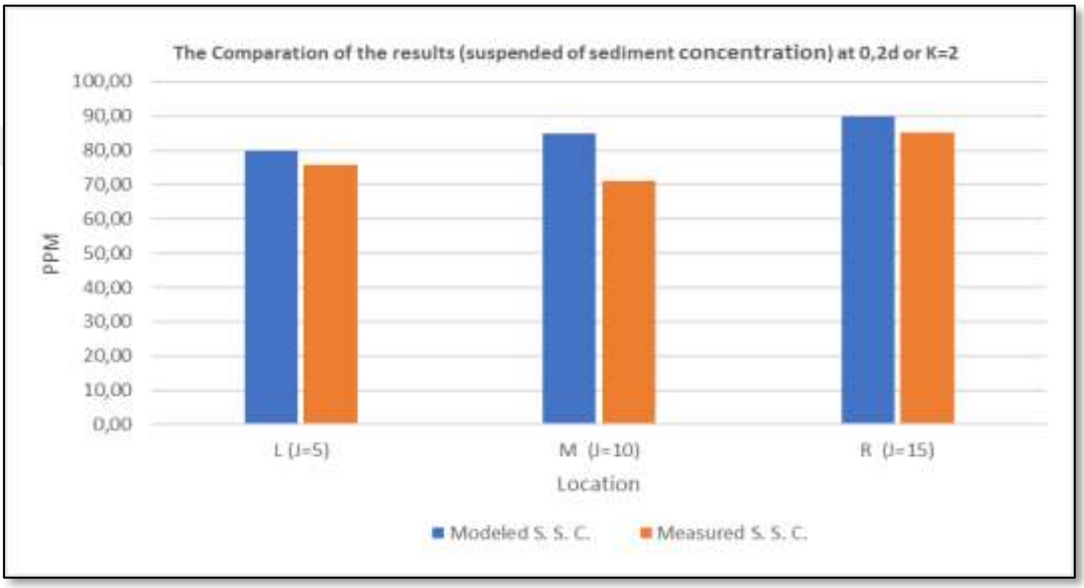


Figure 5.23: The Comparison of Results (Suspended Sediment Concentration) At 0.2d or K2

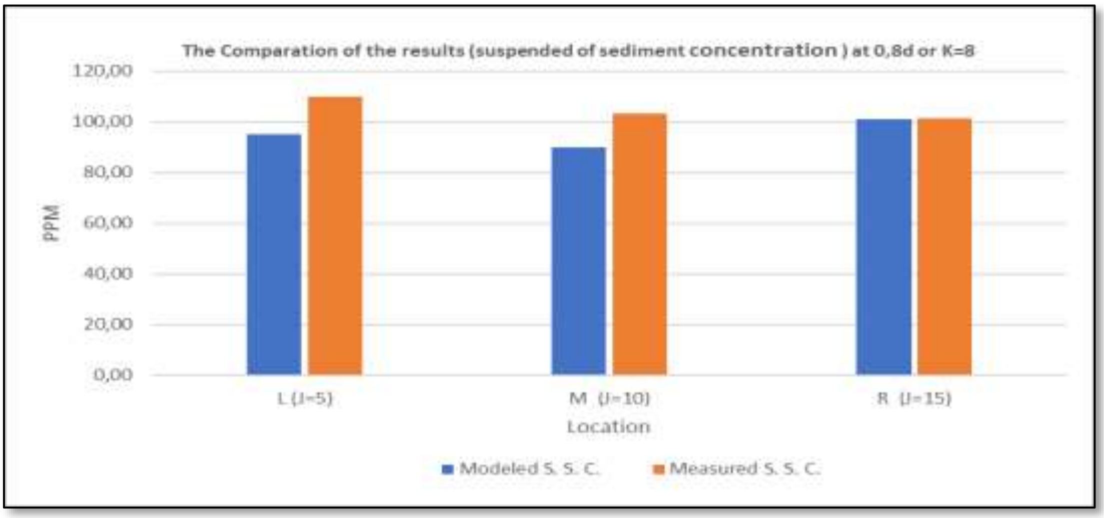


Figure 5.24: The Comparison of Results (Suspended of Sediment Concentration) At 0.6d or K6

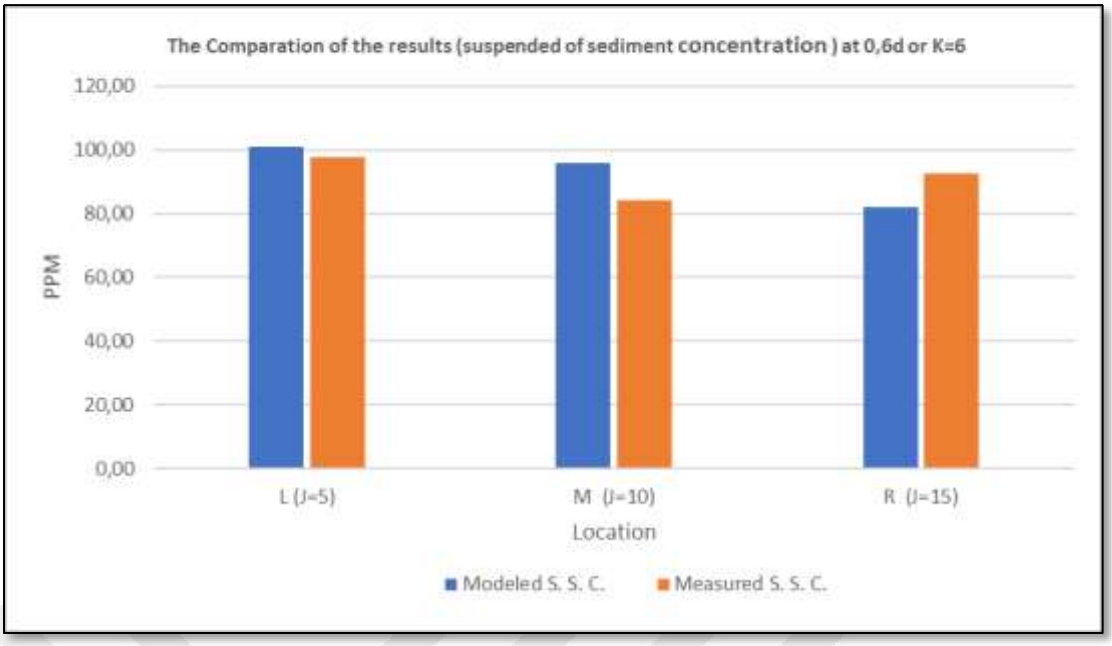


Figure 5.25: The Comparison of Results (Suspended Sediment Concentration) At 0.6d or K6

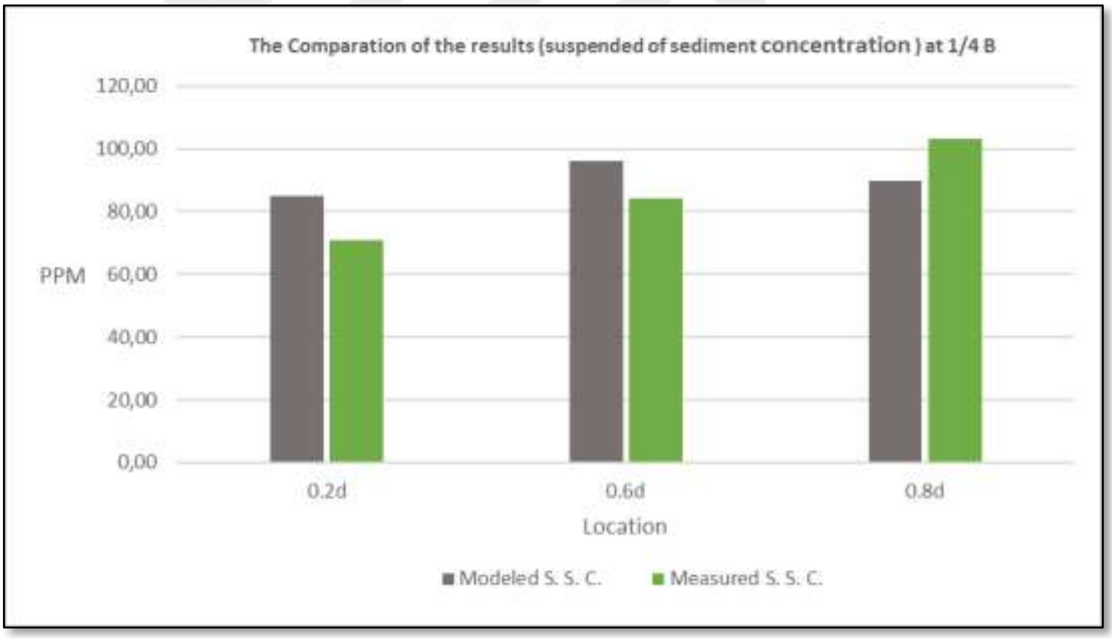


Figure 5.26: The Comparison of Results (Suspended Sediment Concentration) At 1/4B

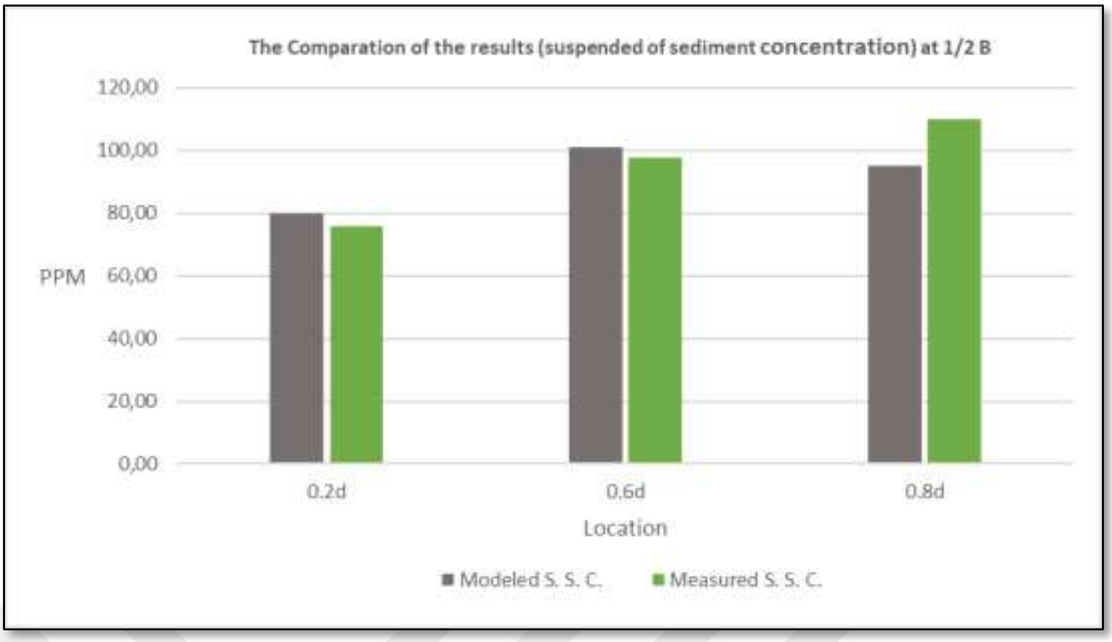


Figure 5.27: The Comparison of Results (Suspended Sediment Concentration) At 1/2B

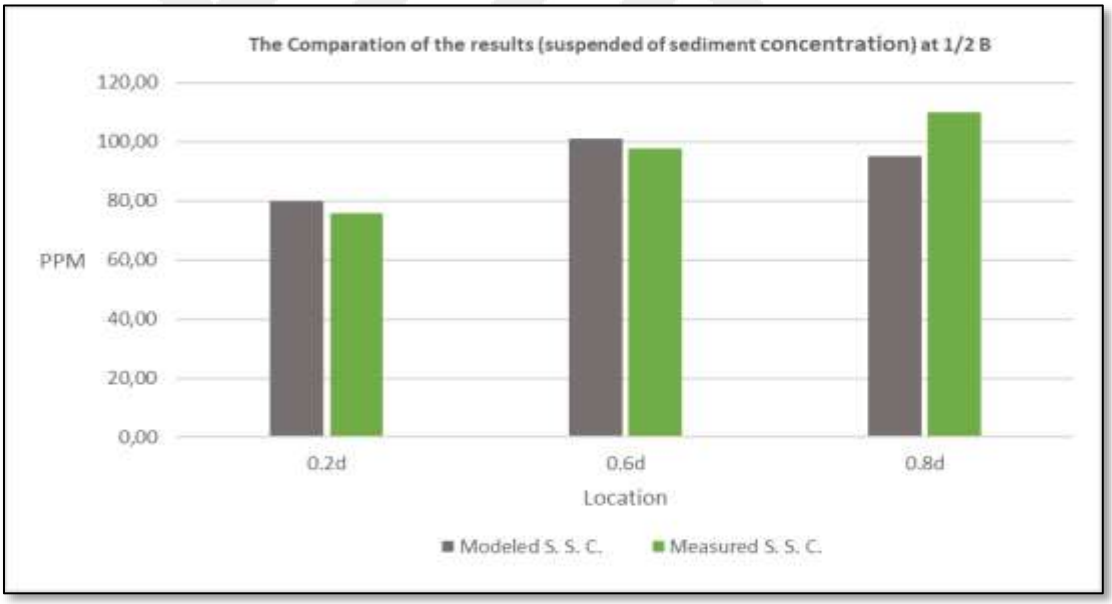


Figure 5.28: The Comparison of Results (Suspended Sediment Concentration) At 3/4B

5.5.3 Scenario 3: three groynes on the left followed by three groynes on each side

In this scenario, three groynes are constructed on the left side of the river, followed by three groynes on each side. This arrangement creates a more complex flow pattern than scenario 1, which can help to promote sediment deposition and control erosion.

By studying the flow between the groynes, it is possible to quantify the amount of silt and sediment that is being transported downstream and gain insights into the formation of river morphology.

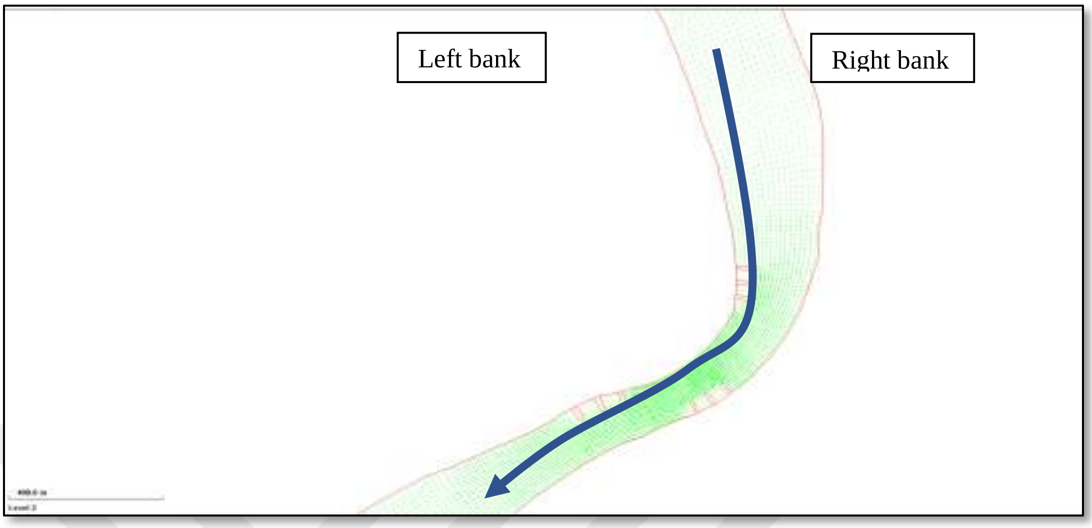


Figure 5.29: Scenario 3: Three Groynes on the Left Followed By Three Groynes on Each Side

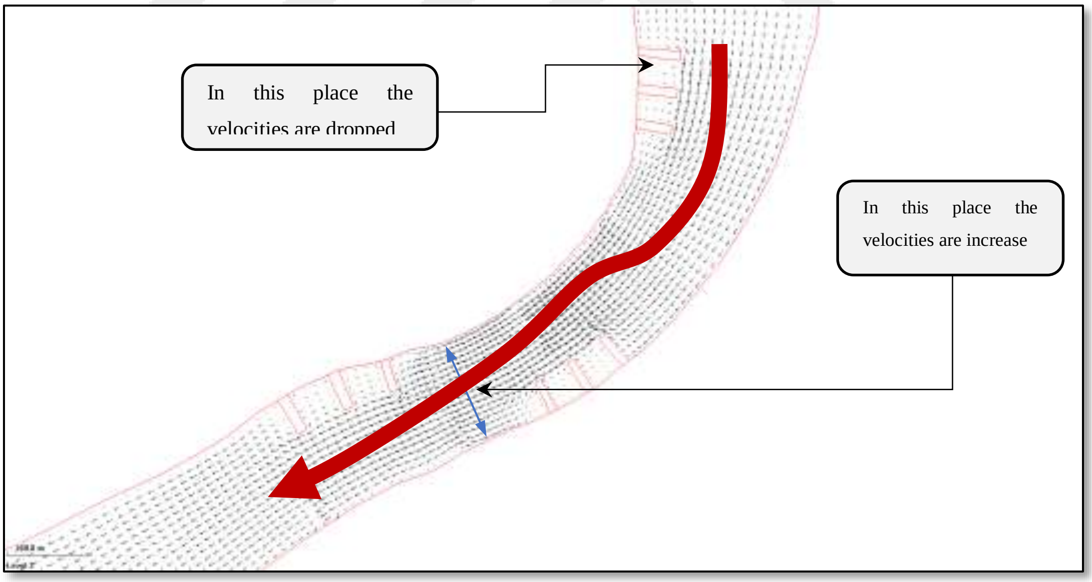


Figure 5.30: The Pattern of Flow in Scenario 3

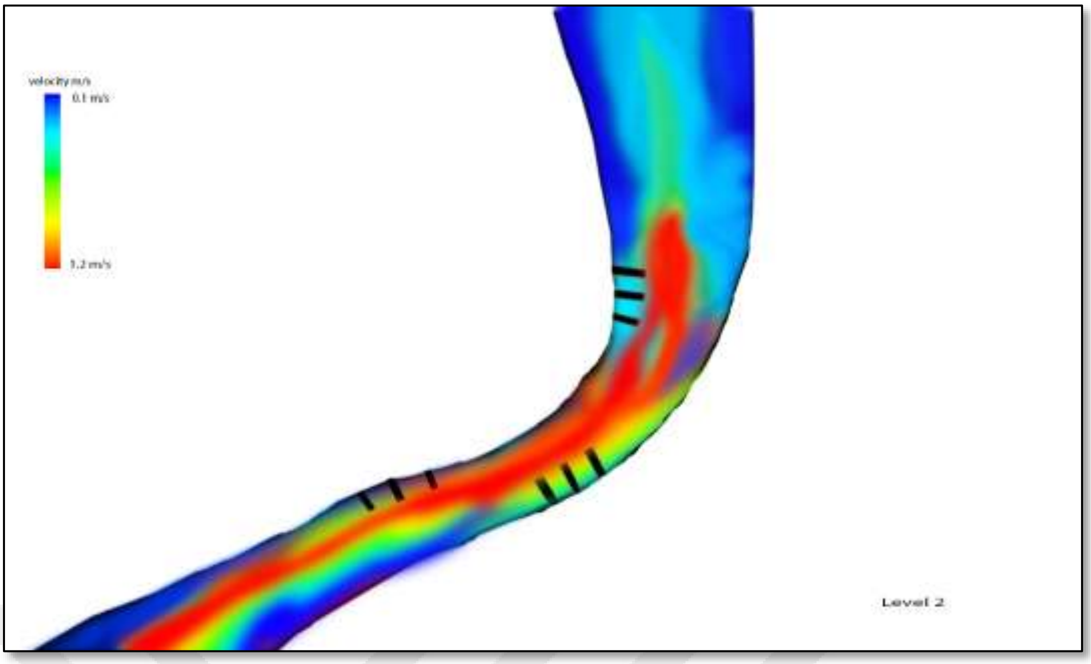


Figure 5.31: The Distribution of Flow as Gradients Colours in Scenario 3

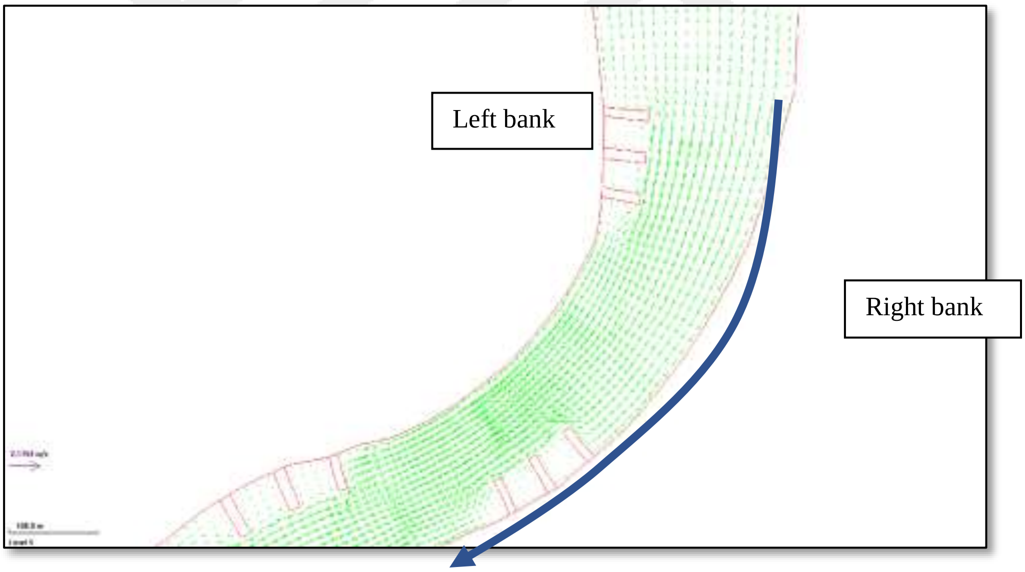


Figure 5.32: The Flow Vectors Pattern in Scenario 3

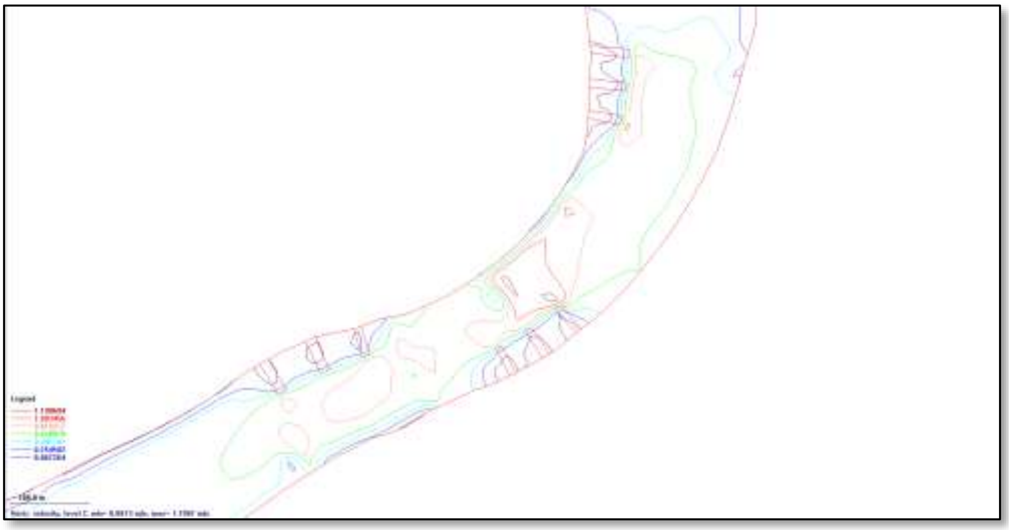


Figure 5.33: The Distributions of Velocities as Colour Lines Scenario 3

Table 5.6: Field Measurements for Concentration of Suspended Sediments and Flow Velocities for the Control Sections. After the scenario 3

Section (i)	Width of section (m)	K	Velocity (m/s)			Concentration (ppm)		
			L	M	R	L	M	R
			J=5	J=10	J=15	J=5	J=10	J=15
200	**254**	**2**	5,50E-01	9,10E-01	1,12E+00	8,50E+01	8,80E+01	9,30E+01
		6	6,20E-01	8,50E-01	8,50E-01	9,00E+01	9,00E+01	8,40E+01
		8	6,50E-01	6,50E-01	7,50E-01	9,10E+01	9,70E+01	9,80E+01

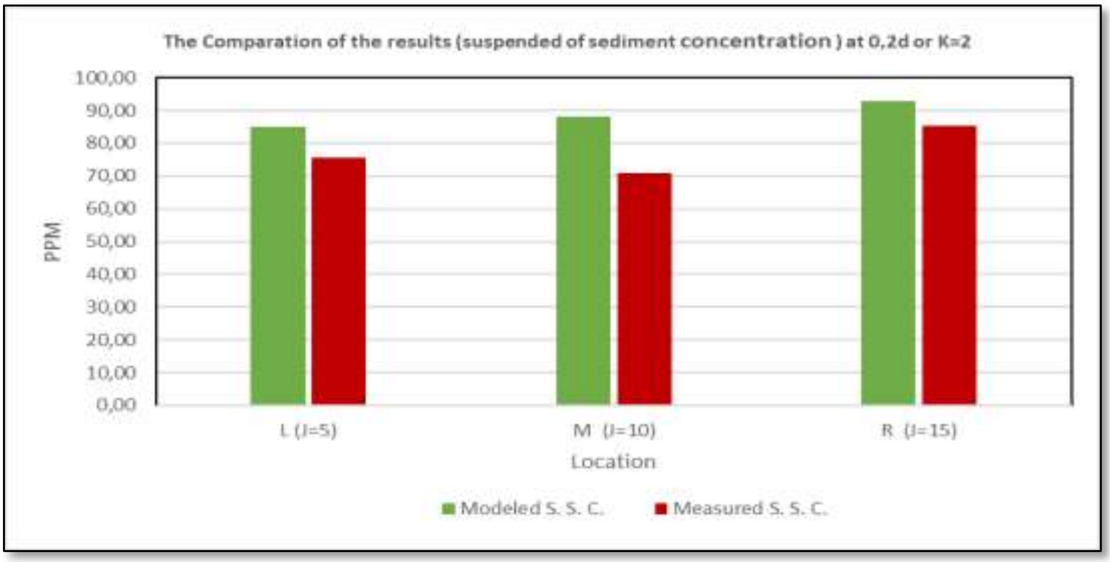


Figure 5.34: The Comparison of Results (Suspended Sediment Concentration) At 0.2d or K2

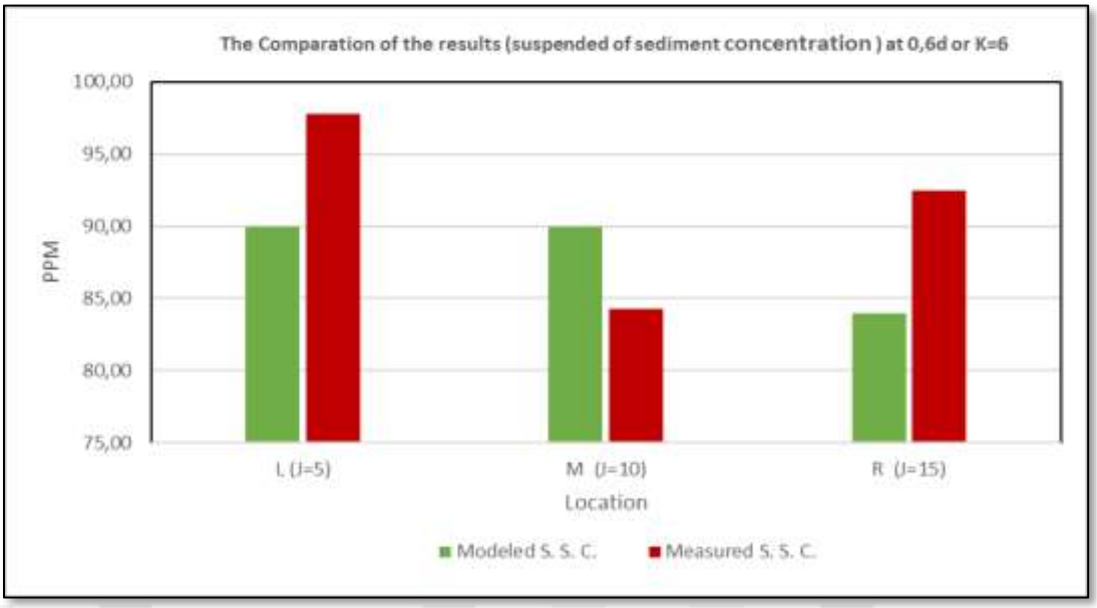


Figure 5.35: The Comparison of Results (Suspended Sediment Concentration) At 0.6d or K6

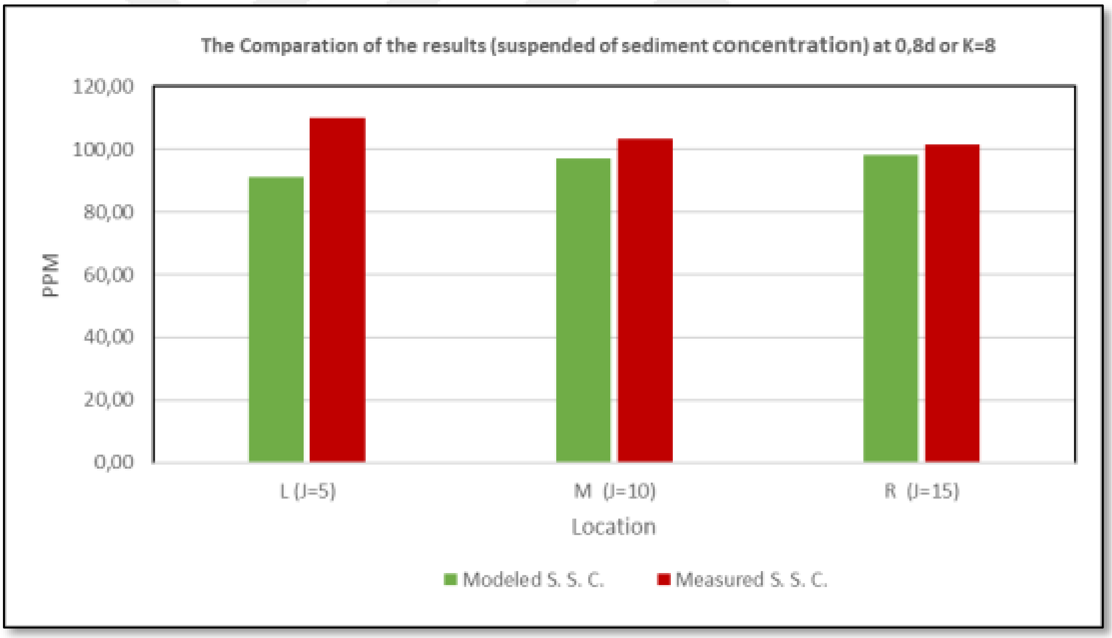


Figure 5.36: The Comparison of Results (Suspended Sediment Concentration) At 0.8d or K8

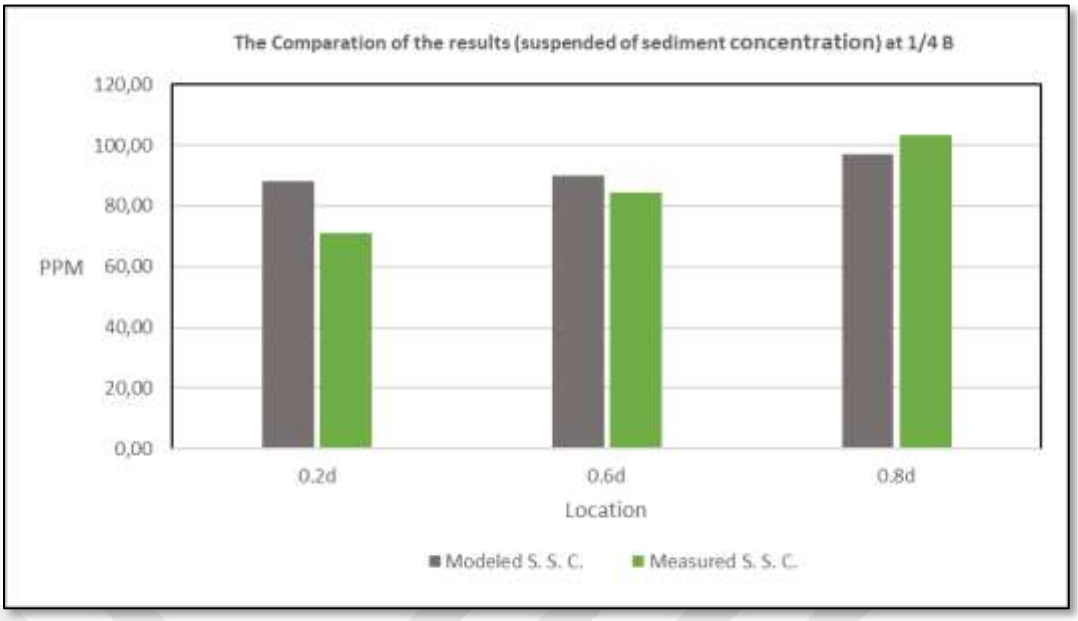


Figure 5.37: The Comparison of Results (Suspended Sediment Concentration) At 1/4B

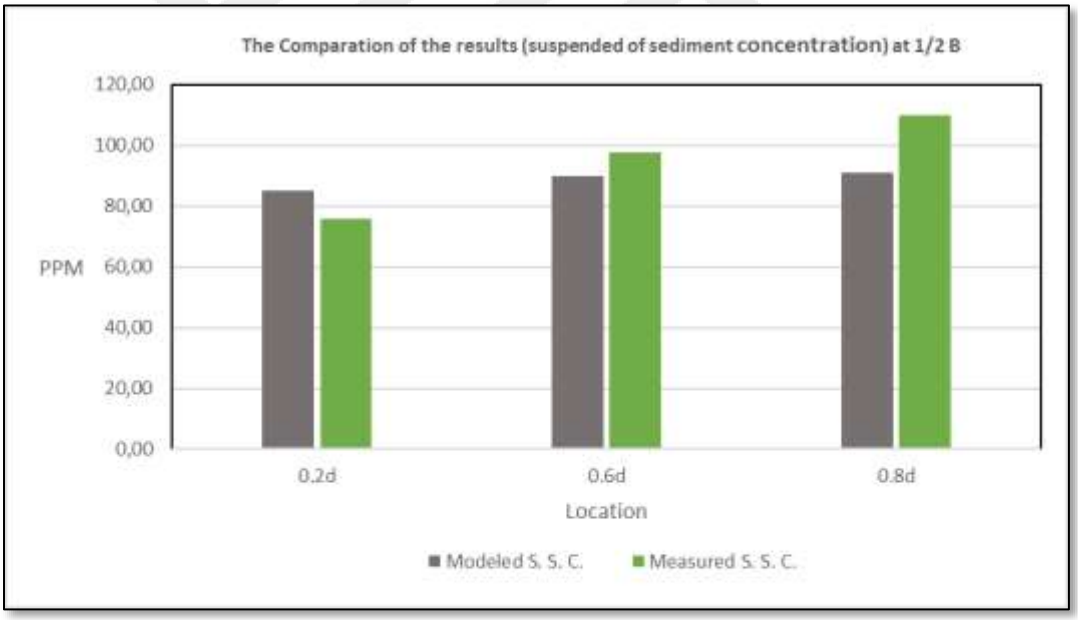


Figure 5.38: The Comparison of Results (Suspended Sediment Concentration) At 1/2B

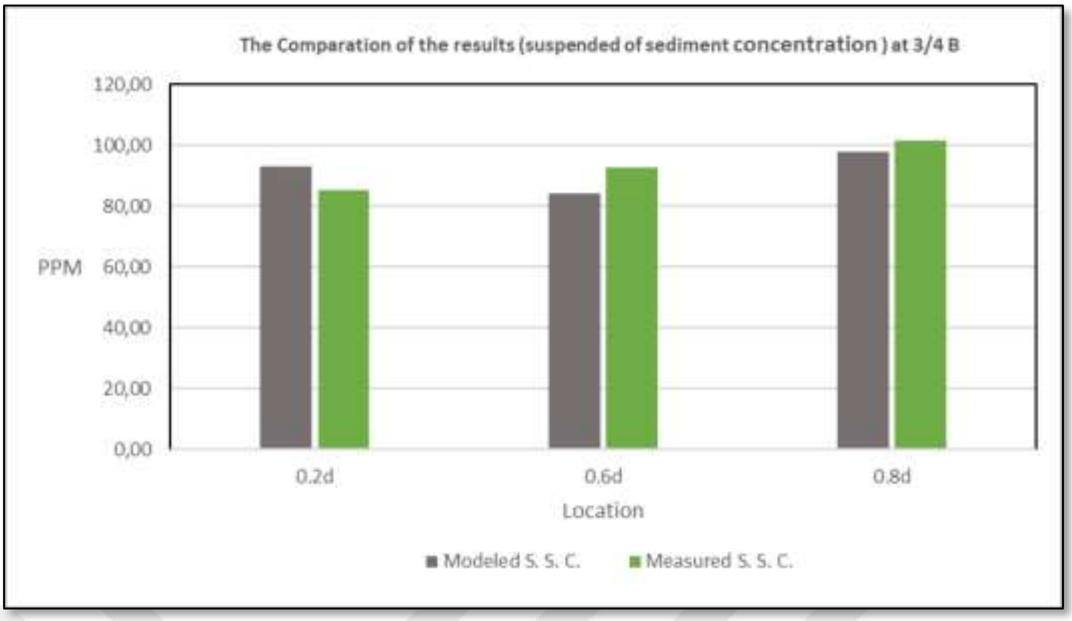


Figure 5.39: The Comparison Of Results (Suspended Sediment Concentration) At 3/4B

5.5.4 Scenario 4: advancing three groynes on right with three groynes on each side

In this scenario, the groynes are advanced, creating a more complex flow pattern than scenario 2. Additionally, there are four groynes on each side of the river.

By studying the flow between the groynes, it is possible to gain insights into the dynamics of sediment transport and the formation of river morphology. This information can be used to optimize the design of groynes and improve their effectiveness in controlling erosion and promoting sediment deposition.

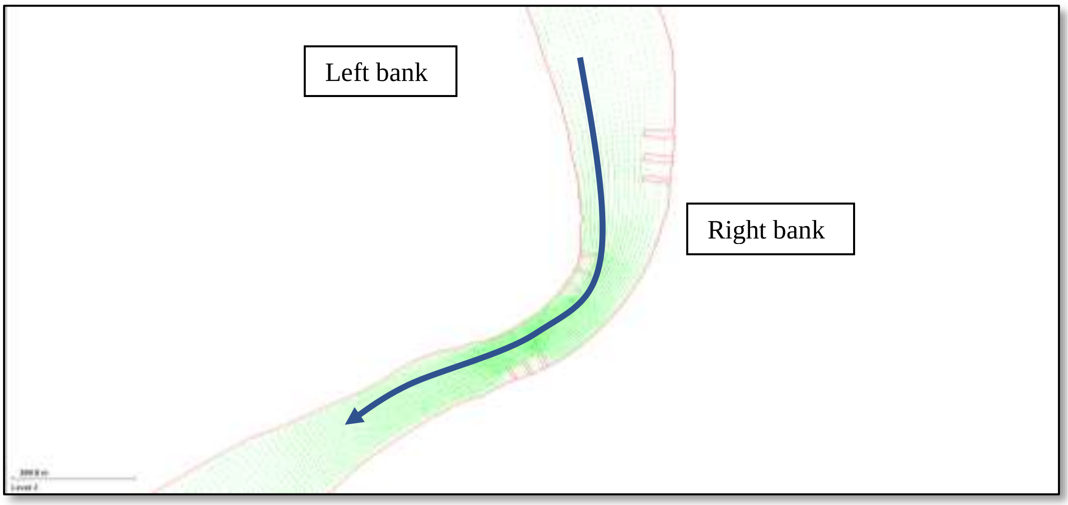


Figure 5.40: Scenario 4: Advancing Three Groynes on the Right with Three Groynes on Each Side

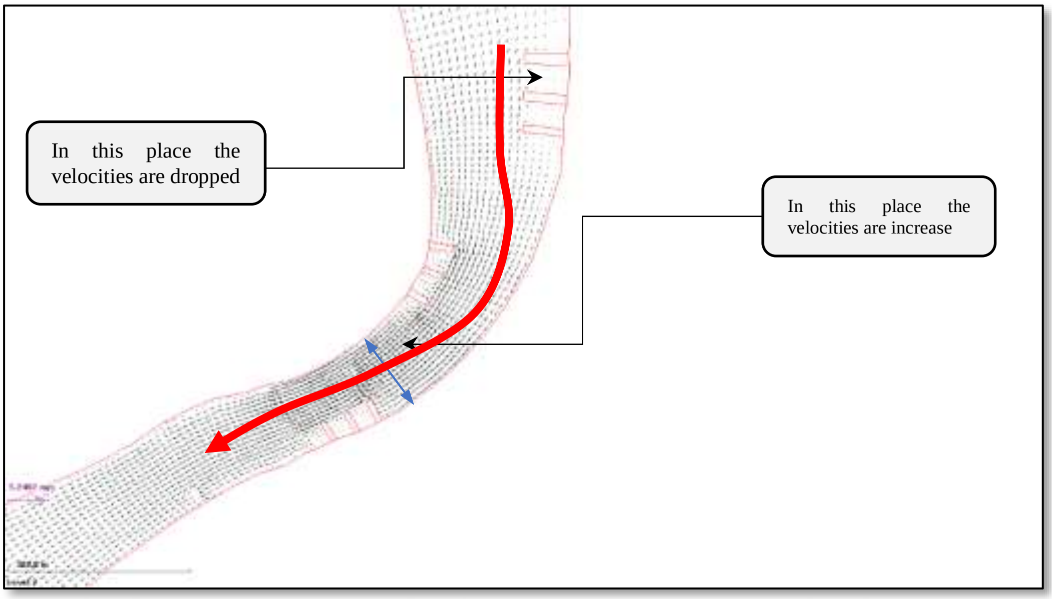


Figure 5.41: The Pattern of Flow in Scenario 4

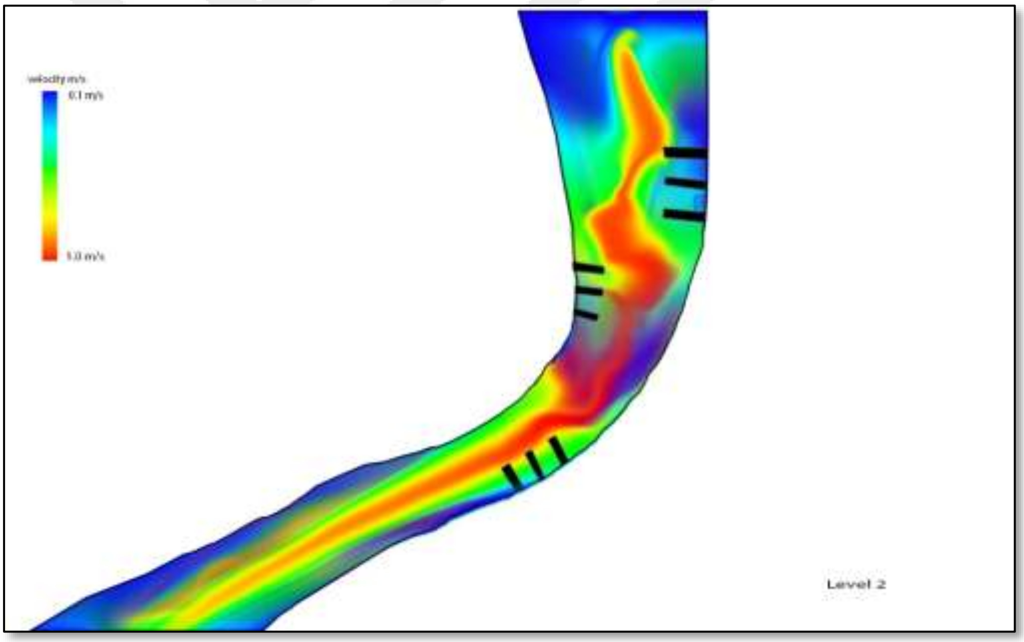


Figure 5.42: The Distribution of Flow as Gradients Colours in Scenario 4

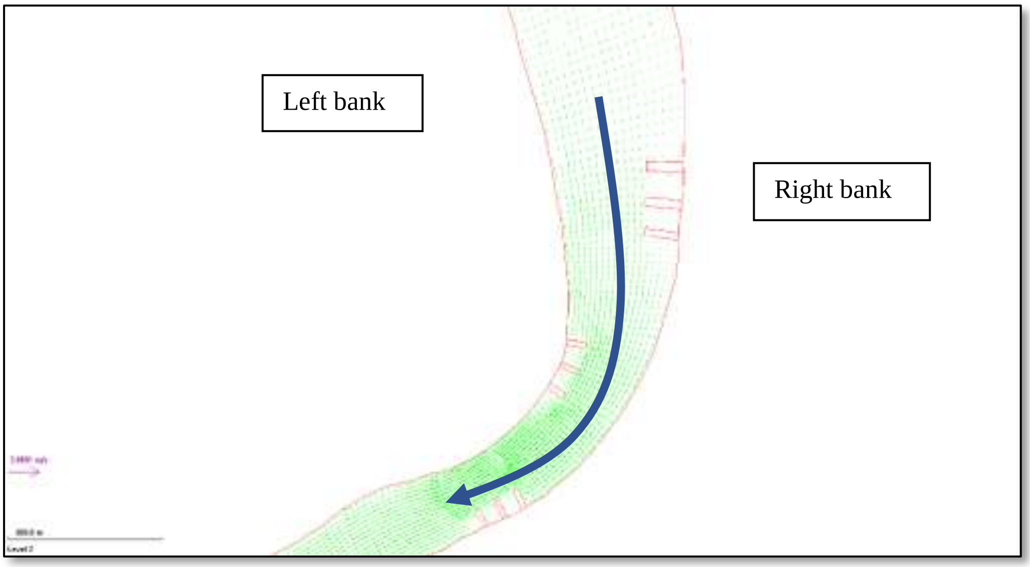


Figure 5.43: The Flow Velocity Vectors Pattern in Scenario 4

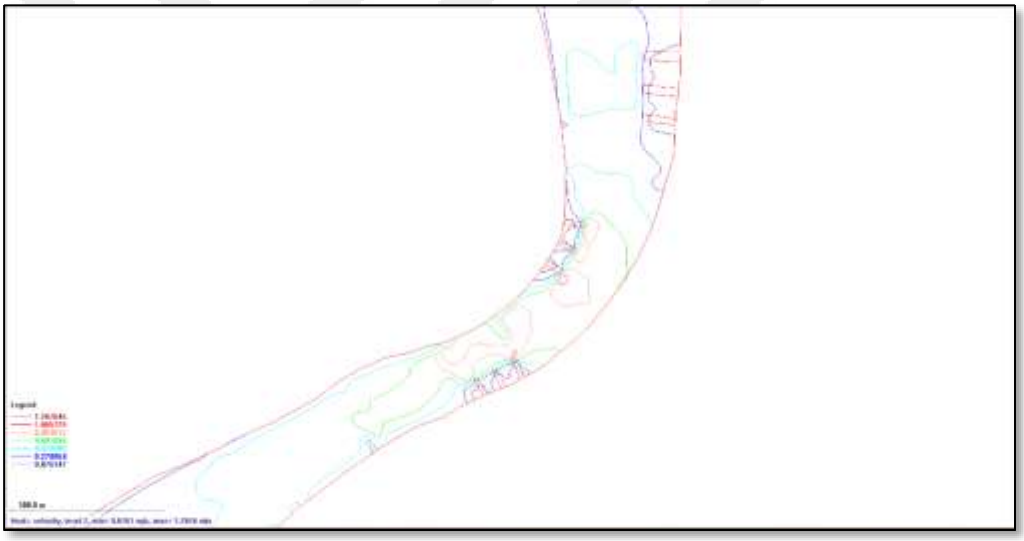


Figure 5.44: The Distributions of Velocities as Colour Lines Scenario 4

Table 5.7: Field Measurements for Concentration of Suspended Sediments and Flow Velocities for the Control Sections. After The Scenario 4

Section (i)	Width of section (m)	K	Velocity (m/s)			Concentration (ppm)		
			L	M	R	L	M	R
			J=5	J=10	J=15	J=5	J=10	J=15
200	254	2	4,50E-01	8,10E-01	9,90E-01	7,50E+01	8,10E+01	9,00E+01
		6	6,10E-01	7,50E-01	6,50E-01	8,50E+01	8,90E+01	8,20E+01
		8	6,00E-01	6,40E-01	7,10E-01	9,20E+01	9,70E+01	9,20E+01

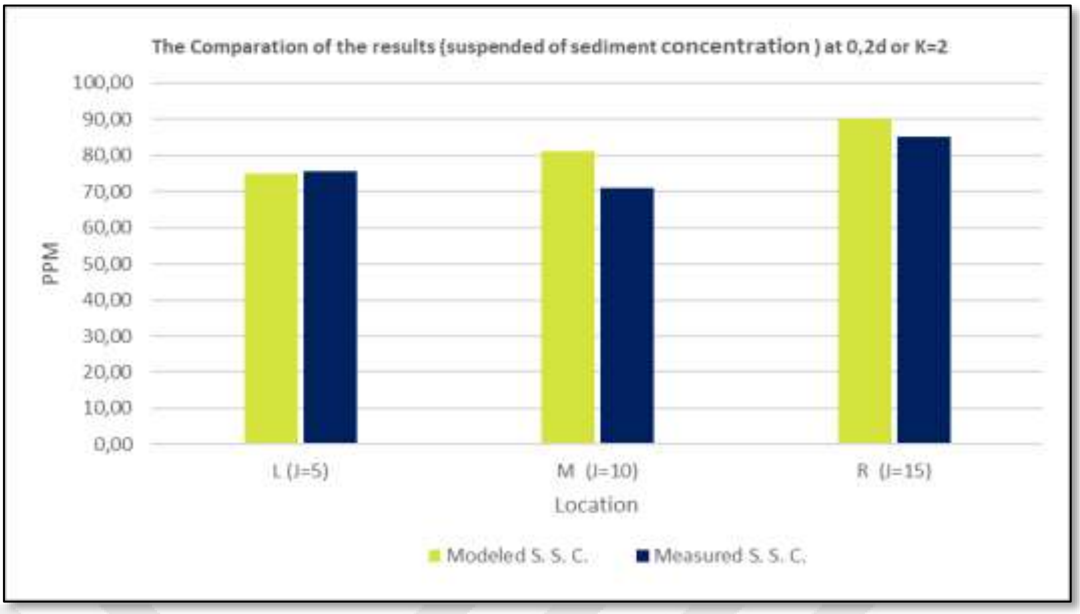


Figure 5.45: The Comparison of Results (Suspended Sediment Concentration) At 0.2d or K2

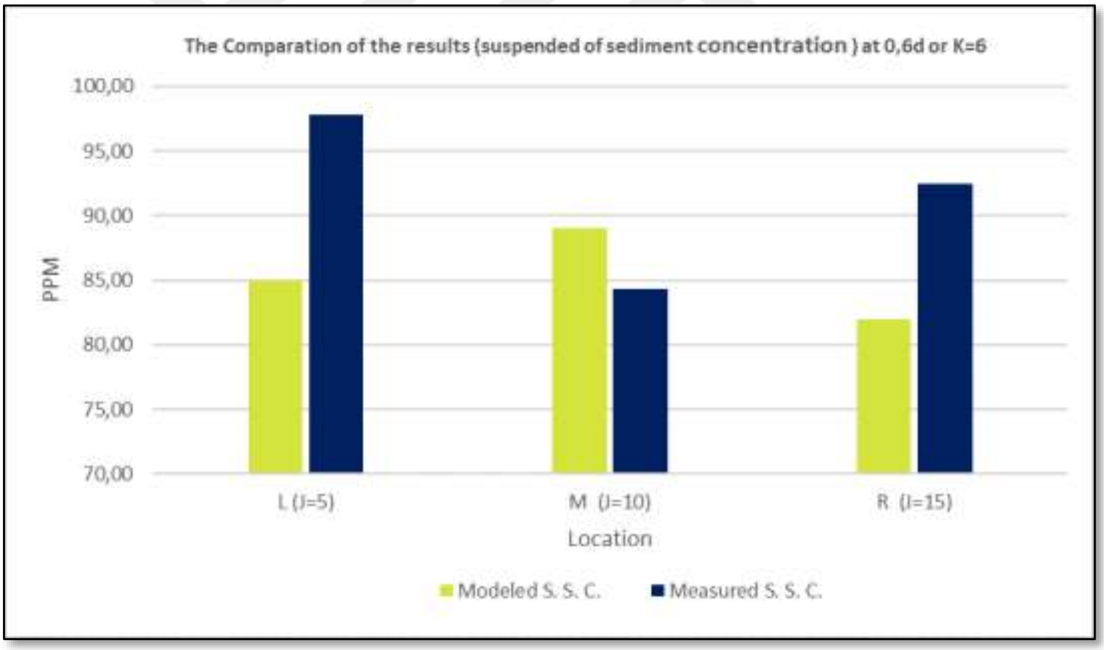


Figure 5.46: The Comparison of Results (Suspended Sediment Concentration) At 0.6d or K6

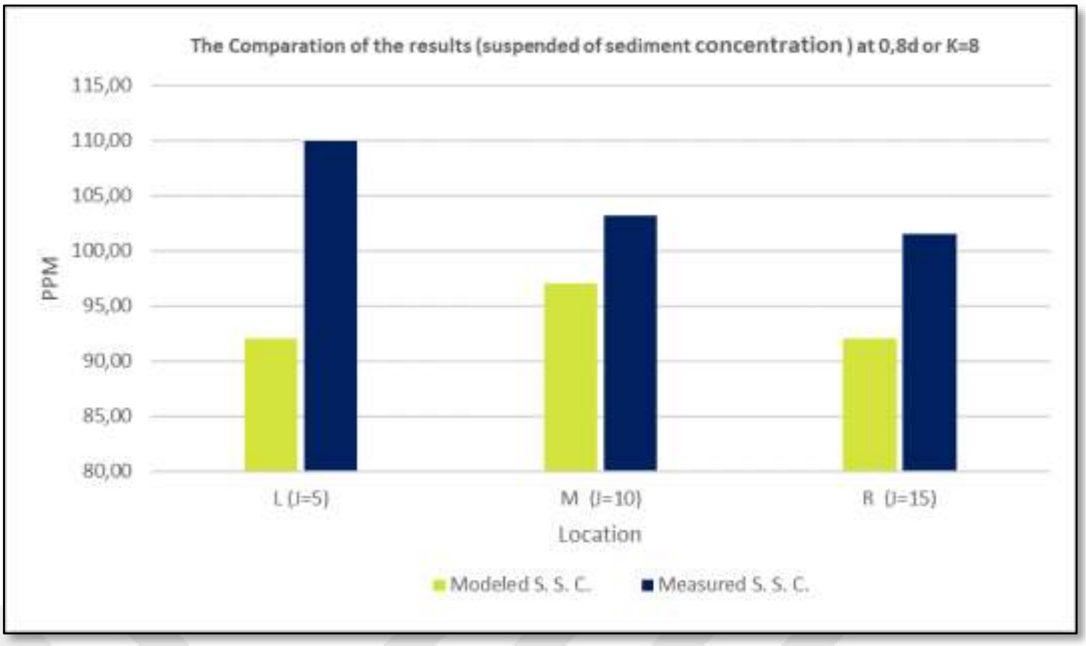


Figure 5.47: The Comparison of Results (Suspended Sediment Concentration) At 0.8d or K8

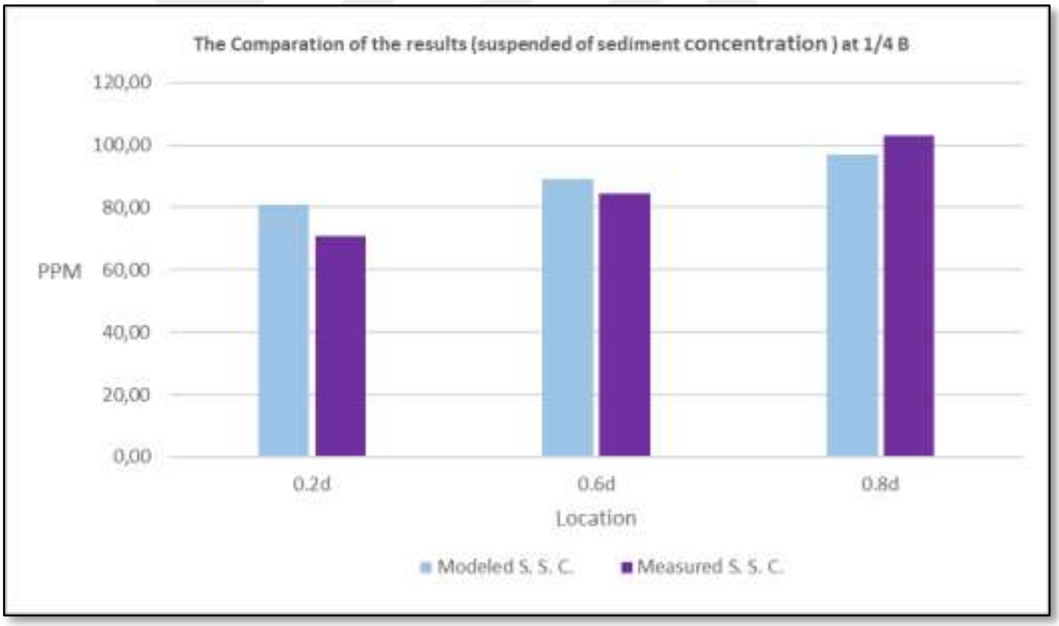


Figure 5.48: The Comparison of Results (Suspended Sediment Concentration) At 1/4B

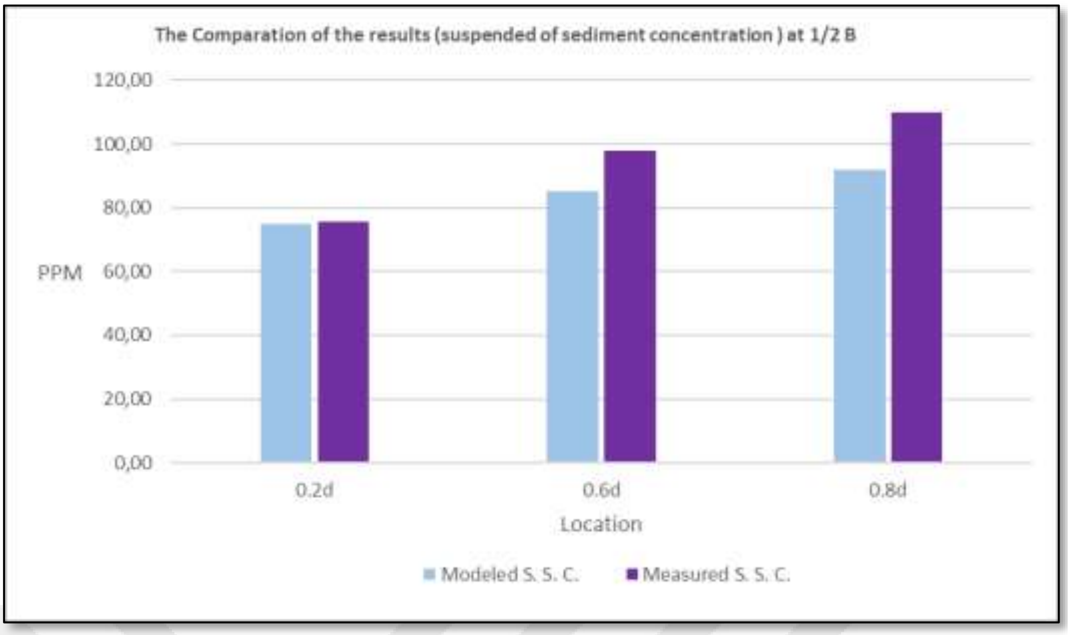


Figure 5.49: The Comparison of Results (Suspended Sediment Concentration) At 1/2B

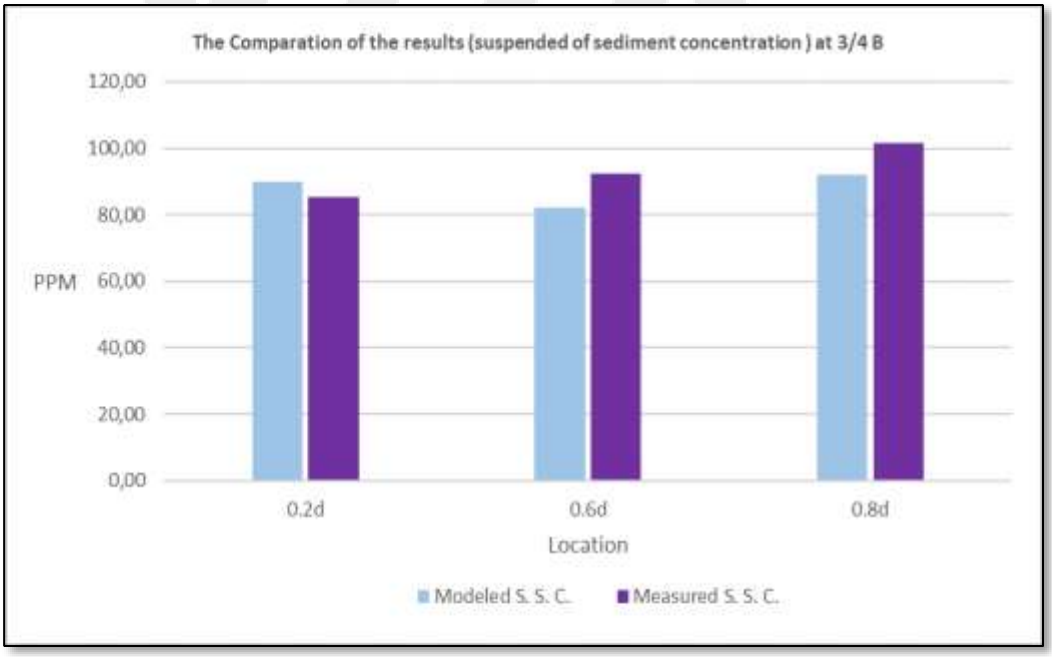


Figure 5.50: The Comparison of Results (Suspended Sediment Concentration) At 3/4B

5.6 Calculate of Sediment Discharge in Study Region and the Results

The study of rivers is crucial for understanding the dynamics of any water systems. Sediment discharge, which refers to the quantity of sediment transported by a river over a specific period, plays a vital role in assessing and comprehending river behavior. Measuring sediment discharge provides valuable insights into erosion patterns, sedimentation rates, channel morphology, water quality, and ecosystem health. In this article, we explore the significance of calculating sediment discharge in river studies and its implications for various fields.

1. Understanding Erosion and Sedimentation: Sediment discharge data helps scientists and researchers understand the erosional processes occurring in a river system. By quantifying the amount of sediment being transported, scientists can assess erosion rates, sediment sources, and the impact of land use practices on river channels. This information is essential for managing and mitigating erosion-related issues such as riverbank instability, sediment deposition in reservoirs, and coastal sedimentation.
2. Assessing Water Quality: Sediment discharge is closely linked to water quality. Excessive sediment loads in rivers can negatively impact aquatic ecosystems by reducing light penetration, smothering benthic organisms, and altering water temperature and oxygen levels. By calculating sediment discharge, scientists can monitor and evaluate the impact of sediment on water quality, aiding in the development of effective conservation and management strategies.
3. Studying Channel Morphology: Sediment discharge measurements contribute to the understanding of river channel morphology. Sediment transport influences the shape, size, and stability of river channels. By studying sediment discharge, researchers can analyze channel patterns, bedload distribution, and the formation of sediment bars and islands. This knowledge assists in predicting and managing changes in river morphology, such as channel shifts, bank erosion, and sedimentation.
4. Flood Risk Assessment: Accurate estimation of sediment discharge is crucial for assessing flood risks in river basins. Sediment plays a significant role in altering a river's capacity to carry water, affecting flow velocities and increasing the likelihood of flooding. Understanding sediment discharge allows scientists to develop flood forecasting models and implement appropriate flood management strategies. It also aids in designing and maintaining infrastructure such as dams, levees, and flood control channels.

5. Impacts on Hydropower and Navigation: Sediment discharge affects the efficiency and lifespan of hydropower infrastructure and navigation channels. Excessive sediment can damage turbines, increase maintenance costs, and reduce power generation capacity. By calculating sediment discharge, engineers and policymakers can make informed decisions regarding reservoir management, sediment flushing operations, and dredging activities to ensure the sustainable operation of hydropower plants and navigational routes.

The calculation of sediment discharge in rivers is of utmost importance in various aspects of river studies. It provides valuable information for understanding erosion processes, assessing water quality, studying channel morphology, evaluating flood risks, and managing infrastructure. Accurate and consistent measurement techniques, such as sediment samplers, stream gauging stations, and remote sensing technologies, enable scientists and decision-makers to gather reliable data for effective river management and conservation efforts. A comprehensive understanding of sediment discharge contributes to the sustainable utilization and protection of our valuable river ecosystems.

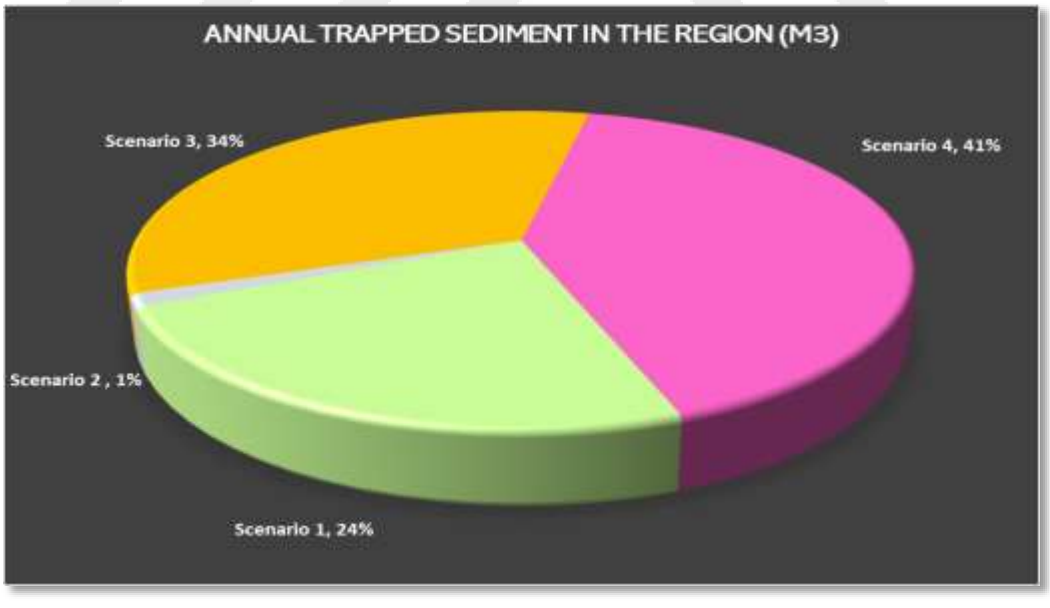


Figure 5.51: 3D Pie Circle for the Percent of the Annual Trapped Sediment in the Region for One Year by Meter Cube

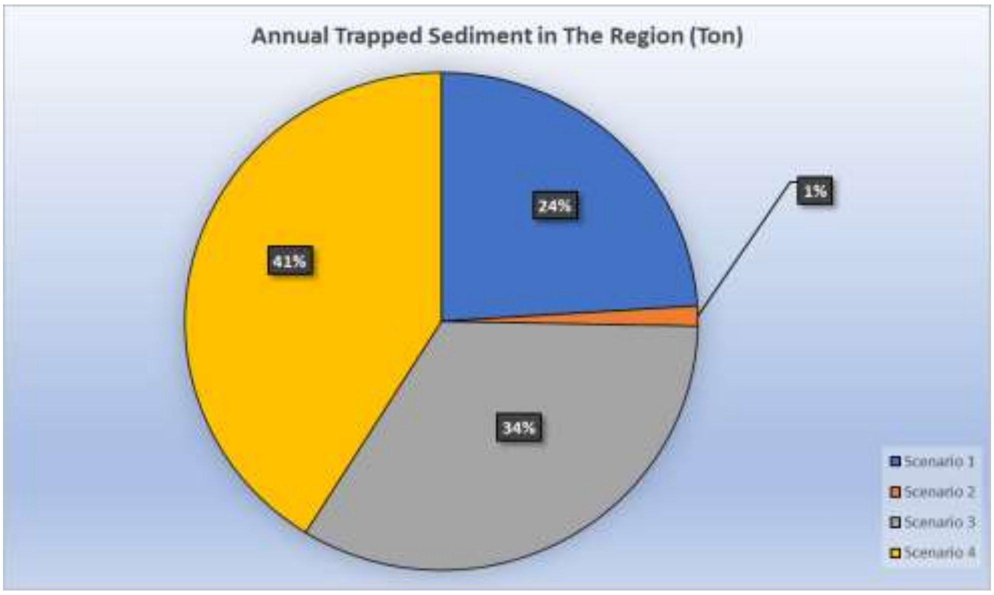


Figure 5.52: Pie Circle for Percent of the Annual Trapped Sediment in the Region for One Year by Ton

Table 5.8: The File Results of the Study (Model and Field)

Scenario	K	Conc. (ppm) Model			Conc. (ppm) Field			Qs Model(kg/s)			Qs(Initial) Region of study (kg/s)			Different (Study-Model)(kg/s)			Ava. of different (kg/s)	Annual Trapped sediment in the region (m^3)	Annual Trapped sediment in the region (Ton)
		L	M	R	L	M	R	L	M	R	L	M	R	L	M	R			
		J=5	J=10	J=15	(1/4B)	(1/2B)	(3/4B)	J=5	J=10	J=15	(1/4B)	(1/2B)	(3/4B)	J=5	J=10	J=15			
Scenario 1	2	9,00E+01	7,55E+01	8,20E+01	75,7	71	85,2	3,00E+01	2,51E+01	2,73E+01	25,2081	23,643	28,3716	-4,76E+00	-1,50E+00	1,07E+00	8,25E-01	2,60E+07	7,00E+04
	6	8,80E+01	9,50E+01	7,82E+01	97,8	84,3	92,5	2,93E+01	3,16E+01	2,60E+01	32,5674	28,0719	30,8025	3,26E+00	-3,56E+00	4,76E+00			
	8	9,00E+01	8,82E+01	1,12E+02	110	103,2	101,5	3,00E+01	2,94E+01	3,73E+01	36,63	34,3656	33,7995	6,66E+00	5,00E+00	-3,50E+00			
Scenario 2	2	8,00E+01	8,50E+01	9,00E+01	75,7	71	85,2	2,66E+01	2,83E+01	3,00E+01	25,2081	23,643	28,3716	-1,43E+00	-4,66E+00	-1,60E+00	4,44E-02	1,40E+06	3,77E+03
	6	1,01E+02	9,60E+01	8,20E+01	97,8	84,3	92,5	3,36E+01	3,20E+01	2,73E+01	32,5674	28,0719	30,8025	-1,07E+00	-3,90E+00	3,50E+00			
	8	9,50E+01	9,00E+01	1,01E+02	110	103,2	101,5	3,16E+01	3,00E+01	3,36E+01	36,63	34,3656	33,7995	5,00E+00	4,40E+00	1,66E-01			
Scenario 3	2	7,50E+01	7,70E+01	9,30E+01	75,7	71	85,2	2,50E+01	2,56E+01	3,10E+01	25,2081	23,643	28,3716	2,33E-01	-2,00E+00	-2,60E+00	1,15E+00	3,64E+07	9,79E+04
	6	8,50E+01	9,00E+01	8,40E+01	97,8	84,3	92,5	2,83E+01	3,00E+01	2,80E+01	32,5674	28,0719	30,8025	4,26E+00	-1,90E+00	2,83E+00			
	8	9,10E+01	9,70E+01	9,80E+01	110	103,2	101,5	3,03E+01	3,23E+01	3,26E+01	36,63	34,3656	33,7995	6,33E+00	2,06E+00	1,17E+00			
Scenario 4	2	7,50E+01	8,10E+01	9,00E+01	75,7	71	85,2	2,50E+01	2,70E+01	3,00E+01	25,2081	23,643	28,3716	2,33E-01	-3,33E+00	-1,60E+00	1,41E+00	4,46E+07	1,20E+05
	6	8,50E+01	8,90E+01	8,20E+01	97,8	84,3	92,5	2,83E+01	2,96E+01	2,73E+01	32,5674	28,0719	30,8025	4,26E+00	-1,57E+00	3,50E+00			
	8	9,20E+01	9,70E+01	9,20E+01	110	103,2	101,5	3,06E+01	3,23E+01	3,06E+01	36,63	34,3656	33,7995	5,99E+00	2,06E+00	3,16E+00			

6. CONCLUSION

The sediment transport study has provided valuable insights into the distribution of sediment across four scenarios. Among these scenarios, it was found that scenario 4 exhibited the highest percentage of sediment trapping, capturing 41% of the total annual trapped sediment in cubic meters. This outcome supports our initial hypothesis, indicating that scenario 4 holds significant potential for designing and implementing groynes in the region.

The significant variations observed among the different scenarios emphasize the importance of understanding the underlying factors influencing sediment transport. While scenario 4 demonstrates the most favorable results, further analysis and modifications are necessary to refine and optimize these scenarios.

Scenario 1, with a sediment trapping percentage of 24%, shows promise but requires further investigation to improve efficiency. By refining the design parameters and considering factors such as groyne placement, size, and orientation, sediment trapping in this scenario can be enhanced.

In scenario 2, the low sediment trapping percentage of 1% raises questions about the effectiveness of the groynes. Detailed analysis is needed to identify any potential limitations or obstacles hindering sediment trapping. Adjusting groyne alignment, spacing, or height may prove beneficial in improving sediment control efficiency.

Scenario 3 demonstrates a relatively high sediment trapping percentage of 34%, indicating favorable conditions for sediment retention. To capitalize on this outcome, further research should focus on understanding the contributing factors, such as sediment sources, river morphology, and flow patterns. This knowledge can guide targeted modifications to maximize sediment trapping efficiency.

Based on the findings, scenario 4 emerges as the most promising for designing groynes in the region. Its high sediment trapping percentage indicates existing conditions that are conducive to effective sediment control. To fully utilize these favorable conditions, it is crucial to investigate and replicate the specific characteristics and features contributing to the success of this scenario. This knowledge will enable the design and implementation of groynes with improved effectiveness in other areas.

In conclusion, the sediment transport study has identified scenario 4 as the most favorable for the design and implementation of groynes. The varying percentages across the scenarios underscore the importance of continuous evaluation and modification of design parameters to optimize sediment trapping efficiency. By addressing factors such as groyne location, alignment, spacing, and flow dynamics, it is possible to enhance sediment control measures and contribute to the sustainable management of the river system. This study provides valuable insights for future river engineering projects and supports the development of effective strategies for sediment management and conservation.

6.1 Discussion

The significant disparity among the four scenarios highlights the importance of understanding the underlying factors contributing to sediment transport. While scenario 4 appears to be the most favorable in terms of sediment trapping, further analysis and modifications can be considered to refine and optimize these scenarios.

1. Scenario 1 (24%): Although this scenario captured a considerable percentage of sediment, there is room for improvement. To enhance sediment trapping, additional investigation could focus on optimizing the location, size, and orientation of groynes. Furthermore, considering variations in flow conditions and sediment characteristics would provide a more comprehensive understanding of sediment transport dynamics.
2. Scenario 2 (1%): The low sediment trapping efficiency in this scenario raises questions regarding the design or placement of groynes. Further exploration is required to identify potential obstacles or limitations and devise suitable modifications. Adjusting groyne alignment, spacing, or height could improve sediment trapping and ultimately enhance the effectiveness of the groynes.
3. Scenario 3 (34%): With a relatively high sediment trapping percentage, scenario 3 shows promise. However, it is essential to investigate the underlying causes contributing to this outcome. Factors such as sediment source areas, river morphology, and flow patterns need to be further

examined to better understand the mechanisms responsible for sediment retention. This knowledge can guide targeted modifications to maximize sediment trapping efficiency.

4. Scenario 4 (41%): The highest sediment trapping percentage observed in scenario 4 suggests that the existing conditions in this scenario are conducive to effective sediment control. Based on this finding, designing groynes in this region aligns with our hypothesis. To capitalize on the favorable sediment trapping performance, further investigations should focus on understanding the specific characteristics and features that make this scenario successful. By analyzing and replicating these conditions, groynes can be designed and implemented more efficiently in other areas.

In summary, the results of the sediment transport study have identified scenario 4 as the most favorable for designing groynes in the region. The varying percentages across the scenarios emphasize the need for continuous evaluation and modification of design parameters to optimize sediment trapping efficiency. By addressing factors such as groyne location, alignment, spacing, and flow dynamics, it is possible to enhance sediment control measures and contribute to the sustainable management of the river system.

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RESUME

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