

**ASSESSMENT OF WATER AVAILABILITY ON LEAN  
PERIOD IN TROPICAL PLATEAU RIVER BASIN, WEST  
BENGAL, INDIA**

A thesis submitted towards partial fulfillment of the requirements for the degree of

**MASTER OF ENGINEERING**

**In Water Resources and Hydraulic Engineering**

**Course affiliated to faculty of Engineering & Technology**

Jadavpur University

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**August – 2022**

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**CERTIFICATE OF RECOMMENDATION**

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**CERTIFICATE OF APPROVAL\*\***

The Final Report is hereby approved as a creditable study of an Engineering subject titled **‘ASSESSMENT OF WATER AVAILABILITY ON LEAN PERIOD IN TROPICAL PLATEAU RIVER BASIN, WEST BENGAL, INDIA’** carried out and presented in a manner of excellence to warrant its acceptance as a prerequisite for the degree of ‘Master of Engineering’ for which it has been submitted. It is understood that by this approval the undersigned does not necessarily endorse or approve any statement made, opinion expressed or conclusion drawn therein but approve the Final Report only as a prerequisite for the Project Work.

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**DECLARATION OF ORIGINALITY AND COMPLIANCE OF  
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I hereby declare that this thesis contains literature survey and original research work by the undersigned candidate, as part of my Master of Engineering in Water Resources & Hydraulic engineering (6TH SEM) degree in the Faculty of Interdisciplinary studies, Jadavpur University during academic session 2019-2022.

All information in this document has been obtained and presented in accordance with academic rules and ethical conduct.

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## ACKNOWLEDGEMENT

I would like to express my deepest gratitude to Prof (Dr).Pankaj Kumar Roy, Director, School Of Water Resources Engineering, Jadavpur University for constantly guiding and correcting the document with care and attention. He has taken pain of going through the term paper and making necessary corrections as and when needed. He has encouraged me to collect necessary information regarding the work

I also express my sincere gratitude.Prof. (Dr.) Asis Majumdar,SWRE, Jadavpur University;Prof.(Dr.) Arunabha Majumder,Professor- Emeritus, SWRE, Jadavpur University;Dr. Rajib Das,Assistant professor, SWRE, Jadavpur University,Dr. Subhasish Das, Assistant Professor, SWRE,Jadavpur University; Dr. Gourab Banerjee, Assistant Professor, SWRE, Jadavpur University for their valuable suggestions.

I would also like to convey my gratitude to Mr.Arnab Ghosh & Ms. Poulami Ray Research Scholar, School Of Water Resources Engineering, and Jadavpur University for his unparalleled support and practical suggestions throughout my work.

I would like to thank Mr. Devendra Singh, Executive Engineer, West Midnapore Division, and Special thanks to Precision Survey Consultancy, for this project and developed the project successfully on behalf of the Precision Survey. I also acknowledge the Digital Library of the School of Water Resources Engineering, Jadavpur University, for allowing access to all the GIS and statistical software.

I wish to express my gratefulness to my batch mates Arghya Das, Ratna De Nandi, Sayak Karmakar and Pratik Maiti for their constant and meticulous encouragement.

Thanks are also due to all the faculties and staffs of School of Water Resources Engineering Jadavpur University for their direct and indirect help and support.

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## **ABSTRACT**

Water is an essential element in human life. Since ancient times, human civilization was based on water in riverside areas. From a geographical point of view, the water requirement for normal human supply is much higher in a plateau region than in a plain region. Although rainwater harvesting cannot provide the natural supply to humans, the people of the plateau depend on artificial dams, often blocking the natural flow of rivers, to provide the necessary water supply. Not only for daily needs, but the importance of water is also immense to meet the raw material needs of various industries. But sometimes, when the demand of people and industry is more than the water capacity of the dam, it becomes unable to meet the required supply. Kangsabati river in West Midnapore district and Anicut dam built on it - are facing the above problems. Being part of the plateau region and due to the high demand of the mining industry, the water demand is usually high. The pressure on the anicut reservoir is very high. Based on the above problems and to determine a specific solution, the present research is based on the total water storage in Kangsabati river and adjacent anicut and its fair share among various stakeholders. After the normal flow of water from Mukutmonipur is stopped, the Kangsabati river is fed by water from various inlets and the Tarafeni river. All these waters are deposited in the anicut area in the river's lower reaches. For determining the resulting total water flow and storage, the HEC-RAS 1D/2D integrated model is used, where the flow along a specific river direction is shown in 1D and the flow storage in the anicut area is shown in 2D. The total water flow carried by the river through the inlets has been determined from the field survey. Simultaneously, the total water storage in the anicut area has been determined through the ADCP cross-sectional survey. Later the total water flow and storage volume of these two regions have validated through HEC-RAS. From the survey period, daily data are calculated by 1- a month volume of discharge per day and stored in 2D. After that, it is calculated as the total volume entering the 2D storage area from the river to Anicut. Rainfall greatly influences river discharge in this area, and the calculated graph shows this. To assess the current and future water availability of Kangsabati River and its adjacent creeks near Midnapore city and its impact on local stakeholders. Particular statistical techniques are evident from the indications ideally used for lean seasonal flow analysis in tropical plateau regions that can be found when reviewing the literature. This research is essential for the local stakeholder to ensure the particular water-sharing man oeuvre among human habitation and industrial agglomeration. The forecasting of the next ten years is also highlighted through the research, which ensures the water availability in lean periodic (April-May) condition throughout the year.

## TABLE OF CONTENTS

<u>TOPICS</u>	<u>PAGE NO.</u>
CHAPTER 1.....	1
1. INTRODUCTION.....	1-4
CHAPTER 2.....	5
2: LITERATURE REVIEW.....	5-8
CHAPTER 3.....	9
3: STUDYAREA.....	9-11
CHAPTER 4.....	12
4.1: OBJECTIVE.....	12
4.2: SCOPE.....	12
4.3: DATA USED.....	13-14
CHAPTER 5.....	15
5.1: METHODOLOGY .....	15
5.1.1: GENERATED CROSS SECTION IN ANICUT.....	15
5.1.2: CALCULATING DISCHARGE IN MODEL.....	16
5.1.3: BATHYMETRIC PROFILE IN HEC-RAS .....	16
5.1.4: PRE CONDITION OF MODEL DEVELOPMENT.....	17
5.1.5: MESH/GRID GENERATION.....	17
5.2: ONE DIMENSIONAL RIVER FLOW.....	19
5.3: 2D ANICUT STORAGE.....	20-21
5.4: ONE DIMENSIONAL & TWO DIMENSIONAL COUPLED MODELLING.....	21-22
5.5: PREDICTION OF DISCHARGE WITH ANICUT VOLUME.....	22-23
CHAPTER 6.....	24
6: RESULTS AND DISCUSSIONS.....	24
6.1: CHARACTERISTICS OF INLET DISCHARGE.....	24-29
6.2: 1D FLOW MODEL.....	29
6.3: 2D ANICUT STORAGE AREA.....	31

6.3.1: CROSS SECTION AND DISCHAGE SUMMARY OF KANGSABATI RIVER	32-53
6.4 WATER SHARING AMONG THE STAKEHOLDERS	57
CHAPTER 7	60
7. CONCLUSION	60-61
CHAPTER 8	61
8: FUTURE SCOPE OF STUDY	61
CHAPTER 9	62
9.1: RECOMMENDATION	62
9.2: REFERENCES	62-64

## LIST OF FIGURES

<u>FIGURE NO.</u>	<u>DESCRIPTION</u>	<u>PAGE NO</u>
FIG 3.1:	Study Area (Upper Kangsabati Basin)	10
FIG 3.2:	Characteristics of Study Area with DEM, Slope, Soil and LULC	11
FIG 4.1:	Scenic Beauty of Upper Kangsabati River	12
FIG 4.2:	Measuring latitude/longitude and elevation by GPS	14
FIG 5.1:	Measurement of velocity of flow by current meter	18
FIG 5.2:	Collecting data from various inlet points	18
FIG 5.3:	All inlets discharge boundary	19
FIG 5.4:	2D Anicut storage with water level in Lean Period (Survey time)	21
FIG 6.1:	Rainfall Condition in Lean Period	24
FIG 6.2:	Water level with CS changes in Tarafeni-Kangsabati off take point	30
FIG 6.3:	Arrangement of CS with 2D Anicut area	30
FIG 6.4:	CS on river flow after HEC-RAS calibration	31
FIG 6.5:	Topographical plan of Medinipur	31
FIG 6.6:	Shows the cross-section 1	32
FIG 6.7:	Shows the cross-section 2	34
FIG 6.8:	Shows the cross-section 3	36
FIG 6.9:	Shows the cross-section 4	38
FIG 6.10:	Shows the cross-section 5	40
FIG 6.11:	Shows the cross-section 6	42
FIG 6.12:	Shows the cross-section 7	44
FIG: 6.13:	Shows the cross-section 8	46
FIG: 6.14:	Shows the cross-section 9	48
FIG: 6.15:	Shows the cross-section 10	50
FIG. 6.16:	Shows the cross-section 11	52
FIG.6.17:	Topographical Sheet of Kangsabati River	54

## LIST OF TABLE

<u>TABLE NO.</u>	<u>DESCRIPTION</u>	<u>PAGE NO</u>
TABLE. 6.1	Location and Characteristics of Inlets	25-28
TABLE. 6.2	Volume of anicut in Lean period	55
TABLE. 6.3	Discharge volume from River to Anicut	56
TABLE.6. 4	Calculation of Volume in Lean period (March to May)	57
TABLE. 6.5	Water Sharing Volume	57
TABLE. 6.6	Distribution of Water as per requirement	58
TABLE. 6.7	Distribution of Water among Stakeholders	58
TABLE.6.8	Comparing River Volume with Withdrawal	59

# CHAPTER 1

## 1. INTRODUCTION

Globally, the rapid increase in population growth and socio-economic development increased the stress on water management. With around 4% of the world's water resources, India became a water-stressed country in 2011. One of the most efficient ways to reduce this stress is to re-allocate water supplies regionally and temporally through appropriate management of surface water reservoirs. After considering a wide range of social, political, economic, and cultural variables in river basins, reservoir operations are inevitably more complex. For example, the water of the Nile River is shared by 250 million people in 11 countries. The water of the Brahmaputra is shared by India, Bangladesh, and China. The water of the Teesta River is shared by India, Sikkim, and Bangladesh.

There are two types of rivers, one perennial river and the other non-perennial river. The Perennial River is a river that carries water all year round and originates from the Himalayas in India, for example, the Ganges and the Brahmaputra. Non-perennial rivers, on the other hand, are rivers that do not have water all year round. These rivers do not have water because they do not originate from glaciers, usually from rainwater—for example, Narmada and Krishna. Plateau is the area in which work has been done by geographical location. A plateau is 300-600 meters above sea level. Its surface is almost flat or undulating and has a steep slope. So, an essential task of the plateau area is to retain water. Since it is not a perennial river, it is vital to retain rainwater. So, the rain on the plateau is one of the most significant issues. So, the rain on the plateau is one of the most significant issues. Waterlogging is less in plateau areas where rainfall is high. The water crisis causes drought in some parts of the plateau area. Floods are caused by heavy rains, which is a significant problem for the area's people. This severe problem has led to an economic downturn. But there is no such problem in the plains because rain or glacier water can remain stagnant. So, there is no need for dams in flat areas. Global warming is directly or indirectly involved in global warming, Building canals and bridges are building huge buildings. Due to this, people create danger by creating their water crisis like silent spectators somewhere. So, we all need to understand how to protect the environment no matter what. People need to be aware, and at the same time, the government needs to be strict and take some reasonable steps like stop planting trees for everyone and planting trees in vacant places. Glaciers are melting as a result of warming. If left unchecked, plateaus will become deserts in the future. Experts worldwide have come up

with ideas for dealing with the water crisis at the plateau. The Loess Plateau Watershed Rehabilitation Project has been set up in China. This paper examines how everything depends on the environment. The people residing in the plateau area have described their dealing with the worst of the water crisis if the environment is not protected. Several countries have developed river models and tried to alleviate the water crisis in the plateau area. According to a survey conducted in the Bolivian area of Japan, the paper's name is Application of 2D numerical simulation for the analysis of the February 2014 Bolivian Amazonia flood: Application of the new HEC-RAS version 5. This paper clearly explains how a 2D model for flood prevention was created using HEC-RAS SOFTWARE to adapt to climate change and geography. The model has run correctly, and the problem has been solved. This paper gives us a good idea of modeling a river in the plateau region which is very important for our project.

According to Qian Li a, Qiuhua Liang (2020) Drainage network models most commonly use different numerical procedures to handle flows in pipes and junctions. Numerous numerical schemes and models of different levels of complexity have been developed and reported to predict flows in pipes. However, calculation of the flow conditions in junctions has received much less attention and has been traditionally achieved by solving only the continuity equation. This method is easy to implement but it neglects the momentum exchange in the junctions and cannot provide sufficient boundary conditions for the pipe calculation. In this work, a novel numerical scheme based on the finite volume solution to the two-dimensional (2D) shallow water equations (SWEs) is proposed to calculate flow dynamics in junctions, which directly takes into account both mass and momentum conservation and removes the necessity of implementing complicated boundary settings for pipe calculations. This new junction simulation method is then coupled with the widely used two-component pressure approach (TPA) for the pipe flow calculation, leading to a new integrated drainage network model. The new 1D-2D coupled drainage network model is validated against an experimental and several idealized test cases to demonstrate its potential for efficient and stable simulation of flow dynamics in drainage networks.

There are many types of water flow, such as static and unstable flow, rotating and non-rotating, uniform and different, one-dimensional and two-dimensional and three-dimensional. The 1D model is considered when the river flows along one side according to the direction of movement. When the river flows in two directions according to its course, horizontally and laterally, it is considered a 2D model. The main goal of this projector is to determine the water distribution, so both 1D and 2D models have been worked on river flow to make water distribution more convenient. To run this model properly, I have used HEC RAS software,

one of the most advanced software for river modeling. AutoCAD software has also been used to draw river cross-sections.

According to Md Shariful Islam (2019) this research is important for Bangladesh and India. As an important and basic life support Material, water is the most precious resource for any It is essential for the continued security of the country and survival of a state. Although fresh demand Water is increasing day by day all over the world Supply is dwindling. Thus, the gap in demand for and its supply of clean water is constantly increasing worldwide. A major report in this regard recently issued by 2030 Water Resources Group. The World Bank has also estimated that the gap between global water demand and reliable supply could reach 40 percent in the next 20 years; especially in developing regions, the water deficit may increase by 50 percent. So there is a shortage of fresh water both are major causes of conflict, as well within the state. A growing world population, Irrigated agriculture needs more, and fast Demand for industrialization will increase scarce water resources that will shape the future Conflict therefore water crisis is one of the main Elements in security discourse. Total per capita water in India Availability has also decreased from 5,000 billion to 1,800 billion cubic meters in 1950 to 2005. It may reach the threshold level of 1,000 billion cubic meters per capita in 2025. The dominant perception in India is that growth Population, pace of urbanization and economic Development will accentuate the pressure on a finite Resources and the answer lies largely supply-side Project and long distance water transfer. It's about worrying about the future India-Bangladesh talks on water sharing, as India No compromising attitude was shown. Thus, this research has important legal, policy, and theoretical implications.

According to Texas Water Development Board(2006) Edwards Plateau is located along the southern border of the province, Plateau Water The planning area (originally designated as Area J) extends from the central Texas Hills The country west of the Rio Grande and Bandera, Edwards, Kerr, Kinney, Real, and Val Verde County. The regional economy is mainly based on tourism, hunting, animal husbandry, Agribusiness, government and military activities. The US Census Bureau performed a census enumeration in 2000, which provides the base year for future population projections. However, future escalation of fuel cost and cost of living could slow this growth rate. Population in the rural counties of Edwards, Kinney and Real are expected to remain relatively constant over the 50-year plan period, however the transient population will likely increase.

The purpose of the 2006 Plateau Region Water Plan is to provide a document on water Planners and water users can refer to long and short term water management

Recommendations are equally important; this plan serves as an educational tool to enlighten all Citizens about the importance of proper management and conservation of delicate water resources of this primitive region. Following the final adoption of the 2006 Plateau Region Water Plan, copies of the plan were provided to each municipality and county commissioners' court in the Region.

Considering the distribution of water, the plateau area is taken to save the plain area as the water scarcity in the plains is not as severe as in the plateaus. The flat area is the Farakka hydroelectric power plant in West Bengal. Groundwater levels are much lower on the plateau than on the plains, resulting in higher drinking water levels on the plateau. Therefore, in most cases, a survey of the total amount of water in the plateau areas throughout the year is done to determine the area's water demand, and the government monitors the issue. If it is a very populated area, it is considered to build a dam at a suitable place and water is distributed accordingly. This district of West Bengal (Medinipur) has a tropical climate with an average annual temperature of 28 degrees. Elsewhere in West Bengal, the river Kangsabati flows through Bankura, Purulia and Medinipur districts. Since Medinipur district is a tropical plateau and the Kangsabati River is not perennial, the district has been chosen for ease of operation as the district's population is 169264, according to the 2011 census. Therefore, experts plan to save water in this district, considering the future water shortage. As a result, a dam was built over the Kangsabati river in 2013 at CAS2V 3H4, DASHIN BENGAI, named Anicut. This Anicut Dam stores rainwater. This stored water is then distributed throughout the year according to the people's needs to benefit agriculture, industry, housework and drinking water.

## CHAPTER 2

### 2. LITERATURE REVIEW

The literature review is an overview of what has been done on a topic before. Scholars in books or paragraphs commonly use this term. There have been many previous studies on the Kangsabati River in India. Some of which have been very well received and the results from those papers are discussed here.

Sushil Bera and Neel Kamal Mishra et al.2021 want to explain the barrier created in the fish population for having the Anicut dam on Kangsabati River in the West Medinipur district. The fish usually move in favorable and unfavorable directions of the water currents, as a result of which the length of the fish increases and the fish breed. However, the construction of the Anicut dam along the river Kangsabati creates a barrier which creates a very unpleasant environment for the fish, which directly and indirectly interferes with the reproduction of the fish, thus altering the normal movement of the fish. Anicut dam is a small place for fish to go from upstream site to downstream site, known as a fish ladder. As a result, the movement of small fish is somewhat expected, but the movement of large fish is affected later. In this paper, researchers have long collected a wealth of information and observed that certain species of fish and aquatic animals are becoming extinct on Earth. To overcome this problem, researchers say, engineers and biologists need to work together.

According to Neha Mittal et al. 2014 Environmental pollution, directly and indirectly, causes climate change which affects the river ecosystem. The way the world is constantly being cut down, the temperature is rising, creating global warming. It has been observed that rainfall is decreasing daily, and the fear of a water crisis is increasing to several theories. In most plateau areas, dam construction is carried out by diverting rainwater to divert rainwater throughout the year. The creation of a dam in the river is changing the normal rhythm of the river and causing damage to aquatic life. They have suggested that some modified basins and river basin management significantly alleviate this problem.

According to Rabin Chakraborty et .al 2021, flood susceptibility mapping is essential because flood risk management can control or prevent the catastrophic damage caused to nature by floods. The erratic climate change caused by the increase in temperature sometimes increases the amount of rainfall during the monsoon season. The dam can store water up to a specific limit, but when the limit is exceeded; the water has to be released, which results in flooding of the downstream site. Researchers, therefore, use different models (such as DLNN, ANN

&PSO) on the Kangsabati River and Flood-prone areas are marked. Engineers have been asked to clear sediment from all the Kangsabati River basins and increase the basin's depth to supply water through it.

According to Manjushree Singh et al. 2011 Agriculture in India continues to be the strongest, with irrigation playing a significant role. The main task of the Irrigation Department is to supply the quantity of water required for cultivation according to water availability. But researchers have found a gap between water demand and supply. So, they have used two software models, ARIMA, to bridge this gap, respectively ARIMA & X-12-ARIMA, for monthly flow forecasting. X-12-ARIMA is more accurate for this study than ARIMA software. They have tried this two software to get excellent results, which is why bridging the supply and demand gap is straightforward.

According to Sujana Dhar and Asis Mazumdar et al. 2009, India is now a developing country with two-thirds of its people directly dependent on agriculture, forest and fisheries. Therefore, researchers have observed the relationship between soil and water during the rainy season. In summer, in the Bankura district on the Kangsabati river, for the convenience of cultivation. The way climate change is happening day after day is a matter of genuine concern. We have evaluated some permits (evaporation, transmission losses and lateral flow) till 2050 to eliminate this problem and have created hydrological modeling by SWAT analysis. This model maintains a completely continuous flow and is in motion to transport.

According to Debasis Ghosh et al. 2020, there is a severe water crisis in the plateau region because of the nature of the land. The water cannot remain stable due to the elevation of the groundwater and its effects. Researchers have done some reviews on the upper Kangsabati river basin. About 1820 sq. km of upper Kangsabati river basin is very suitable for groundwater, so it has high soil holding capacity. But some space is about 592 sq. km for very inconsistent groundwater. GPZ is used to overcome this situation and use RS and GIS software. Also, recommend land use and land cover.

According to Subhod Chandra pal et al.2021, The amount of rainfall during the monsoon season is not average, leading to flooding. When a dam violates the water storage limit, water is slowly released to reduce the pressure on the dam, resulting in severe damage to the river bed in the vicinity of the river. It is why the soil is washed away with water, known as land degradation. Researchers have observed that the relationship between soil and water is deteriorating. SWAT analysis is required for this type of problem. Also, the SLR-EBF method is used to implement water-induced erosion. These methods can predict a healthy

future. These steps need to be taken to prevent land degradation. This result will benefit all stakeholders and regional planners, and those doing research in the future will need to take some appropriate steps.

In addition to the Kangsabati River, several researchers have worked on various rivers in India, most notably the author RP Pandey et al.2003. The Sun River and the Barab River flow through the district of Orissa; its water availability has been determined in the lean season. He made these observations every week, mainly in January-May. It has been observed that industrial water demands up to 36000 meters <sup>3</sup> / day in the lean season. This massive industry demand is not enough for the availability of river water. It can see that the water availability and flow condition of the San River is 6-7 times more than that of the Barab river. Therefore, researchers have concluded that the water supply from the Sun River to the Barab River can meet that industrial demand.

DR.Pankaj Kumar Roy has studied groundwater in the vicinity of the Shilabati River in the tropical plateau region. Due to the geographical location of the river, the groundwater level in the area is deficient, resulting in drought in many places. The Shilabati River has nine sub-watersheds with a total area of 3881 km <sup>2</sup>. Planning and management to strengthen sub-watersheds with the help of several classical algorithms help raise the groundwater level directly and indirectly.

There are also several papers on water share worldwide, including Mikhail G jay, who is from Libya country, has done a study on water conflict and made several statements about water scarcity. Says to stop water misuse as soon as possible. He also said that if we do not stop wasting water, we will create a terrible situation in the world. In the future, disputes between countries over water will escalate and escalate into violence. Population growth is another major cause of the water crisis, which is causing a lot of damage in the world, so the government of every country has to take strict action in this regard. Everyone must work together to prevent water wastage, but this problem will eliminate.

Azazkhan I. Pathan et al. 2020 want to explain Floods are the most terrifying form of nature. Floods usually have two sides, good and bad, but the bad side is more than the good side. Floods have a direct impact on people's lives, such as economics and agriculture. The catastrophic floods caused a terrible food crisis. The effects are severe in the riverside areas. To overcome this problem, the researcher created a 1d model using HECRAS software, which gives some relief.

According to Sajjad Haider et al. 2021 from china Floods have a profound effect on people's daily lives as well as on river crossings and very strong influences, as a result of which the river banks are completely broken and the flow of water cannot be kept within a certain limit. Although researchers have taken the initiative, this problem has not been addressed due to premature behavior of nature and unusual behavior of the public. This problem is not only of India but of every country so this researcher from China HECRAS software made a model using some relief.

Some researchers have written papers on river modeling, including Tobias Bleninger, a German man whose one-dimensional flow modeling has been observed over the RHINE. He used HEC-RAS software to make this model. Since the river flow is steady and one-dimensional, the one-dimensional model survives. This model explains the obstruction of water flow in the river and how to prevent the river bed friction at the river's bottom for sediment transport.

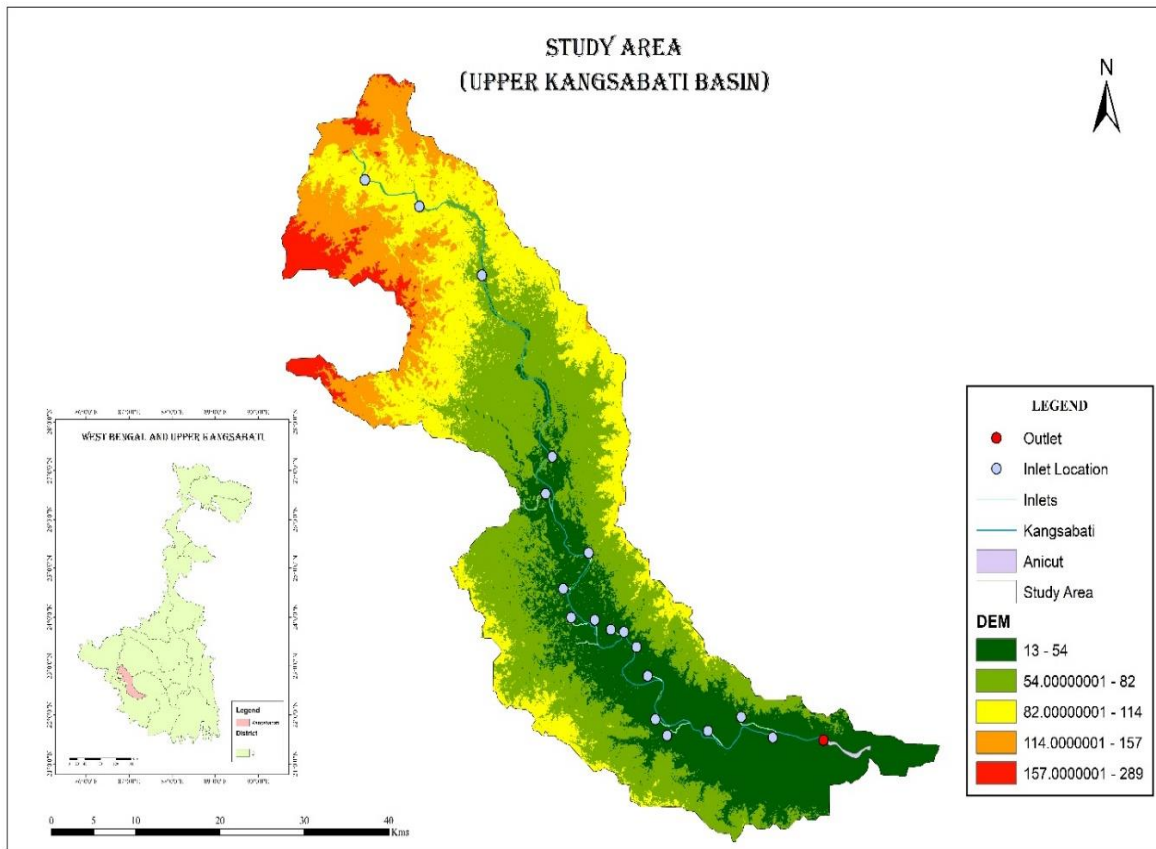
Reading the papers of all the researchers written above, we can get some whole idea from the work that has been done before on lean period, water share and water availability in tropical plateau regions on different rivers. A different topic is selected using this idea.

## CHAPTER 3

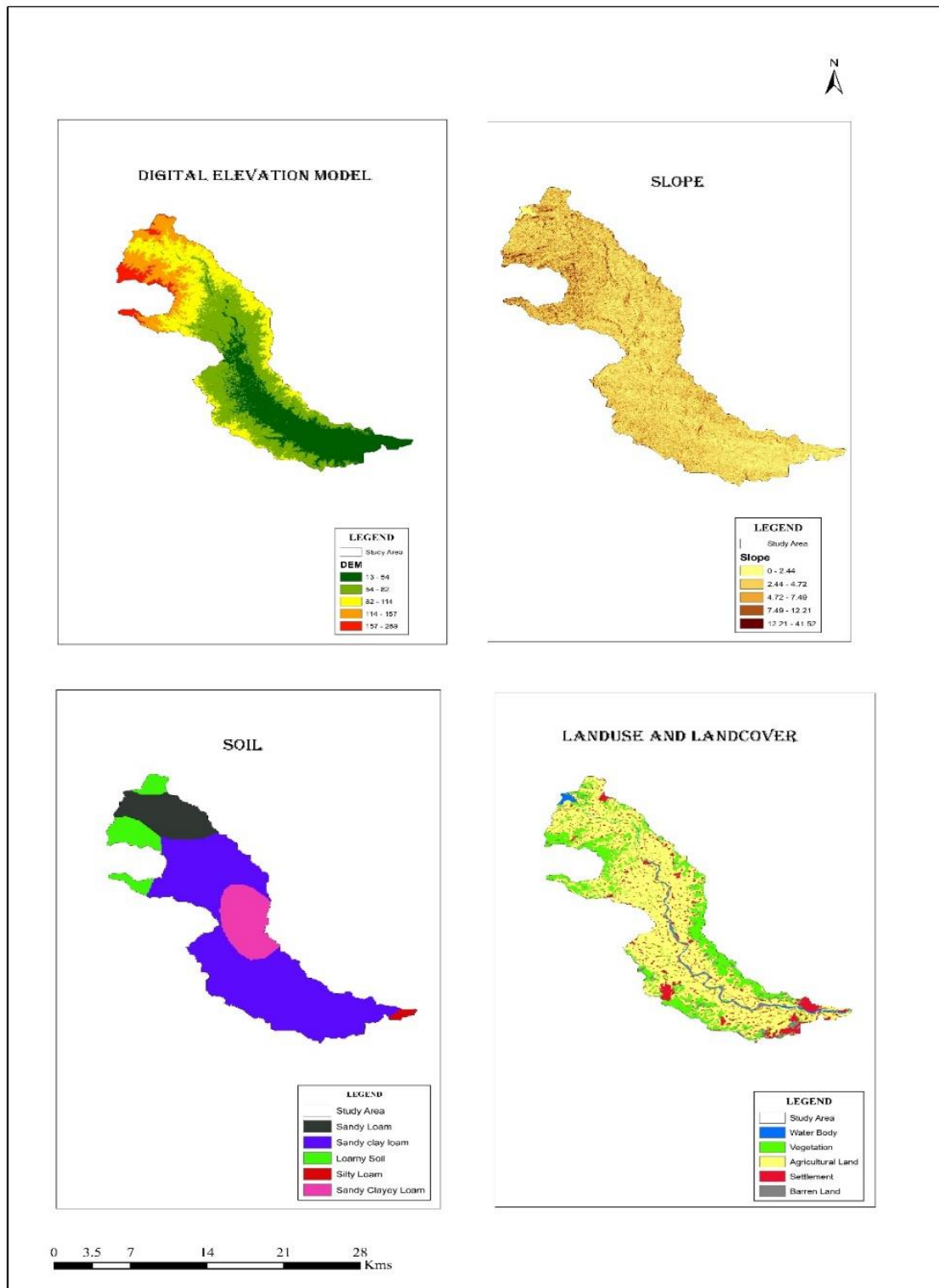
### 3. STUDY AREA

The 'Kangsabati' is a non-perennial river which is originated from the Chota Nagpur plateau of the Jharkhand state of India. This river flows through Bankura, Purulia, West Medinipur, and East Medinipur districts before finally flowing into the Bay of Bengal. Kangsabati meets the 'Kumari River' at Mukutmonipur of Bankura district, West Bengal which is a major right hand tributary of Kangsabati. In our project, we have considered the river stretch (113 km) from Mukutmonipur Dam, Bankura district to Kasai halt rail station, Paschim Medinipur district, West Bengal with a basin area of 1705 sq. Km. In our study area, there are thirty-two (32) numbers of inlets that contribute to discharge to Kangsabati River, out of which only five (5) inlets are non-perennial. The two major inlets named Tarafeni River and Kaalazeera River contribute maximum discharge throughout the year. The geomorphological feature of the river basin is divided into three sections: pre-Cambrian granite gneiss dominates the upper basin, primary and secondary laterite formation dominates the middle segment, and water and seasonal features dominate the lower area. The study area experiences an annual average rainfall of 163.9 cm (according to GoI, Ministry Of Earth Sciences India, Meteorological Department, 2020) with maximum and minimum temperatures of 45 °C and 17 °C respectively. The mean annual temperature of this region is 29° c with high humidity. The nature of vegetation is mainly deciduous and important forest covers mainly Mahua, Palash, Sal, Babla, Bel, etc. The study area is divided mainly into two blocks viz. Medinipur and Jhargram district. The study area is also divided into 132 villages according to the Indian Census 2011 and there is a 5,913,457 population within the study area.

The main elevation of this area ranges between 41 to 250 m and the total area tilted towards the south from the origination of the river. The region has some domical and semi-domical undulation to prove its characteristics as a plateau region. There are some steep features in the north western part of the region (13<sup>0</sup> - 41<sup>0</sup>), proves the undulating characteristics in the upper portion of river basin. In the mid-portion of the region is mainly covered by sandy clay loam type of soil, whereas the upper part is generally bifurcated with sandy loam soil. Being a part of Chota Nagpur plateau region, the land use pattern of the mid portion is mainly agriculture and some forest cover is found in the furthest eastern and western corners of the basin. Medinipur city is located in the end most corner of the river basin and Jhargram is located in north-western corner of the Tarafeni River.



**Fig.3.1 Study Area (Upper Kangsabati Basin)**



**Fig. 3.2 Characteristics of Study Area with DEM, Slope, Soil and LULC**

## CHAPTER 4

### 4.1 OBJECTIVE

The main objective of this thesis based on the review of the above problem is, To evaluate the present and future water availability and its effect on local stakeholders upon Kangsabati River and its adjoining inlets beside Medinipur town.

### 4.2 Scope:

- To examine the condition of all inlets in the Kangsabati River basin from Mukutmonipur to Medinipur town and its adjoining areas. Most of all inlets are rain-fed and non-perennial in nature.
- To understand the field terrain condition and slope aspects across the river basin and their impact on the discharge of inlets.
- To conduct a bathymetric survey near the catchment portion of anicut dam (Near Medinipur town) for analyzing the bottom condition of the river.
- To collect all the necessary data regarding water availability conditions in Kangsabati River (DEM, rainfall, LULC, slope, soil).
- To perform some scientific and empirical models for evaluating the water availability condition of the area and its future scenario.



**Fig. 4.1 Scenic Beauty of Upper Kangsabati River**

### 4.3 DATA USED

Primary data are collected from the field survey through Kangsabati River and inlet point. In the first approach, we have specified the various sub-basin areas and the proper location of Kangsabati River by Google earth pro software. The sub-basin area is mainly used for agricultural, domestic and industrial purpose etc. The Field Survey was started to collect the data from upper sub basin area to lower sub basin area step by step. By selecting a particular sub basin area, measured the latitude, longitude and elevation by GPS (Global Positioning System), which is very easy to operate for anyone. After that to find out the flow of velocity of sub basin to the direction of flow we used digital current meter, which is kept at a certain depth not submerged fully in water. Using the current meter, note down the flow velocity and depth of water accurately. Then measuring the top bed width and wetted bed width with the help of 50 meter measuring tape.

The planning of DTM (Digital Terrain Modeling) of the anicut was possible by using ADCP (Acoustic Doppler Current Profiler) on upper Kangsabati basin area. For conducting cross-section, we were making use of the vessel, which was equipped with GPS (Global Positioning System), Trimble SPS 356 GNSS (Global Navigation Satellite System) and operated under the RTK (real-time kinematic). We used a network of reference stations that provided Geodetic and Cartographic Institute. The cross-sections took place at a distance of averagely 432 m along river stretch with an average width of 300 m inside the anicut. The Cross-section has been carried out at an average of 2 m intervals. Measured points of the anicut bed in WGS84 transformed into a national coordinate system (x, y, z). Data was loaded into MS-Inroads, and then we created DTM of the anicut bed and DTM of regulation low water level. By the intersection of these models, we have generated isolines that have reduced regulation of low water level. The result of processing and evaluation of data has been developed through the isolines plan of the measured section of the anicut by WIN RIVER II. With the help of an interpolating algorithm, each cross-section measures the discharge and velocity in a particular cross-section. After getting the cross-sectional value, it is put in HEC-RAS software for computing 1D river flow through the cross-section. Also, DEM has been developed based on satellite images obtained to measure the area's height around the river channel for ease of operation in Arc GIS 10.4. Through DEM, the relationship between 3D object space (X, Y, Z) and 2D image space (r, c) is created based on the information received from the sensors of the satellite. The rational polynomial coefficient (RPC) converts the specific sensor model to the geodetic ground point through the pixel

coordinates of the image. In addition, the bathymetric data obtained from ADCP are arranged in cross-section on DEM in anicut with the help of HEC-Geo RAS software under Arc GIS 10.4. In addition to cross-section, river line, bank line and flow line are arranged on DEMs and prepare for simulation in RAS mapper of HEC-RAS v 6. The river section is considered as one dimensional flow model and the anicut section is also considered as 2D storage medium. The primary data regarding discharge and velocity is collected from field through Current meter from 23.04.2022 to 22.05.2022. The prediction of river discharge including storage is analyzed through EPR (Exponential Polynomial Regression) method.



**Fig: 4.2** Measuring latitude/longitude and elevation by GPS

## CHAPTER 5

### 5.1 METHODOLOGY

The statistical techniques in particular are clear from the indications are ideally used for lean season flow analysis in tropical plateau regions that are found when reviewing the literature. The study monitored the flow of the Kangsabati Sub-basin Rivers every week during the lean season (April-May). The statistical approach is very important for this study which seeks to analyze the flow characteristics of streams. Stream flow is different during lean season in every week because of depending on water availability. It is more likely that this level is considered safe if the lean season flow is somewhat dependent on the base flow.

#### 5.1.1 Generated Cross-section in Anicut

In a cross-profile area, ADCP acquires velocity through the water profile along the acoustic path of the instrument. The acoustic energy changes with the frequency of the water column in the rate of energy change.

$$V = \frac{CF_D}{2F_s} \quad (1)$$

Where,  $V$  is the velocity of water parallel to the acoustic path,  $C$  is the speed of sound in the water,  $F_D$  is the difference in frequency due to doppler shift ( $F_B - F_s$ ),  $F_s$  is the frequency of transmitted acoustic energy and  $F_B$  is the frequency of the backscattered acoustic energy. The value of discharge computes through the moving boat with ADCP in real time by crossing the river from one bank to another. The total discharge value in a cross-section summed with the value from the top, bottom, measured, right, and left edge of the sectional area.

$$Q = Q_{Left\ Edge} + Q_{Top} + Q_{Measured} + Q_{Bottom} + Q_{Right\ Edge} \quad (2)$$

Where,  $Q$  is the total discharge,  $Q_{Left\ Edge}$  is the discharge estimated in the unmeasured area of left bank,  $Q_{Top}$  is the discharge estimated in the top unmeasured area,  $Q_{Measured}$  is the discharge measured directly by ADCP,  $Q_{Bottom}$  is the discharge estimated in the bottom unmeasured area and  $Q_{Right\ Edge}$  is the discharge estimated in the unmeasured area near right bank. With the help of an interpolating algorithm, each cross-section measures the discharge and velocity in a particular cross-section. After getting the cross-sectional value, it puts in HEC-RAS 6 software for computing sediment transportation through bridge scour.

### 5.1.2 Calculating Discharge in Model

To determine the discharge data, we have drawn all the cross-sectional sub basin area, which is like a trapezoidal section. After getting the trapezoidal section we can find out the area of sub basin by using the formula of,

$$A = 1/n \times (b + nd)d$$
$$\text{Discharge}(Q) = \text{area}(A) \times \text{velocity of flow}(V) \quad (3)$$

Where, b is the width, n is the slope and d is the depth.

### 5.1.3 Bathymetric Profile in HEC-RAS

The bathymetric profile can be obtained based on the energy equation that is formed based on the flow of water between two cross-sections while moving from one cross-section to another.

$$h_2 + z_2 + \frac{\alpha_2 V_2^3}{2g} = h_1 + z_1 + \frac{\alpha_1 V_1^3}{2g} + h_e \quad (4)$$

Where, h is the water depth of cross-sections, V is average velocity between cross Sects. 1 And 2, Z is the elevation of main channel invert,  $\alpha$  is the velocity weighting coefficient with areal differentiation between two cross sections,  $h_e$  is the energy head loss and g are the gravitational attraction.

$$Q = \frac{1}{n} AR^{2/3} S_f^{1/2} \quad (5)$$

Where, Q is the flow discharge, n is the Manning roughness coefficient, A is the flow area, R is hydraulic radius and C is expansion and contraction loss coefficient. Contraction occurs when the velocity of the downstream river is higher than upstream. When there is very little change between the two cross-sections with the subcritical flow, the amount of contraction and expansion coefficients is 0.1 and 0.3, respectively. In HEC-RAS, when we develop the cross-section of the river bed profile, the velocity is calculated automatically with the help of area and discharge. But in developing the cross-sectional conveyance, the manning's equation follows there,

$$V = \frac{k}{n} R_h^{2/3} S^{1/2} \quad (6)$$

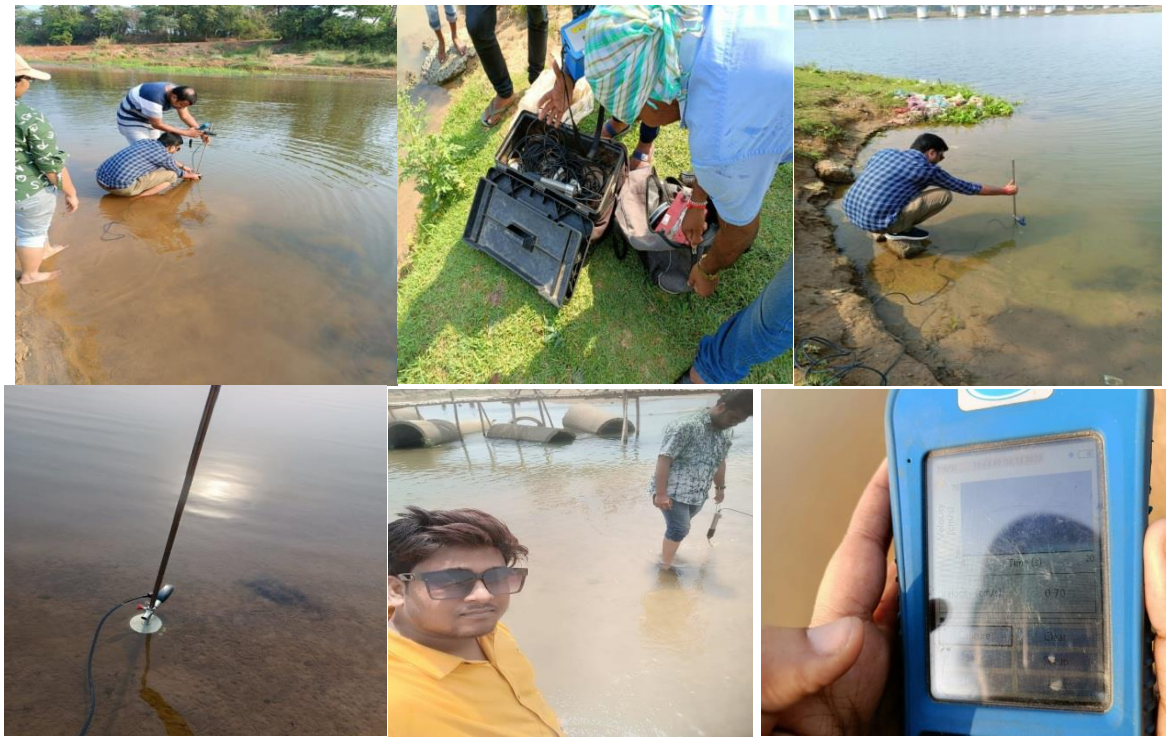
where,  $V$  is the average cross-sectional velocity,  $n$  is the manning coefficient,  $R_h$  is the hydraulic radius,  $S$  is the slope of hydraulic grade line and  $K$  is the conversion factor in SI unit. In the case of a sand bed river, the bed roughness is another important portion of the velocity distribution in a particular cross-sectional area.

#### **5.1.4 Pre-condition of Model Development**

River flow is shown throughout the models by making DEM for simulation. The seasonal flow hydrograph for the 1D river routing model is shown as the upstream boundary condition, and the frictional slope value (0.02) is taken as the downstream boundary condition. Since the value of DEM is very high here ( $> 150$  m) and there is a huge difference, we define the frictional slope as the downstream boundary condition. In HEC -RAS 1D-2D coupled hydrodynamic models, 1D river flow is mainly used as input, which helps create an inundation area. On the other hand, the 2D flow model helps establish the inundation area through mesh generation and connects the boundary condition with the lateral structure.

#### **5.1.5 Mesh/Grid Generation**

In 2D flood flow or inundation modeling, the whole anicut section is divided into some grids or mesh. These can be of different types such as regular or rectangular grid, triangular or irregular grid, or flexible mesh. As the terrain is very bumpy, there is a lot of inconsistency in the grid structure. However, it is often seen that fluid simulation is very good with the help of accurate grids, but irregular grids are used for calculations through correction. 2D modeling is currently being improved using the adaptive mesh refinement method and the hybrid 1D – 2D variable grid sizing technique. HEC-RAS uses sub-grid bathymetry equations to determine bathymetry. Use of relatively large numerical methods and mass conservation is used to calculate bathymetric data accurately. Since the 2D areas are based on sub-grid bathymetry equations and are rectangular, the cell volume ( $\Omega(H)$ ) and the cell face area ( $A_k(H)$ ) are based on water elevation  $H$ . The formation of this sub-grid mesh often involves reading and solving problems with orthogonal and non-orthogonal grids. 100 m by 100 m grid resolution with 466 cells and 190 Ha area is used to enlarge the anicut size and volume, making it possible to show the most characteristic range of 2D area.



**Fig: 5.1** Measurement of velocity of flow by current meter



**Fig: 5.2** Collecting data from various inlet points

## 5.2 1D River flow

In a 1D river hydraulic modeling, the river flow is assumed to flow along the longitudinal direction. In the case of the 1D model, river bathymetric terrain is estimated with the help of a cross-section and simulation of flow parameters is done in such a way that water depth and flow velocity can be easily measured. The bathymetric condition of the river is analyzed through normal bathymetric parameters through the river. For ease of measurement, HEC - RAS imagines a horizontal plane along the flow direction through each cross-section. It allows the momentum dispersion between the river and the riparian region. In the 1D flow model, the unsteady flow routing is done using the Saint-Venant equation, where continuity and momentum exchange are included.

$$\frac{\partial A}{\partial t} + \frac{\partial Q}{\partial x} = 0 \quad (7)$$

$$\frac{\partial Q}{\partial t} + \frac{\partial \left( \frac{Q^2}{A} \right)}{\partial x} + gA \frac{\partial H}{\partial x} + gA(S_0 - S_f) = 0 \quad (8)$$

Where,  $A$  is the cross-sectional area,  $t$  is the time,  $Q$  is the water flow,  $x$  is the measured distance in the longitudinal direction of the channel,  $g$  the is the gravitational acceleration,  $H$  is the height of water level above the datum,  $S_0$  is the river bed slope and  $S_f$  is the frictional slope. Also, the unsteady flow equation of the 1D model uses a four-point implicit scheme, where space derivatives and functional values are assessed at interior points.



**Fig. 5.3 All inlets discharge boundary**

### 5.3 2D Anicut Storage

The main feature of the 2D flood model is that it assists the lateral and longitudinal flow of water, but the measurement of flow in the vertical range is not acceptable here. In the 2D model, the landmass is divided into several mesh or grids. For this reason, the 2D model is also referred to as a sub-grid model in HEC RAS, where topographical data can be retrieved according to the grid area. In the 2D model, sub-grid bathymetry is determined based on shallow water and diffusion wave equation.

$$C = \frac{V\Delta T}{\Delta X} \leq 2.0 \text{ (with a max } C = 5) \quad (9)$$

Where, C is the courant number, V is the flood wave celerity, ΔT is the computational time step and ΔX is the average cell size. In addition, the 2D unsteady flow equation is based entirely on the implicit finite volume algorithm, which calculates large time intervals. It makes the 2D unsteady flow model much more mature and robust than the traditional finite element technique. Unsteady flow routing solves continuity and momentum conservation equations based on space and time in the flow model.

$$\frac{\partial H}{\partial t} + \frac{\partial(hu)}{\partial x} + \frac{\partial(hv)}{\partial y} + q = 0 \quad (10)$$

$$\frac{\partial u}{\partial t} + u \frac{\partial u}{\partial x} + v \frac{\partial u}{\partial y} = -g \frac{\partial H}{\partial x} + v_t \left( \frac{\partial^2 u}{\partial x^2} + \frac{\partial^2 u}{\partial y^2} \right) - C_f u + fv \quad (11)$$

$$\frac{\partial v}{\partial t} + u \frac{\partial v}{\partial x} + v \frac{\partial v}{\partial y} = -g \frac{\partial H}{\partial y} + v_t \left( \frac{\partial^2 v}{\partial x^2} + \frac{\partial^2 v}{\partial y^2} \right) - C_f v + fu \quad (12)$$

Where, t is the time, q is the source term, u and v are the velocity components in x and y directions, H is the water surface elevation which develops by surface elevation z (x,y) and water depth h (x,y,t) in the continuity equation. But in the momentum conservation equation,  $v_t$  is the horizontal viscosity coefficient  $C_f$  is the bottom friction and f is the Coriolis parameter. The horizontal viscosity, bottom friction and frictional slope assumed through the equations,

$$v_t = Dh u^* \quad (13)$$

$$C_f = \frac{n^2 g |V|}{R^{4/3}} \quad (14)$$

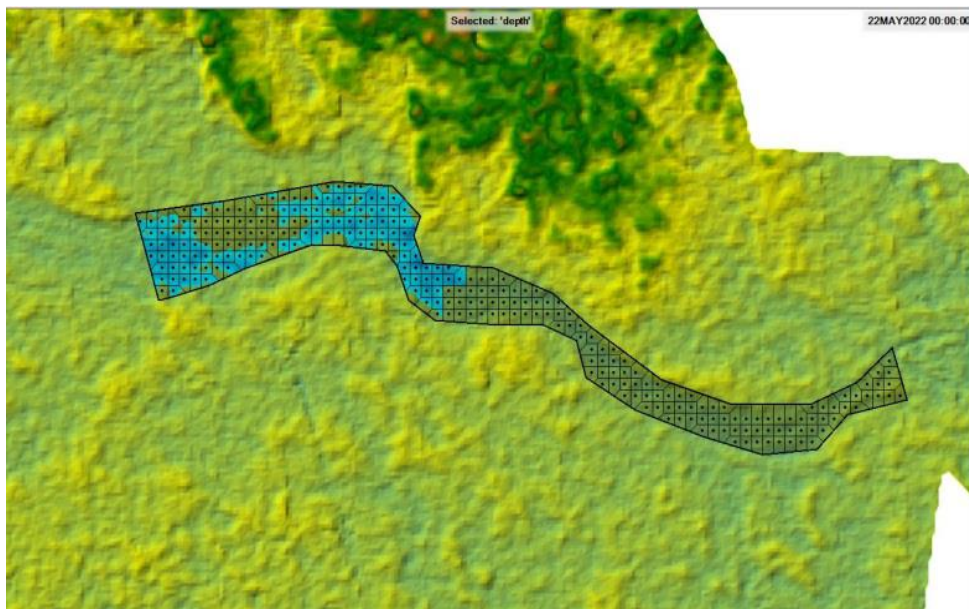
$$f = 2\omega \sin \varphi \quad (15)$$

Where, D is the non-dimensional empirical constant (0.33-0.77), h is the water depth in the cross-section,  $u^*$  is the shear velocity, R is the hydraulic radius (m), V is the magnitude of the velocity vector (m/s), n the is manning roughness coefficient ( $s/m^{1/3}$ ),  $\omega$  is the 0.000073 m/s and part of sidereal angular velocity,  $\varphi$  is the latitude (consider as  $23^\circ$ ). Based on these

equations, we get the HEC-RAS sub-grid bathymetry mass conservation equation, which is as follows,

$$\frac{\Omega(H^{n+1}) - \Omega(H^n)}{\Delta t} + \sum_k V_k \cdot n_k A_k(H) + Q = 0 \quad (16)$$

Where  $\Omega$  is the volumetric three-dimensional space occupied by fluid,  $Q$  the is source/sink term crosses the bottom and top surface,  $n$  and  $n+1$  represents the index time steps between two consecutive time  $\Delta t$ ,  $V_k$  is the average velocity,  $n_k$  is the area, and  $A_k(H)$  is the unit normal vector at face  $k$ .



**Fig. 5.4 2D Anicut storage with water level in Lean Period (Survey time)**

#### **5.4 1D-2D coupled modeling**

The 2D model has been simulated in either 1D, 2D or 1D / 2D based on unsteady flow. But the 1D-2D coupled model is shown as a flow 1D model in the river, and the 2D model shows hydro dynamically anicut storage. In this case, the 2D areas are connected to the 1D flow model through the weir junction. The concept of the 1D-2D coupled model is completely new in HEC-RAS. River flow and storage are exchanged between 1D and 2D regions, and water surface elevation varies based on a periodic change. The algorithm of the 1D-2D coupled model relies on the flow element, which allows the immersion of headwater, tail water and lateral structures to be calculated step by step over time. The 1D-2D coupled model solves itself with the lateral structure, where the 2D storage area is connected to the 1D cross-

section. When river water enters in the anicut section, it is measured using standard weir equations.

$$dQ = C(y_{\omega s} - y_{\omega})^{2/3} dx \quad (17)$$

Where, 'dQ' is the structural flow over the length element dx,  $y_{\omega s}$  is the surface water elevation,  $y_{\omega}$  is the structure elevation, 'C' is the weir coefficient. Since the 2D model is made up of multiple grids, a mixed hybrid discretization approach is used to prove the orthogonally of these grids from a statistical point of view. Although the limited differences between the grids are discussed in approximate time derivatives, the limited volume discusses the spatial range of grids that are not locally orthogonal. When the volume of the grids are compared with the derivatives over time, it is as follows,

$$\frac{\partial \Omega}{\partial t} \approx \frac{\Omega(H^{n+1}) - \Omega(H^n)}{\Delta t} \quad (18)$$

The following equation determines the spatial limiting differences of the grids,

$$\nabla H \cdot n' = \frac{\partial H}{\partial n'} \approx \frac{H_2 - H_1}{\Delta n'} \quad (19)$$

Where,  $n'$  is the distance between cell centres. When grids are not locally orthogonal, the values of grid faces and grid term H are determined as follows,

$$\nabla H \approx \frac{\oint_L H n dl}{A'} \quad (20)$$

Where, L is the dual grid boundary,  $A'$  is the area of the dual cells. Reviewing the various equations mentioned above, the mixed hybrid equations that are formed for the 1D-2D coupled model are as follows,

$$\frac{\partial H}{\partial n} = (n \cdot n') \frac{\partial H}{\partial n'} + (n \cdot T') \frac{\partial H}{\partial T'} \quad (21)$$

Where, T and  $T'$  are the directions orthogonal to n and n+1. The first part of the equation is based on the approximate finite difference, but the next part is based on the finite volume scheme.

### 5.5 Prediction of Discharge with Anicut Volume

Exponential Polynomial Regression (EPR) is a data-driven hybrid regression technique, based on evolutionary computing used for discharge and water volume prediction. EPR has been used successfully in solving several problems in civil engineering. The following two steps roughly describe the underlying features of EPR, aimed to search for polynomial structures representing a system. In the first step, the selection of exponents for polynomial

expressions are carried out, employing an evolutionary searching strategy by means of genetic algorithms. In the second step, numerical regression using the least square method is conducted, aiming to compute the coefficients of the previously selected polynomial terms. The general form of expression in EPR can be presented as follows,

$$y = \sum_{j=1}^m F(X, f(X), a_j) + a_0 \quad (22)$$

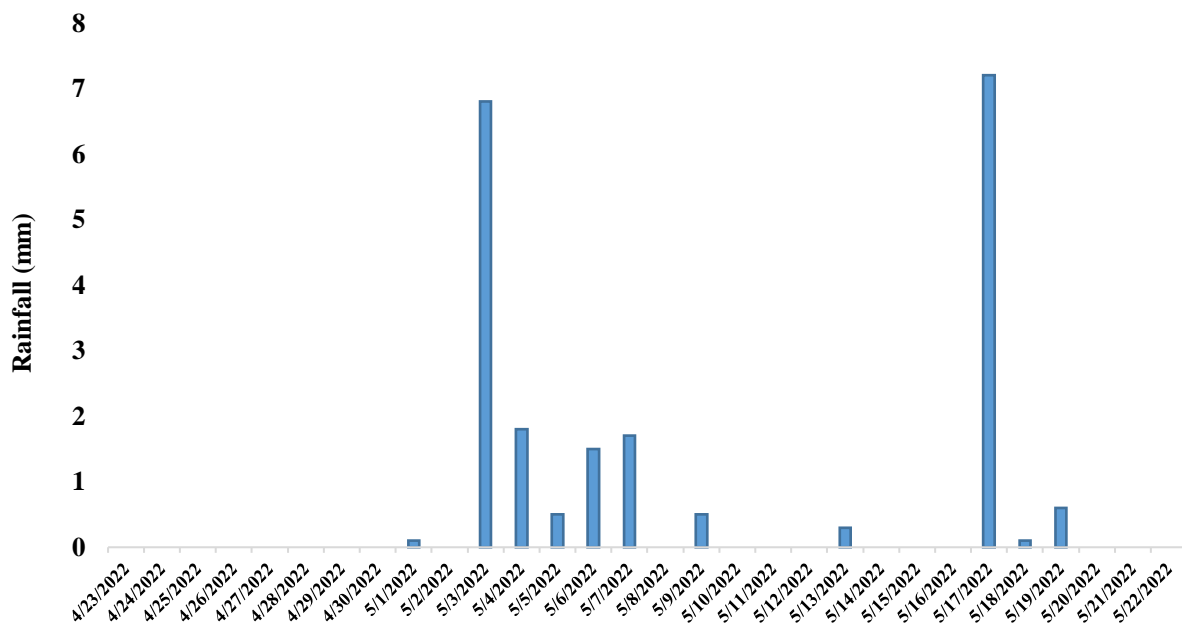
Where,  $y$  is the estimated vector of the output of the process;  $m$  is the number of terms of the target expression;  $F$  is a function constructed by the process;  $X$  is the matrix of input variables;  $f$  is a function defined by the user and  $a_j$  is a constant.

# CHAPTER 6

## 6 RESULTS AND DISCUSSIONS

### 6.1 Characteristics of Inlet Discharge

The area along all the Kangsabati Rivers is included in the tropical extreme climate, so rainfall is limited and a warm climate is observed during the lean period. Even after coming out of Mukutmonipur, the main flow of this river is completely dependent on rainfall and water from inlets. Notable among these inlets are the Tarafeni River to the northwest and the Kaalazeera River to the west. Basically, the water from these rivers and inlets has saved the main flow of the Kangsabati River. The main flow of the Kangsabati River is shown here based on the discharge of inlets from 23rd April to 22nd May. First of all, the amount of rainfall based on the survey period is given (**Fig. 9**). All inlet locations are highlighted in the study area location map. However, location pinpoints are mentioned separately here. The inlets are detailed in two districts, Bankura and West Midnapore. However, some of these inlets are completely closed or decaying. It goes without saying that there is no water in them except in the rainy season. Based on this rainfall, the flow of Tarafeni and Kaalazeera rivers with inlets has been measured here and shown in **Table 1**.



**Fig. 6.1 Rainfall Condition in Lean Period**

**Table: 6.1 Location and Characteristics of Inlets**

Inlet Number	Lat/Long	Location	Condition	Bed Width (m)	Velocity (m/s)	Depth (m)	C/S Area(m <sup>2</sup> )	Discharge (m <sup>3</sup> /sec)	Catchment Area (Ha)	Remarks
1	22°57'9.97"N 86°47'44.75"E	Ghagra, Lakshmandihi	Clogged							
2	22°56'2.20"N 86°48'18.08"E	Bankati	Flow	7.2	0.0369	0.25	1.844552842	0.068064	2.36	considering Trapezoidal ( with 52 <sup>o</sup> side slope)
3	22°55'22.91"N 86°51'29.06"E	Dharampur	Clogged							
4	22°54'48.08"N 86°51'52.57"E	Parkul	Clogged							
5	22°54'32.45"N 86°51'46.71"E	Chhola Gara	Clogged							
6	22°54'50.74"N 86°53'46.03"E	Lachkunda Waterfall	Flow	12	0.0863	0.2	0.463553855	0.040004698	1.68	considering Trapezoidal ( with 62 <sup>o</sup> side slope)
7	22°52'19.98"N 86°55'48.81"E	Madhupur Swabujdwip	Clogged							
8	22°51'12.08"N 86°55'42.99"E	Khatanga	Clogged							
9	22°50'34.93"N 86°55'59.89"E	Mayna	Clogged							
10	22°50'39.89"N 86°55'46.92"E	Champabani	Flow	8.83	0.0134	0.3	0.837268469	0.011219397	25	considering Trapezoidal ( with 47 <sup>o</sup> side slope)
11	22°49'47.92"N 86°56'12.65"E	Dhepua	Clogged							
12	22°44'46.38"N 86°59'41.94"E	Jetpara	Clogged							

13	22°41'45.86"N 86°59'19.70"E	Thakurbada	Clogged							
14	22°40'27.57"N 87° 0'17.44"E	Belapal	Flow	25.28	0.0125	0.05	0.680910179	0.008511377	31.3	considering Trapezoidal ( with 56 <sup>0</sup> side slope)
15	22°38'22.07"N 86°59'51.58"E	<b>Tarafeni River,</b> Lachipur	Flow	76.47	0.034	0.36	12.99585504	0.441859071	854	considering Trapezoidal ( with 39 <sup>0</sup> side slope)
16	22°35'2.75"N 87° 2'36.48"E	Baghakuli, Lalgarh	Pipe Flow (Diameter 1 m)		0.787	0.16	0.081131866	0.063850778	4.3	
17	22°33'1.40"N 87° 0'59.60"E	Binpur CSC Center	Flow	25.28	0.0125	0.05	0.680910179	0.008511377	31.3	considering Trapezoidal ( with 56 <sup>0</sup> side slope)
18	22°31'24.52"N 87° 1'29.48"E	Dahapal, Bandorbani	Flow	9.3	0.0023	0.08	0.605332768	0.001392265	75.7	considering Trapezoidal ( with 48 <sup>0</sup> side slope)
19	22°29'58.78"N 87° 1'47.75"E	Jorakenudi, Cherabani	Flow	15	0.0145	0.06	0.551601315	0.007998219	85.9	considering Trapezoidal ( with 38 <sup>0</sup> side slope)
20	22°30'43.69"N 87° 4'1.35"E	Nandaria	Flow	8.6	0.058	0.12	0.879945323	0.050948834	86.4	considering Trapezoidal ( with 51 <sup>0</sup> side slope)
21	22°30'36.24" N 87°4'52.01" E	Near Bhairab Kundu	Flow	12	0.0863	0.2	0.463553855	0.040004698	2.59	considering Trapezoidal ( with 62 <sup>0</sup> side slope)

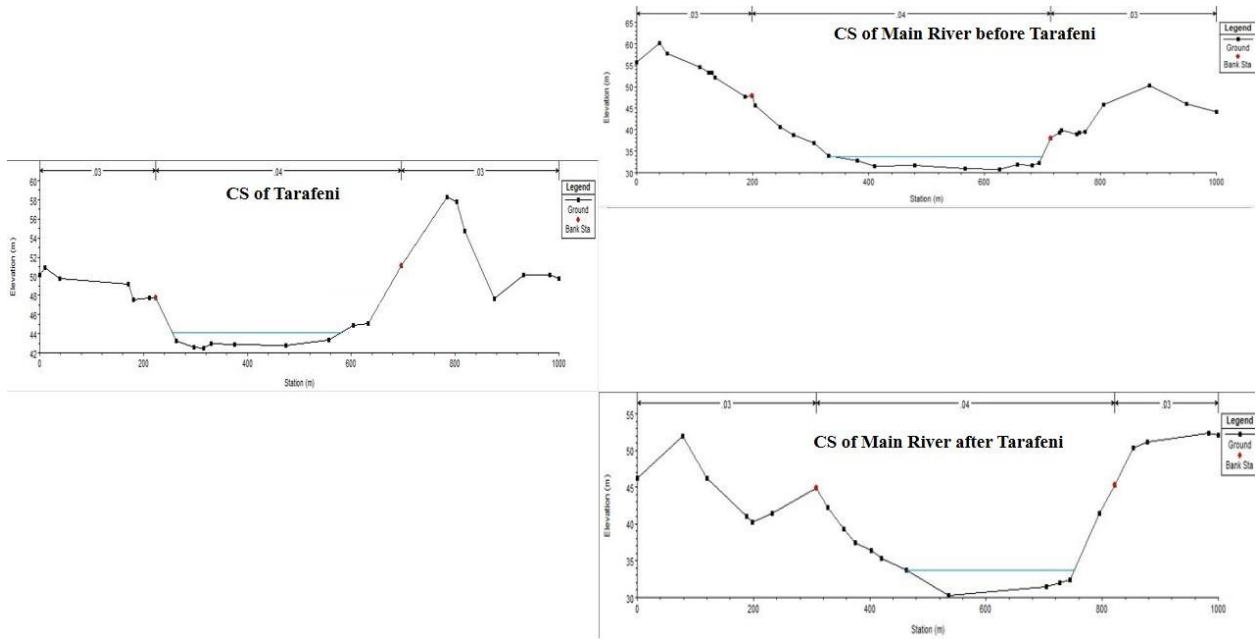
22	22°29'44.62"N 87°5'41" E	Dherua CRPF Camp	Flow	7.2	0.0369	0.25	1.844552842	0.068064	2.98	considering Trapezoidal ( with 32° side slope)
23	22°28'7.63" N 87°6'23.33" E	Boilasol Bridge	Flow	23	0.065	0.14	0.654762082	0.042559535	16.8	considering Trapezoidal ( with 52° side slope)
24	22°25'40.74" N 87°6'52.3" E	Near Akhrasol	Flow	11.62	0.01369	0.15	1.098748012	0.01504186	12.5	considering Trapezoidal ( with 48° side slope)
25	22°24'45.68"N 87° 7'37.68"E	Near Jaypur or Sardiha Rail Station ( <b>Kaalazeera Nadi</b> )	Flow	36.95	0.145	0.18	2.274463954	0.329001211	13.3	considering Trapezoidal ( with 37° side slope)
26	22°24'39.59"N 87°14'23.40"E	Kankabati	Flow	28	0.0429	0.18	2.138853568	0.091756818	15.6	considering Trapezoidal ( with 53° side slope)
27	22°24'19.83"N 87°16'13.99"E	Kenduapal	Clogged							
28	22°24'43.41"N 87°17'40.21"E	Narampur	Clogged							
29	22°31'16.27"N 87° 3'0.36"E	Nischitpur, Barakala	Flow	8.83	0.0134	0.3	0.837268469	0.011219397	25	considering Trapezoidal ( with 53° side slope)
30	22°23'29.37"N 87°19'26.33"E	Keshpal Kangsabati river station	Clogged							

31	22°25'1.32"N 87°10'14.52"E	Farid Chak	Flow	17	0.0635	0.1	0.895778678	0.056881946	34.6	considering Trapezoidal ( with 55° side slope)
32	22°25'48.7" N 87°12'22.04" E	Near Gurguripal Eco Park	Flow	10	0.0894	0.16	0.160998782	0.014393291	9.96	considering Trapezoidal ( with 59° side slope)

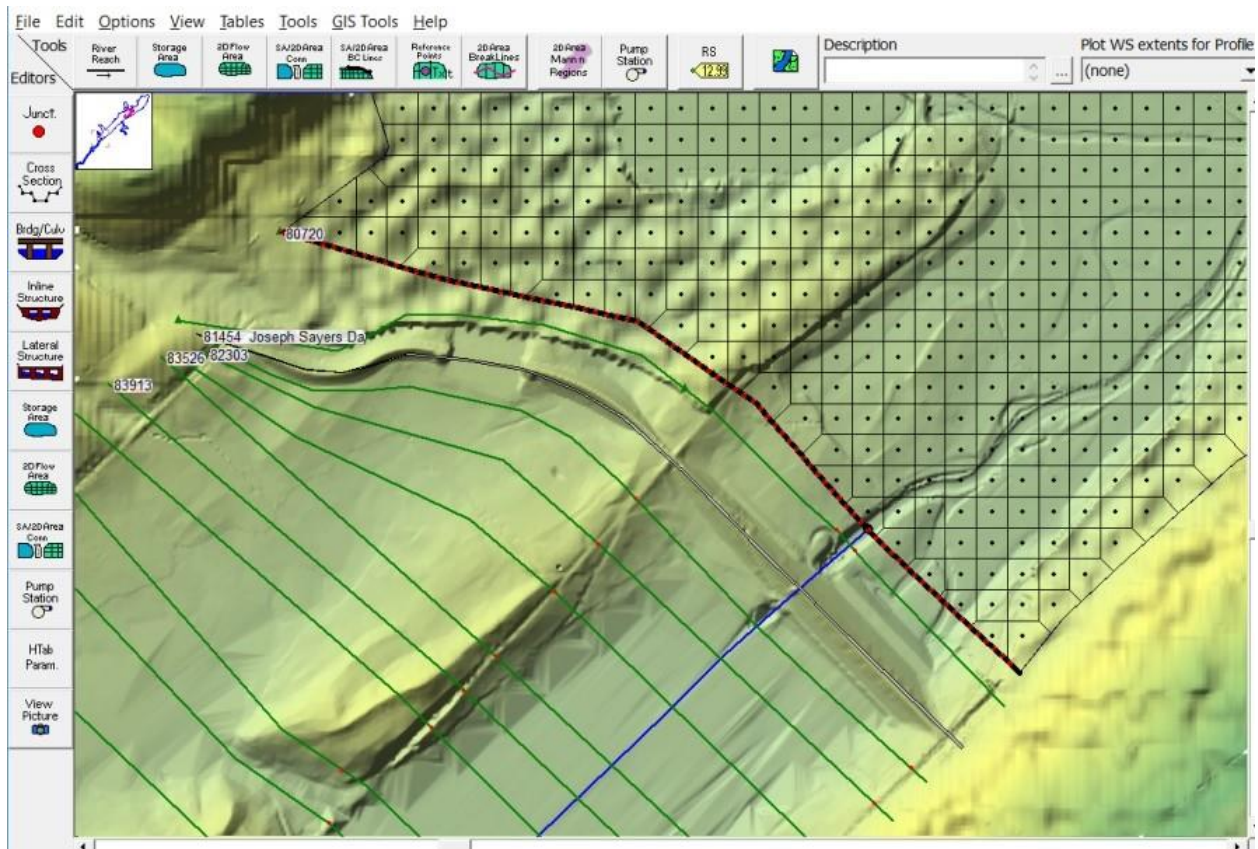
The 1D-2D coupled hydrodynamic model shows river flow and storage inundation in the Kangsabati River along the Jhargram-Medinipur area. The whole model is based on lean period data to facilitate the discussion, i.e., 23<sup>rd</sup> April, 2022 to 22<sup>nd</sup> May, 2022 is calculated. When creating cross-sections for 1D flow, Manning's n value is taken to justify the vegetation and land use character. Manning's value for left overbank, channel, and right over bank is 0.035, 0.040 and, 0.035 respectively. The value of manning has been taken to be 0.050 as 2D regions are prone to agriculture and rice production. However, this value is different in urban and residential areas.

## **6.2 1D Flow Model**

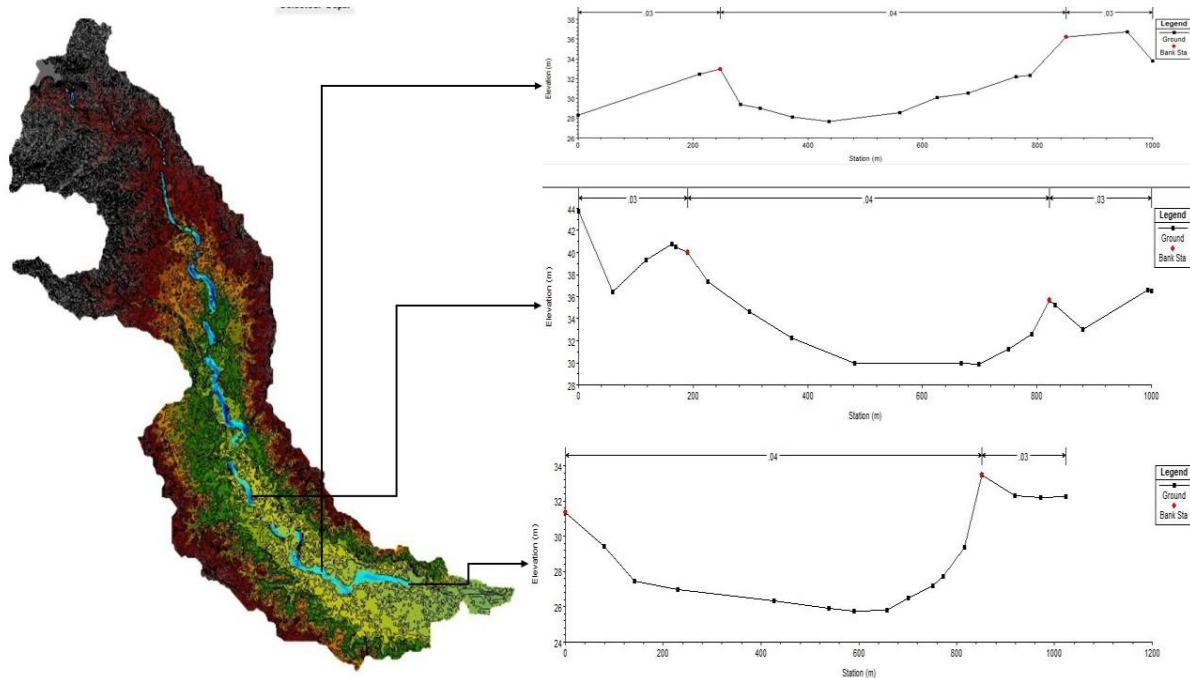
The 1D-2D coupled hydrodynamic HEC-RAS model is calibrated based on four factors - water level, water surface elevation, velocity and depth. In addition, since the model is based on seasonal changes, the model is calibrated and validated based on statistical analysis and data obtained from pre, post and during the monsoon. However, there is not much difference between the performance of the HEC-RAS model on the observed and simulated data. Actually, based on 1D flow model, some CS areas have been analyzed both on inlets and Main River itself. The CS area on inlets is very crippled and undulating in nature and they are wetted mainly due to rain. After a splash of rainfall, all the inlet's water flows towards main channel and fed the river. The CS portion of Main River is changed in some portions, after getting discharged from inlets. The change is observed mainly due to entrainment of sand load from bed. In the **Fig. 10**, the CS area of Tarafeni River is compared with before and after entering with the main river. The water level of the main river has increased after getting water from the Tarafeni River. It proves that upper basin of Kangsabati river is getting discharged from inlets in lean period. In HEC-RAS 1D flow model, all CS are tangentially arranged over the river bed and joined with particular CS before entering in Anicut or storage area. The average width of the CS is 100 m and varies with normal river bed. The gap between each is CS in HEC-RAS model ranges from 1.5 to 2 km (Fig). Except that, In lean period, the water flows in specific direction. The flow of river changes with CS in particular direction of the river flow.



**Fig. 6.2** Water level with CS changes in Tarafeni-Kangsabati off take point



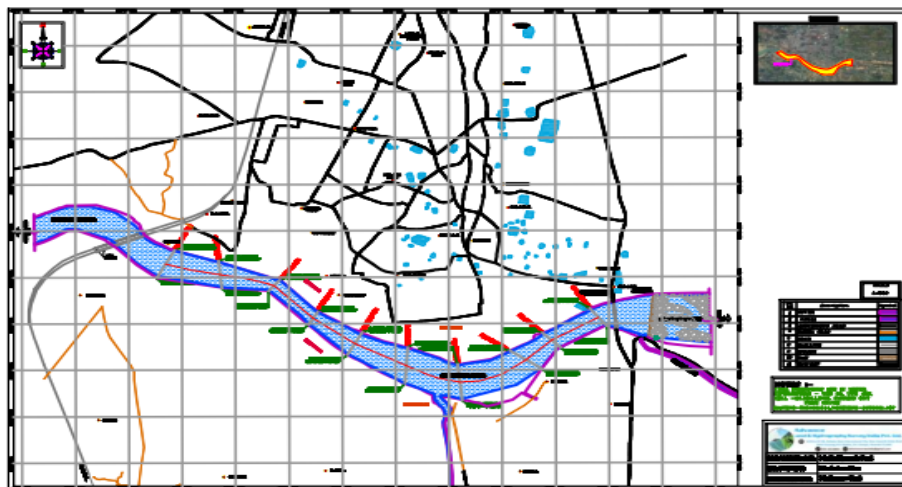
**Fig. 6.3** Arrangement of CS with 2D Anicut area



**Fig. 6.4 CS on river flow after HEC-RAS calibration**

### 6.3 2D Anicut Storage area

The anicut region is measured by bathymetric survey first. The ADCP survey is conducted in the region with proportional gap and a particular RL (23 m). The map shows the proper position of the CS in anicut and after that all the report (Velocity-Discharge graph and CS) generated from the survey is presented here.



**FIG: 6.5. TOPOGRAPHICAL PLAN OF MEDINIPUR**

### 6.3.1 CROSS SECTION AND DISCHARGE SHEET OF KANGSABATI RIVER

#### 1. CROSS SECTIONAL PLAN OF CS-1:-

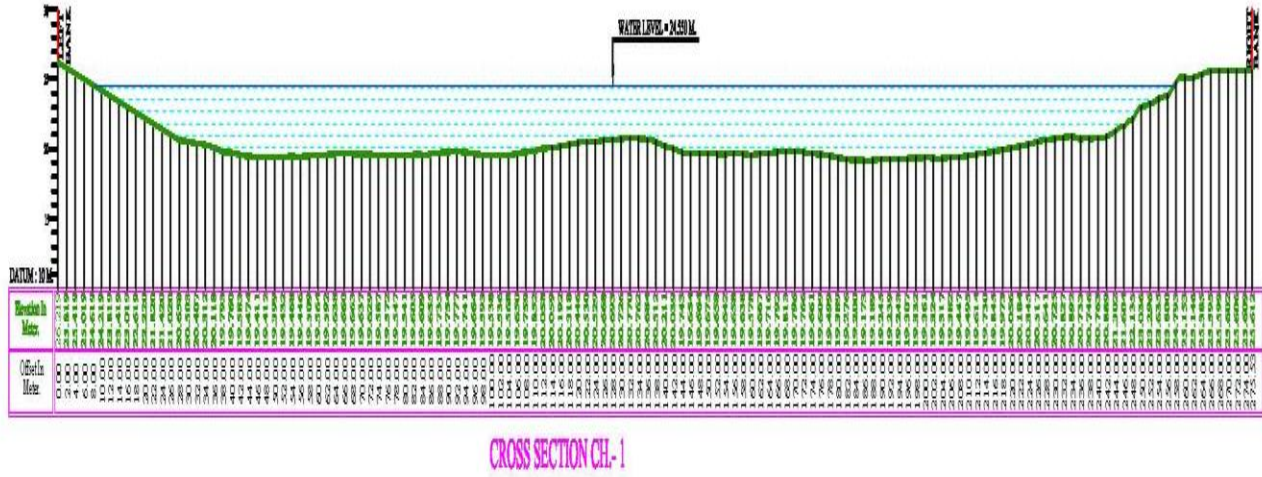


Fig. 6.6 shows the cross-section 1

## 1.1 Discharge Summary Report of CS-1:-

Station Number: 17.04.22medinipore						Meas. No: 0												
Station Name: 1						Date: 04/17/2022												
Party:		Width: 222.8 m				Processed by:												
Boat/Motor:		Area: 1016.1 m <sup>2</sup>				Mean Velocity: -0.010 m/s												
Gage Height: 0.000 m		G.H.Change: 0.000 m				Discharge: -9.64 m <sup>3</sup> /s												
Area Method: Avg. Course		ADCP Depth: 0.000 m				Index Vel.: 0.00 m/s		Rating No.: 1										
Nav. Method: Bottom Track		Shore Ens.:10				Adj. Mean Vel: 0.00 m/s		Qm Rating: U										
MagVar Method: None (0.0°)		Bottom Est: Power (0.1667)				Rated Area: 0.000 m <sup>2</sup>		Diff.: 0.000%										
Depth: Composite (BT)		Top Est: Power (0.1667)				Control1: Unspecified												
Discharge Method: None						Control2: Unspecified												
% Correction: 0.00						Control3: Unspecified												
Screening Thresholds:						ADCP:												
BT 3-Beam Solution: YES		Max. Vel.: 2.34 m/s				Type/Freq.: RiverRay / 600 kHz												
WT 3-Beam Solution: YES		Max. Depth: 5.51 m				Serial #: 10209		Firmware: 44.24										
BT Error Vel.: 1.00 m/s		Mean Depth: 4.56 m				Bin Size: 20 cm		Blank: 16 cm										
WT Error Vel.: 10.00 m/s		% Meas.: 71.81				BT Mode: Auto		BT Pings: Dyn										
BT Up Vel.: 10.00 m/s		Water Temp.: None				WT Mode: Auto		WT Pings: Dyn										
WT Up Vel.: 10.00 m/s		ADCP Temp.: 32.2 °C				WZ : 5												
Use Weighted Mean Depth: YES																		
Performed Diag. Test: NO						Project Name: 17.04.22medinipore_0.mmt												
Performed Moving Bed Test: NO						Software: 2.18												
Performed Compass Calibration: NO Evaluation: NO																		
Meas. Location:																		
Tr.#	Edge Distance		#Ens.	Discharge						Width	Area	Time		Mean Vel.		% Bad		
	L	R		Top	Middle	Bottom	Left	Right	Total			Start	End	Boat	Water	Ens.	Bins	
000	L	0.00	0.00	166	-0.357	-5.45	-1.67	0.000	0.000	-7.48	221.6	1014.4	00:44	00:47	1.37	-0.01	15	3
001	R	0.00	0.00	159	-0.606	-8.39	-2.80	0.000	0.000	-11.8	224.0	1017.9	00:49	00:51	1.45	-0.01	2	0
<b>Mean</b>		0.00	0.00	162	-0.482	-6.92	-2.24	0.000	0.000	-9.64	222.8	1016.1	<b>Total</b>	00:06	1.41	-0.01	8	1
<b>SDev</b>		0.00	0.00	5	0.176	2.08	0.803	0.000	0.000	3.06	1.6	2.5			0.06	0.00		
<b>SD/M</b>		0.00	0.00	0.03	0.37	0.30	0.36	0.00	0.00	0.32	0.01	0.00			0.04	0.37		
<b>Remarks:</b>																		

## 2. CROSS SECTIONAL PLAN OF CS-2:-

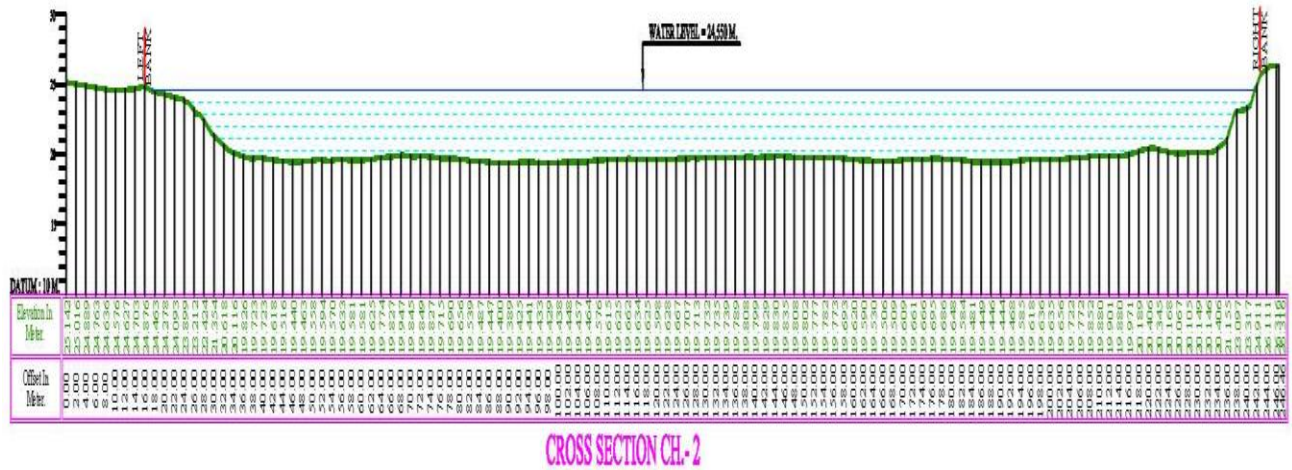
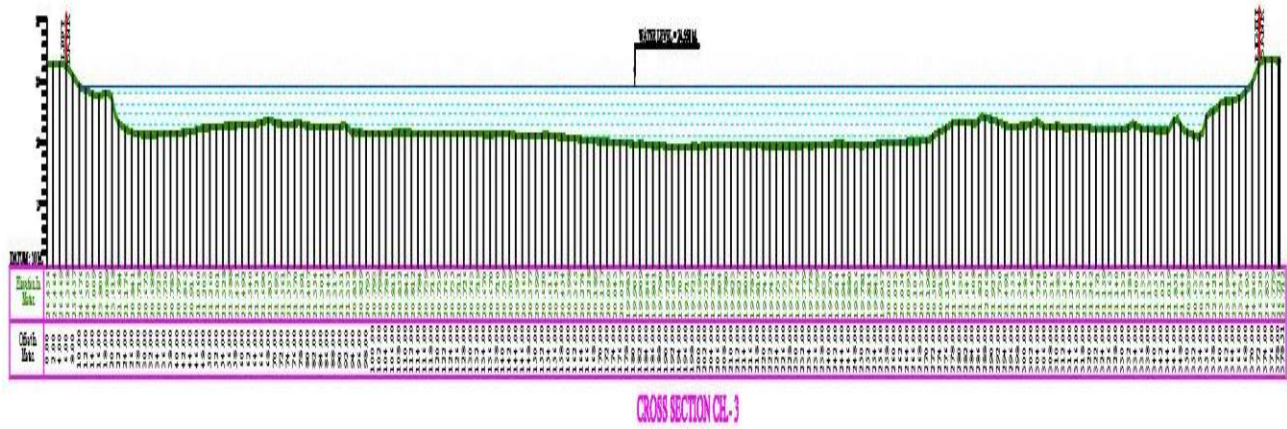


Fig. 6.7 shows the cross-section 2

## 2.1 Discharge Summary Report of CS-2:-

Station Number: 17.04.22medinipore										Meas. No: 0								
Station Name: 1										Date: 04/17/2022								
Party:			Width: 206.0 m				Processed by:											
Boat/Motor:			Area: 960.3 m <sup>2</sup>				Mean Velocity: 0.004 m/s											
Gage Height: 0.000 m			G.H.Change: 0.000 m				Discharge: 3.64 m <sup>3</sup> /s											
Area Method: Avg. Course			ADCP Depth: 0.000 m				Index Vel.: 0.00 m/s		Rating No.: 1									
Nav. Method: Bottom Track			Shore Ens.: 10				Adj. Mean Vel: 0.00 m/s		Qm Rating: U									
MagVar Method: None (0.0°)			Bottom Est: Power (0.1667)				Rated Area: 0.000 m <sup>2</sup>		Diff.: 0.000%									
Depth: Composite (BT)			Top Est: Power (0.1667)				Control1: Unspecified		Control2: Unspecified		Control3: Unspecified							
Discharge Method: None																		
% Correction: 0.00																		
Screening Thresholds:					ADCP:													
BT 3-Beam Solution: YES					Max. Vel.: 1.10 m/s					Type/Freq.: RiverRay / 600 kHz								
WT 3-Beam Solution: YES					Max. Depth: 5.16 m					Serial #: 10209		Firmware: 44.24						
BT Error Vel.: 1.00 m/s					Mean Depth: 4.66 m					Bin Size: 10 cm		Blank: 16 cm						
WT Error Vel.: 10.00 m/s					% Meas.: 78.60					BT Mode: Auto		BT Pings: Dyn						
BT Up Vel.: 10.00 m/s					Water Temp.: None					WT Mode: Auto		WT Pings: Dyn						
WT Up Vel.: 10.00 m/s					ADCP Temp.: 32.3 °C					WZ : 5								
Use Weighted Mean Depth: YES																		
Performed Diag. Test: NO										Project Name: 17.04.22medinipore_0.mmt								
Performed Moving Bed Test: NO										Software: 2.18								
Performed Compass Calibration: NO Evaluation: NO																		
Meas. Location:																		
Tr.#	Edge Distance		#Ens.	Discharge						Width	Area	Time		Mean Vel.		% Bad		
	L	R		Top	Middle	Bottom	Left	Right	Total			Start	End	Boat	Water	Ens.	Bins	
002	L	0.00	0.00	190	0.017	2.86	0.762	0.000	0.000	3.64	206.0	960.3	01:02	01:05	1.37	0.00	3	1
<b>Mean</b>		0.00	0.00	190	0.017	2.86	0.762	0.000	0.000	3.64	206.0	960.3	<b>Total</b>	00:03	1.37	0.00	3	1
<b>SDev</b>																		
<b>SD/M</b>																		
<b>Remarks:</b>																		

### 3. CROSS SECTIONAL PLAN OF CS-3:-



**Fig. 6.8** shows the cross-section 3

### 3.1 Discharge Summary Report of CS-3:-

Station Number: 17.04.22medinipore						Meas. No.: 0												
Station Name: 1						Date: 04/17/2022												
Party:			Width: 175.4 m			Processed by:												
Boat/Motor:			Area: 656.1 m <sup>2</sup>			Mean Velocity: 0.034 m/s												
Gage Height: 0.000 m			G.H.Change: 0.000 m			Discharge: 0.016 m <sup>3</sup> /s												
Area Method: Avg. Course				ADCP Depth: 0.000 m				Index Vel.: 0.00 m/s		Rating No.: 1								
Nav. Method: Bottom Track				Shore Ens.:10				Adj. Mean Vel: 0.00 m/s		Qm Rating: U								
MagVar Method: None (0.0°)				Bottom Est: Power (0.1667)				Rated Area: 0.000 m <sup>2</sup>		Diff.: 0.000%								
Depth: Composite (BT)				Top Est: Power (0.1667)				Control1: Unspecified										
Discharge Method: None								Control2: Unspecified										
% Correction: 0.00								Control3: Unspecified										
Screening Thresholds:						ADCP:												
BT 3-Beam Solution: YES			Max. Vel.: 2.84 m/s			Type/Freq.: RiverRay / 600 kHz												
WT 3-Beam Solution: YES			Max. Depth: 4.83 m			Serial #: 10209		Firmware: 44.24										
BT Error Vel.: 1.00 m/s			Mean Depth: 2.09 m			Bin Size: 20 cm		Blank: 16 cm										
WT Error Vel.: 10.00 m/s			% Meas.: 8809.68			BT Mode: Auto		BT Pings: Dyn										
BT Up Vel.: 10.00 m/s			Water Temp.: None			WT Mode: Auto		WT Pings: Dyn										
WT Up Vel.: 10.00 m/s			ADCP Temp.: 32.4 °C			WZ : 5												
Use Weighted Mean Depth: YES																		
Performed Diag. Test: NO						Project Name: 17.04.22medinipore_0.mmt												
Performed Moving Bed Test: NO						Software: 2.18												
Performed Compass Calibration: NO Evaluation: NO																		
Meas. Location:																		
Tr.#	Edge Distance		#Ens.	Discharge						Width	Area	Time		Mean Vel.		% Bad		
	L	R		Top	Middle	Bottom	Left	Right	Total			Start	End	Boat	Water	Ens.	Bins	
003	R	0.00	0.00	219	-0.335	2.73	-2.37	0.000	0.000	0.031	350.7	1312.2	01:13	01:16	1.63	0.00	10	1
004	L	0.00	0.00	16	0.000	0.000	0.000	0.000	0.000	0.001	0.0	0.0	01:18	01:19	0.01	0.07	94	0
<b>Mean</b>		0.00	0.00	117	-0.168	1.37	-1.18	0.000	0.000	0.016	175.4	656.1	<b>Total</b>	00:05	0.82	0.03	52	1
<b>SDev</b>		0.00	0.00	144	0.237	1.93	1.67	0.000	0.000	0.021	248.0	927.8			1.15	0.05		
<b>SD/M</b>		0.00	0.00	1.23	1.41	1.41	1.41	0.00	0.00	1.33	1.41	1.41			1.39	1.41		
<b>Remarks:</b>																		

#### 4. CROSS SECTIONAL PLAN OF CS-4:-

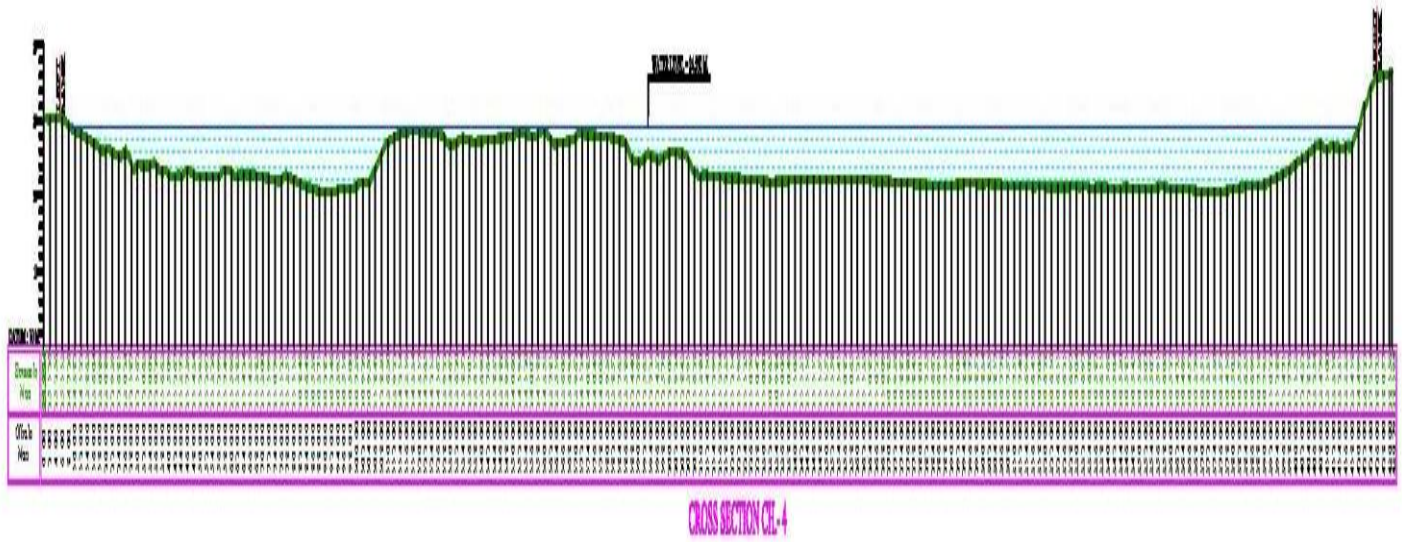


Fig. 6.9 shows the cross-section 4

#### 4.1 Discharge Summary Report of CS-4:-

Station Number: 17.04.22medinipore										Meas. No: 0								
Station Name: 1										Date: 04/17/2022								
Party:				Width: 406.3 m				Processed by:										
Boat/Motor:				Area: 1344.2 m <sup>2</sup>				Mean Velocity: -0.011 m/s										
Gage Height: 0.000 m				G.H.Change: 0.000 m				Discharge: -13.4 m <sup>3</sup> /s										
Area Method: Avg. Course				ADCP Depth: 0.000 m				Index Vel.: 0.00 m/s		Rating No.: 1								
Nav. Method: Bottom Track				Shore Ens.: 10				Adj. Mean Vel: 0.00 m/s		Qm Rating: U								
MagVar Method: None (0.0°)				Bottom Est: Power (0.1667)				Rated Area: 0.000 m <sup>2</sup>		Diff.: 0.000%								
Depth: Composite (BT)				Top Est: Power (0.1667)				Control1: Unspecified										
Discharge Method: None								Control2: Unspecified										
% Correction: 0.00								Control3: Unspecified										
Screening Thresholds:								ADCP:										
BT 3-Beam Solution: YES				Max. Vel.: 2.90 m/s				Type/Freq.: RiverRay / 600 kHz										
WT 3-Beam Solution: YES				Max. Depth: 5.33 m				Serial #: 10209		Firmware: 44.24								
BT Error Vel.: 1.00 m/s				Mean Depth: 3.31 m				Bin Size: 20 cm		Blank: 16 cm								
WT Error Vel.: 10.00 m/s				% Meas.: 92.78				BT Mode: Auto		BT Pings: Dyn								
BT Up Vel.: 10.00 m/s				Water Temp.: None				WT Mode: Auto		WT Pings: Dyn								
WT Up Vel.: 10.00 m/s				ADCP Temp.: 32.4 °C				WZ : 5										
Use Weighted Mean Depth: YES																		
Performed Diag. Test: NO										Project Name: 17.04.22medinipore_0.mmt								
Performed Moving Bed Test: NO										Software: 2.18								
Performed Compass Calibration: NO Evaluation: NO																		
Meas. Location:																		
Tr.#	Edge Distance		#Ens.	Discharge						Width	Area	Time		Mean Vel.		% Bad		
	L	R		Top	Middle	Bottom	Left	Right	Total			Start	End	Boat	Water	Ens.	Bins	
005	R	0.00	0.00	270	-1.10	-14.9	-1.79	0.000	0.000	-17.8	399.6	1310.4	01:26	01:31	1.48	-0.01	19	1
006	L	0.00	0.00	206	-0.006	-9.94	0.956	0.000	0.000	-8.99	413.1	1378.0	01:33	01:36	1.89	-0.01	32	1
<b>Mean</b>		0.00	0.00	238	-0.552	-12.4	-0.416	0.000	0.000	-13.4	406.3	1344.2	<b>Total</b>	00:10	1.68	-0.01	25	1
<b>SDev</b>		0.00	0.00	45	0.772	3.51	1.94	0.000	0.000	6.22	9.5	47.8			0.29	0.00		
<b>SD/M</b>		0.00	0.00	0.19	1.40	0.28	4.67	0.00	0.00	0.46	0.02	0.04			0.17	0.47		
<b>Remarks:</b>																		

## 5. CROSS SECTIONAL PLAN OF CS-5:-

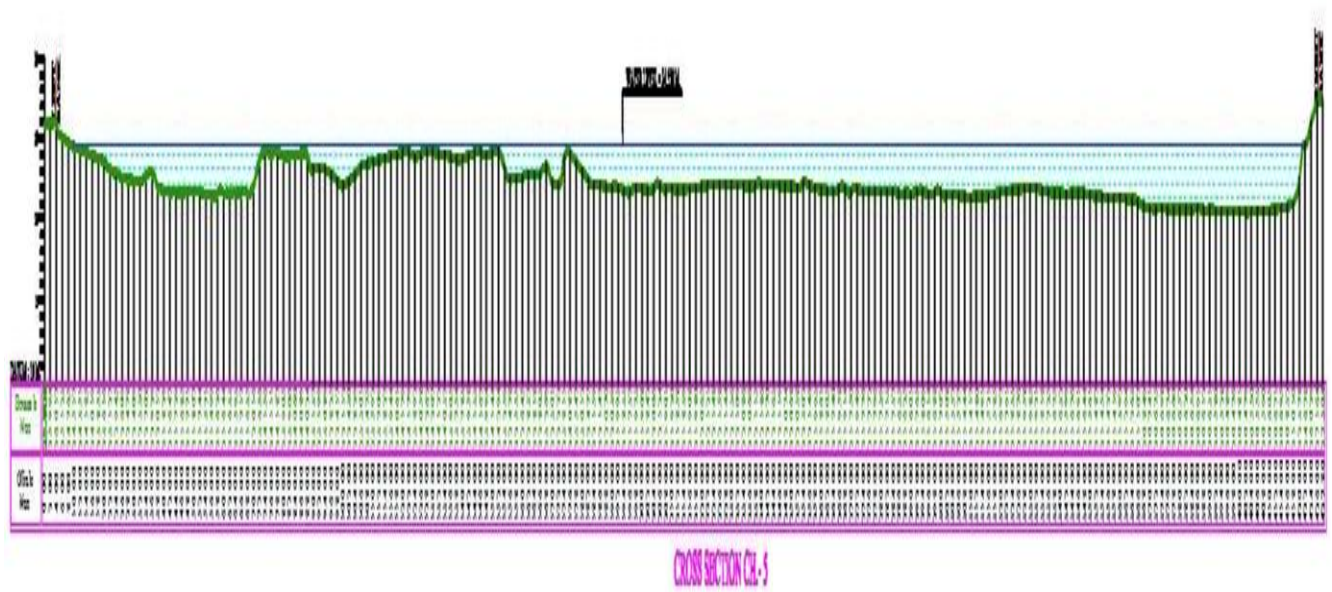


Fig. 6.10 shows the cross-section 5

## 5.1 Discharge Summary Report of CS-5:-

Station Number: 17.04.22medinipore										Meas. No: 0								
Station Name: 1										Date: 04/17/2022								
Party:				Width: 383.9 m				Processed by:										
Boat/Motor:				Area: 1107.9 m <sup>2</sup>				Mean Velocity: 0.001 m/s										
Gage Height: 0.000 m				G.H.Change: 0.000 m				Discharge: 0.220 m <sup>3</sup> /s										
Area Method: Avg. Course				ADCP Depth: 0.000 m				Index Vel.: 0.00 m/s		Rating No.: 1								
Nav. Method: Bottom Track				Shore Ens.: 10				Adj. Mean Vel.: 0.00 m/s		Qm Rating: U								
MagVar Method: None (0.0°)				Bottom Est: Power (0.1667)				Rated Area: 0.000 m <sup>2</sup>		Diff.: 0.000%								
Depth: Composite (BT)				Top Est: Power (0.1667)				Control1: Unspecified										
Discharge Method: None								Control2: Unspecified										
% Correction: 0.00								Control3: Unspecified										
Screening Thresholds:				ADCP:														
BT 3-Beam Solution: YES				Max. Vel.: 2.33 m/s				Type/Freq.: RiverRay / 600 kHz										
WT 3-Beam Solution: YES				Max. Depth: 4.26 m				Serial #: 10209		Firmware: 44.24								
BT Error Vel.: 1.00 m/s				Mean Depth: 2.89 m				Bin Size: 10 cm		Blank: 16 cm								
WT Error Vel.: 10.00 m/s				% Meas.: 0.00				BT Mode: Auto		BT Pings: Dyn								
BT Up Vel.: 10.00 m/s				Water Temp.: None				WT Mode: Auto		WT Pings: Dyn								
WT Up Vel.: 10.00 m/s				ADCP Temp.: 32.6 °C				WZ : 5										
Use Weighted Mean Depth: YES																		
Performed Diag. Test: NO										Project Name: 17.04.22medinipore_0.mmt								
Performed Moving Bed Test: NO										Software: 2.18								
Performed Compass Calibration: NO Evaluation: NO																		
Meas. Location:																		
Tr.#	Edge Distance		#Ens.	Discharge						Width	Area	Time		Mean Vel.		% Bad		
	L	R		Top	Middle	Bottom	Left	Right	Total			Start	End	Boat	Water	Ens.	Bins	
007	R	0.00	0.00	388	0.329	-2.30	-0.433	0.000	0.000	-2.40	385.3	1139.4	01:43	01:50	1.05	-0.00	21	1
008	L	0.00	0.00	235	0.786	-1.10	3.16	0.000	0.000	2.84	382.6	1076.3	01:52	01:56	1.59	0.00	30	2
<b>Mean</b>		0.00	0.00	311	0.558	-1.70	1.36	0.000	0.000	0.220	383.9	1107.9	<b>Total</b>	00:12	1.32	0.00	25	1
<b>SDev</b>		0.00	0.00	108	0.323	0.845	2.54	0.000	0.000	3.70	1.9	44.6			0.38	0.00		
<b>SD/M</b>		0.00	0.00	0.35	0.58	0.50	1.86	0.00	0.00	16.80	0.00	0.04			0.29	7.07		
<b>Remarks:</b>																		

## 6. CROSS SECTIONAL PLAN OF CS-6:-

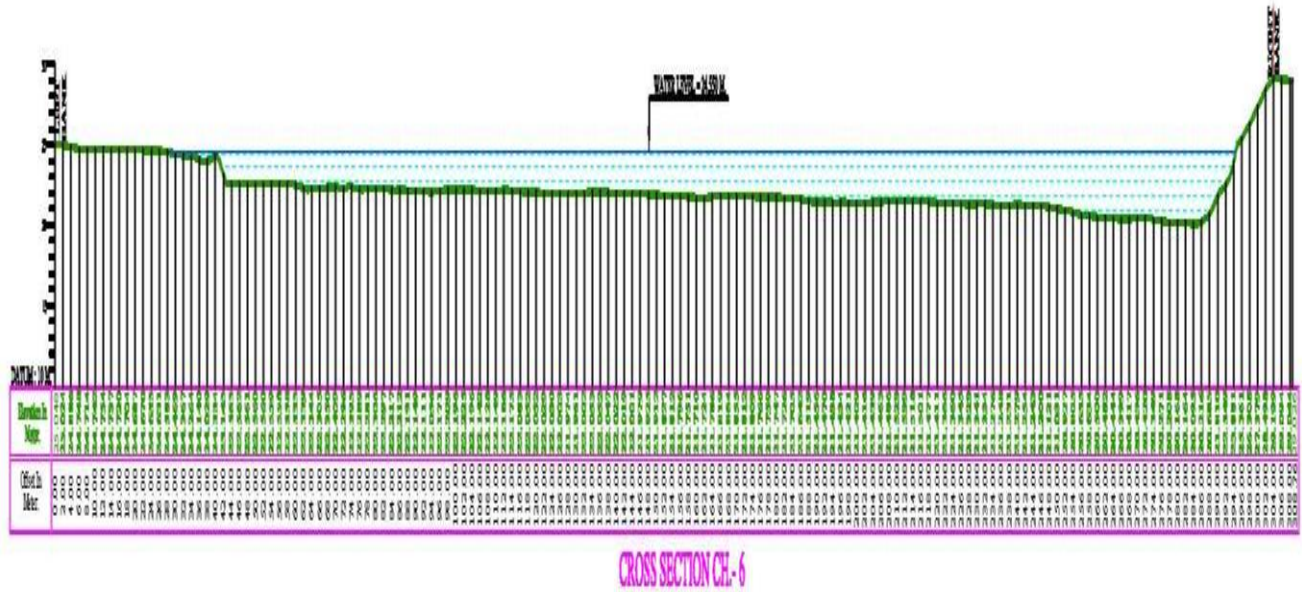


Fig. 6.11 shows the cross-section 6

## 6.1 Discharge Summary Report of CS-6:-

Station Number: 17.04.22medinipore						Meas. No: 0												
Station Name: 1						Date: 04/17/2022												
Party:		Width: 413.1 m				Processed by:												
Boat/Motor:		Area: 1378.0 m <sup>2</sup>				Mean Velocity: -0.007 m/s												
Gage Height: 0.000 m		G.H.Change: 0.000 m				Discharge: -8.99 m <sup>3</sup> /s												
Area Method: Avg. Course		ADCP Depth: 0.000 m				Index Vel.: 0.00 m/s		Rating No.: 1										
Nav. Method: Bottom Track		Shore Ens.:10				Adj. Mean Vel: 0.00 m/s		Qm Rating: U										
MagVar Method: None (0.0°)		Bottom Est: Power (0.1667)				Rated Area: 0.000 m <sup>2</sup>		Diff.: 0.000%										
Depth: Composite (BT)		Top Est: Power (0.1667)				Control1: Unspecified												
Discharge Method: None						Control2: Unspecified												
% Correction: 0.00						Control3: Unspecified												
Screening Thresholds:				ADCP:														
BT 3-Beam Solution: YES				Max. Vel.: 2.49 m/s				Type/Freq.: RiverRay / 600 kHz										
WT 3-Beam Solution: YES				Max. Depth: 4.32 m				Serial #: 10209		Firmware: 44.24								
BT Error Vel.: 1.00 m/s				Mean Depth: 3.34 m				Bin Size: 10 cm		Blank: 16 cm								
WT Error Vel.: 10.00 m/s				% Meas.: 110.56				BT Mode: Auto		BT Pings: Dyn								
BT Up Vel.: 10.00 m/s				Water Temp.: None				WT Mode: Auto		WT Pings: Dyn								
WT Up Vel.: 10.00 m/s				ADCP Temp.: 32.5 °C				WZ : 5										
Use Weighted Mean Depth: YES																		
Performed Diag. Test: NO						Project Name: 17.04.22medinipore_0.mmt												
Performed Moving Bed Test: NO						Software: 2.18												
Performed Compass Calibration: NO Evaluation: NO																		
Meas. Location:																		
Tr.#	Edge Distance		#Ens.	Discharge						Width	Area	Time		Mean Vel.		% Bad		
	L	R		Top	Middle	Bottom	Left	Right	Total			Start	End	Boat	Water	Ens.	Bins	
006	L	0.00	0.00	206	-0.006	-9.94	0.956	0.000	0.000	-8.99	413.1	1378.0	01:33	01:36	1.89	-0.01	32	1
<b>Mean</b>		<b>0.00</b>	<b>0.00</b>	<b>206</b>	<b>-0.006</b>	<b>-9.94</b>	<b>0.956</b>	<b>0.000</b>	<b>0.000</b>	<b>-8.99</b>	<b>413.1</b>	<b>1378.0</b>	<b>Total</b>	<b>00:03</b>	<b>1.89</b>	<b>-0.01</b>	<b>32</b>	<b>1</b>
<b>SDev</b>																		
<b>SD/M</b>																		
<b>Remarks:</b>																		

## 7. CROSS SECTIONAL PLAN OF CS-7:-

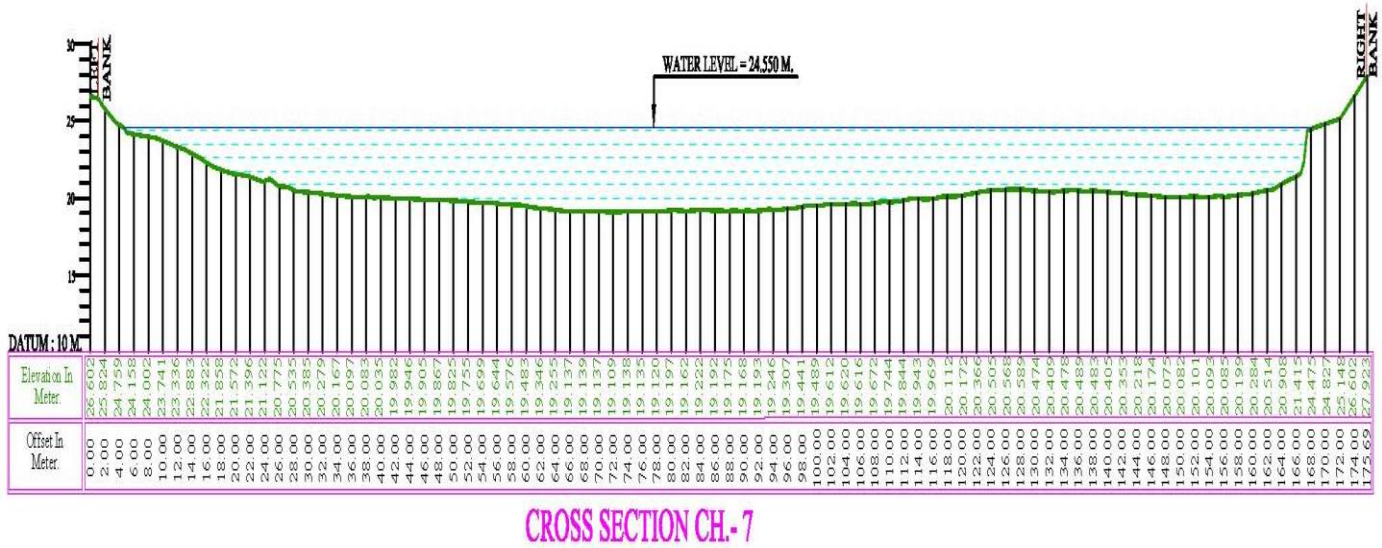


Fig. 6.12 shows the cross-section 7

## 7.1 Discharge Summary Report of CS-7:-

Station Number: 17.04.22medinipore										Meas. No: 0								
Station Name: 1										Date: 04/17/2022								
Party:			Width: 385.3 m				Processed by:											
Boat/Motor:			Area: 1139.4 m <sup>2</sup>				Mean Velocity: -0.002 m/s											
Gage Height: 0.000 m			G.H.Change: 0.000 m				Discharge: -2.40 m <sup>3</sup> /s											
Area Method: Avg. Course			ADCP Depth: 0.000 m				Index Vel.: 0.00 m/s		Rating No.: 1									
Nav. Method: Bottom Track			Shore Ens.: 10				Adj. Mean Vel: 0.00 m/s		Qm Rating: U									
MagVar Method: None (0.0°)			Bottom Est: Power (0.1667)				Rated Area: 0.000 m <sup>2</sup>		Diff.: 0.000%									
Depth: Composite (BT)			Top Est: Power (0.1667)				Control1: Unspecified											
Discharge Method: None							Control2: Unspecified											
% Correction: 0.00							Control3: Unspecified											
Screening Thresholds:					ADCP:													
BT 3-Beam Solution: YES					Max. Vel.: 2.23 m/s					Type/Freq.: RiverRay / 600 kHz								
WT 3-Beam Solution: YES					Max. Depth: 4.26 m					Serial #: 10209		Firmware: 44.24						
BT Error Vel.: 1.00 m/s					Mean Depth: 2.96 m					Bin Size: 10 cm		Blank: 16 cm						
WT Error Vel.: 10.00 m/s					% Meas.: 95.66					BT Mode: Auto		BT Pings: Dyn						
BT Up Vel.: 10.00 m/s					Water Temp.: None					WT Mode: Auto		WT Pings: Dyn						
WT Up Vel.: 10.00 m/s					ADCP Temp.: 32.6 °C					WZ : 5								
Use Weighted Mean Depth: YES																		
Performed Diag. Test: NO										Project Name: 17.04.22medinipore_0.mmt								
Performed Moving Bed Test: NO										Software: 2.18								
Performed Compass Calibration: NO Evaluation: NO																		
Meas. Location:																		
Tr.#	Edge Distance		#Ens.	Discharge						Width	Area	Time		Mean Vel.		% Bad		
	L	R		Top	Middle	Bottom	Left	Right	Total			Start	End	Boat	Water	Ens.	Bins	
007	R	0.00	0.00	388	0.329	-2.30	-0.433	0.000	0.000	-2.40	385.3	1139.4	01:43	01:50	1.05	-0.00	21	1
<b>Mean</b>		0.00	0.00	388	0.329	-2.30	-0.433	0.000	0.000	-2.40	385.3	1139.4	<b>Total</b>	00:06	1.05	-0.00	21	1
<b>SDev</b>																		
<b>SD/M</b>																		
<b>Remarks:</b>																		

### 8. CROSS SECTIONAL PLAN OF CS-8:-

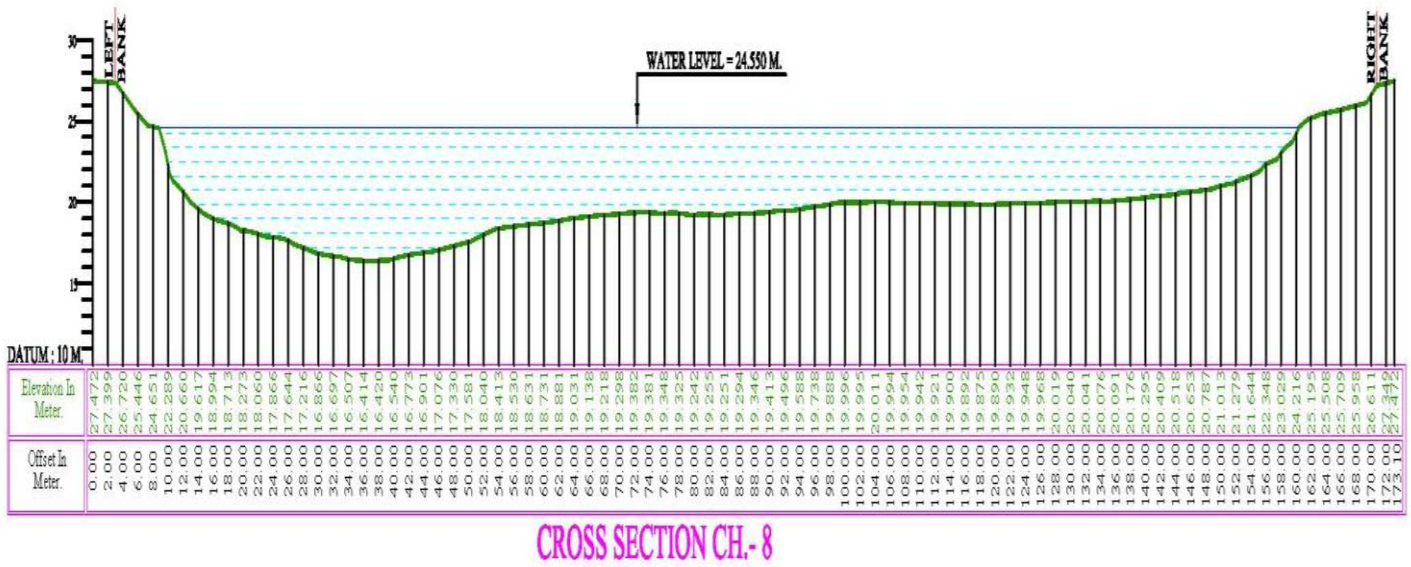


Fig. 6.13 shows the cross-section 8

## 8.1 Discharge Summary Report of CS-8:-

Station Number: 17.04.22medinipore										Meas. No: 0								
Station Name: 1										Date: 04/17/2022								
Party:			Width: 382.6 m				Processed by:											
Boat/Motor:			Area: 1076.3 m <sup>2</sup>				Mean Velocity: 0.003 m/s											
Gage Height: 0.000 m			G.H.Change: 0.000 m				Discharge: 2.84 m <sup>3</sup> /s											
Area Method: Avg. Course			ADCP Depth: 0.000 m				Index Vel.: 0.00 m/s		Rating No.: 1									
Nav. Method: Bottom Track			Shore Ens.:10				Adj. Mean Vel: 0.00 m/s		Qm Rating: U									
MagVar Method: None (0.0°)			Bottom Est: Power (0.1667)				Rated Area: 0.000 m <sup>2</sup>		Diff.: 0.000%									
Depth: Composite (BT)			Top Est: Power (0.1667)				Control1: Unspecified											
Discharge Method: None							Control2: Unspecified											
% Correction: 0.00							Control3: Unspecified											
Screening Thresholds:					ADCP:													
BT 3-Beam Solution: YES					Max. Vel.: 2.33 m/s													
WT 3-Beam Solution: YES					Max. Depth: 4.05 m													
BT Error Vel.: 1.00 m/s					Mean Depth: 2.81 m													
WT Error Vel.: 10.00 m/s					% Meas.: 0.00													
BT Up Vel.: 10.00 m/s					Water Temp.: None													
WT Up Vel.: 10.00 m/s					ADCP Temp.: 32.6 °C													
Use Weighted Mean Depth: YES					Type/Freq.: RiverRay / 600 kHz													
					Serial #: 10209      Firmware: 44.24													
					Bin Size: 10 cm      Blank: 16 cm													
					BT Mode: Auto      BT Pings: Dyn													
					WT Mode: Auto      WT Pings: Dyn													
					WZ : 5													
Performed Diag. Test: NO										Project Name: 17.04.22medinipore_0.mmt								
Performed Moving Bed Test: NO										Software: 2.18								
Performed Compass Calibration: NO    Evaluation: NO																		
Meas. Location:																		
Tr.#	Edge Distance		#Ens.	Discharge						Width	Area	Time		Mean Vel.		% Bad		
	L	R		Top	Middle	Bottom	Left	Right	Total			Start	End	Boat	Water	Ens.	Bins	
008	L	0.00	0.00	235	0.786	-1.10	3.16	0.000	0.000	2.84	382.6	1076.3	01:52	01:56	1.59	0.00	30	2
<b>Mean</b>		0.00	0.00	235	0.786	-1.10	3.16	0.000	0.000	2.84	382.6	1076.3	<b>Total</b>	00:04	1.59	0.00	30	2
<b>SDev</b>																		
<b>SD/M</b>																		
<b>Remarks:</b>																		

## 9. CROSS SECTIONAL PLAN OF CS-9:-

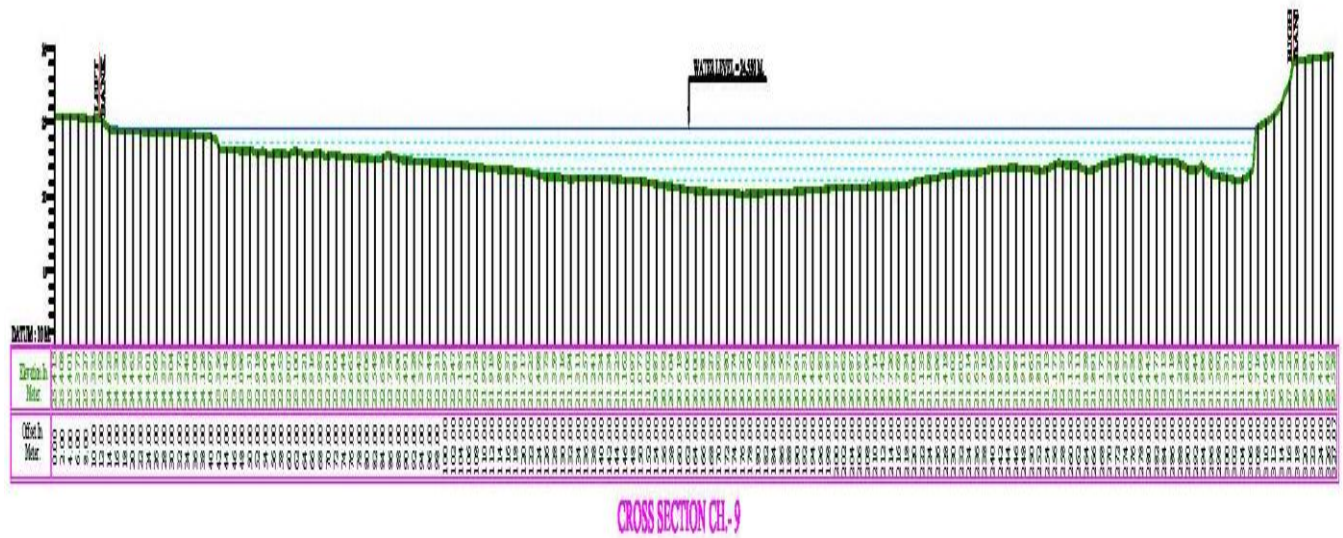


Fig. 6.14 shows the cross-section 9

## 9.1 Discharge Summary Report of CS-9:-

Station Number: 17.04.22medinipore					Meas. No: 0													
Station Name: 1					Date: 04/17/2022													
Party:		Width: 270.9 m			Processed by:													
Boat/Motor:		Area: 740.4 m <sup>2</sup>			Mean Velocity: 0.007 m/s													
Gage Height: 0.000 m		G.H.Change: 0.000 m			Discharge: 5.11 m <sup>3</sup> /s													
Area Method: Avg. Course		ADCP Depth: 0.000 m			Index Vel.: 0.00 m/s		Rating No.: 1											
Nav. Method: Bottom Track		Shore Ens.:10			Adj. Mean Vel: 0.00 m/s		Qm Rating: U											
MagVar Method: None (0.0°)		Bottom Est: Power (0.1667)			Rated Area: 0.000 m <sup>2</sup>		Diff.: 0.000%											
Depth: Composite (BT)		Top Est: Power (0.1667)			Control1: Unspecified													
Discharge Method: None					Control2: Unspecified													
% Correction: 0.00					Control3: Unspecified													
Screening Thresholds:				ADCP:														
BT 3-Beam Solution: YES				Max. Vel.: 2.91 m/s				Type/Freq.: RiverRay / 600 kHz										
WT 3-Beam Solution: YES				Max. Depth: 4.49 m				Serial #: 10209      Firmware: 44.24										
BT Error Vel.: 1.00 m/s				Mean Depth: 2.73 m				Bin Size: 10 cm      Blank: 16 cm										
WT Error Vel.: 10.00 m/s				% Meas.: 31.14				BT Mode: Auto      BT Pings: Dyn										
BT Up Vel.: 10.00 m/s				Water Temp.: None				WT Mode: Auto      WT Pings: Dyn										
WT Up Vel.: 10.00 m/s				ADCP Temp.: 32.8 °C				WZ : 5										
Use Weighted Mean Depth: YES																		
Performed Diag. Test: NO					Project Name: 17.04.22medinipore_0.mmt													
Performed Moving Bed Test: NO					Software: 2.18													
Performed Compass Calibration: NO    Evaluation: NO																		
Meas. Location:																		
Tr.#		Edge Distance		#Ens.	Discharge					Width	Area	Time		Mean Vel.		% Bad		
		L	R		Top	Middle	Bottom	Left	Right			Total	Start	End	Boat	Water	Ens.	Bins
009	R	0.00	0.00	247	0.886	1.59	2.63	0.000	0.000	5.11	270.9	740.4	02:05	02:09	1.26	0.01	21	1
<b>Mean</b>		0.00	0.00	247	0.886	1.59	2.63	0.000	0.000	5.11	270.9	740.4	<b>Total</b>	00:04	1.26	0.01	21	1
<b>SDev</b>																		
<b>SD/M</b>																		
<b>Remarks:</b>																		

## 10. CROSS SECTIONAL PLAN OF CS-10

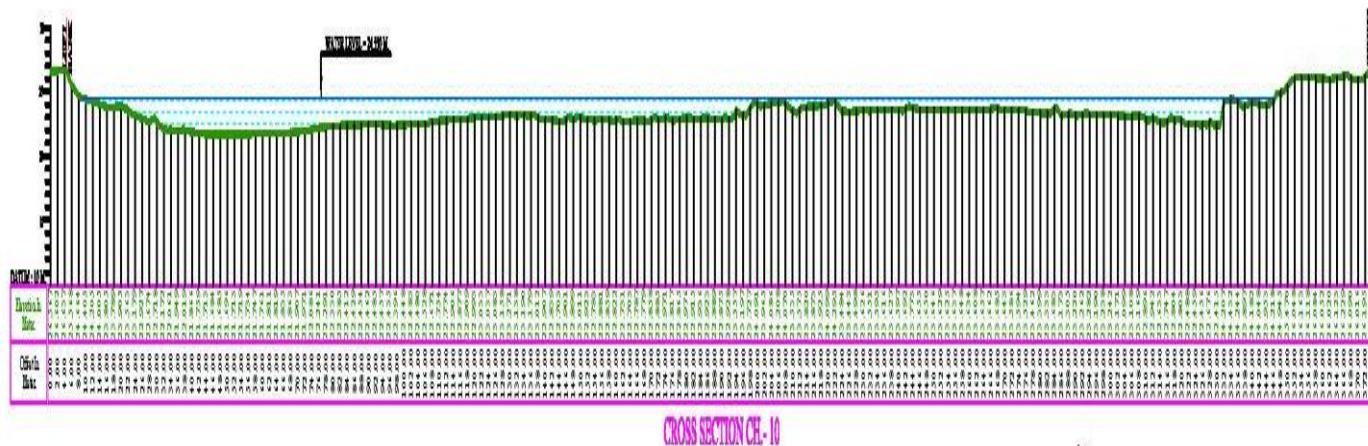


Fig. 6.15 shows the cross-section 10

## 10.1 Discharge Summary Report of CS-10:-

Station Number: 17.04.22medinipore										Meas. No: 0								
Station Name: 1										Date: 04/17/2022								
Party:			Width: 155.9 m				Processed by:											
Boat/Motor:			Area: 695.4 m <sup>2</sup>				Mean Velocity: -0.001 m/s											
Gage Height: 0.000 m			G.H.Change: 0.000 m				Discharge: -0.497 m <sup>3</sup> /s											
Area Method: Avg. Course			ADCP Depth: 0.000 m				Index Vel.: 0.00 m/s		Rating No.: 1									
Nav. Method: Bottom Track			Shore Ens.:10				Adj. Mean Vel: 0.00 m/s		Qm Rating: U									
MagVar Method: None (0.0°)			Bottom Est: Power (0.1667)				Rated Area: 0.000 m <sup>2</sup>		Diff.: 0.000%									
Depth: Composite (BT)			Top Est: Power (0.1667)				Control1: Unspecified											
Discharge Method: None								Control2: Unspecified										
% Correction: 0.00								Control3: Unspecified										
Screening Thresholds:										ADCP:								
BT 3-Beam Solution: YES			Max. Vel.: 1.36 m/s				Type/Freq.: RiverRay / 600 kHz											
WT 3-Beam Solution: YES			Max. Depth: 5.46 m				Serial #: 10209		Firmware: 44.24									
BT Error Vel.: 1.00 m/s			Mean Depth: 4.46 m				Bin Size: 10 cm		Blank: 16 cm									
WT Error Vel.: 10.00 m/s			% Meas.: 30.85				BT Mode: Auto		BT Pings: Dyn									
BT Up Vel.: 10.00 m/s			Water Temp.: None				WT Mode: Auto		WT Pings: Dyn									
WT Up Vel.: 10.00 m/s			ADCP Temp.: 32.6 °C				WZ : 5											
Use Weighted Mean Depth: YES																		
Performed Diag. Test: NO										Project Name: 17.04.22medinipore_0.mmt								
Performed Moving Bed Test: NO										Software: 2.18								
Performed Compass Calibration: NO Evaluation: NO																		
Meas. Location:																		
Tr.#	Edge Distance		#Ens.	Discharge						Width	Area	Time		Mean Vel.		% Bad		
	L	R		Top	Middle	Bottom	Left	Right	Total			Start	End	Boat	Water	Ens.	Bins	
010	L	0.00	0.00	157	-0.108	-0.153	-0.235	0.000	0.000	-0.497	155.9	695.4	02:18	02:21	1.12	-0.00	9	0
<b>Mean</b>		0.00	0.00	157	-0.108	-0.153	-0.235	0.000	0.000	-0.497	155.9	695.4	<b>Total</b>	00:02	1.12	-0.00	9	0
<b>SDev</b>																		
<b>SD/M</b>																		
<b>Remarks:</b>																		

# 11. CROSS SECTIONAL PLAN OF CS-11:-

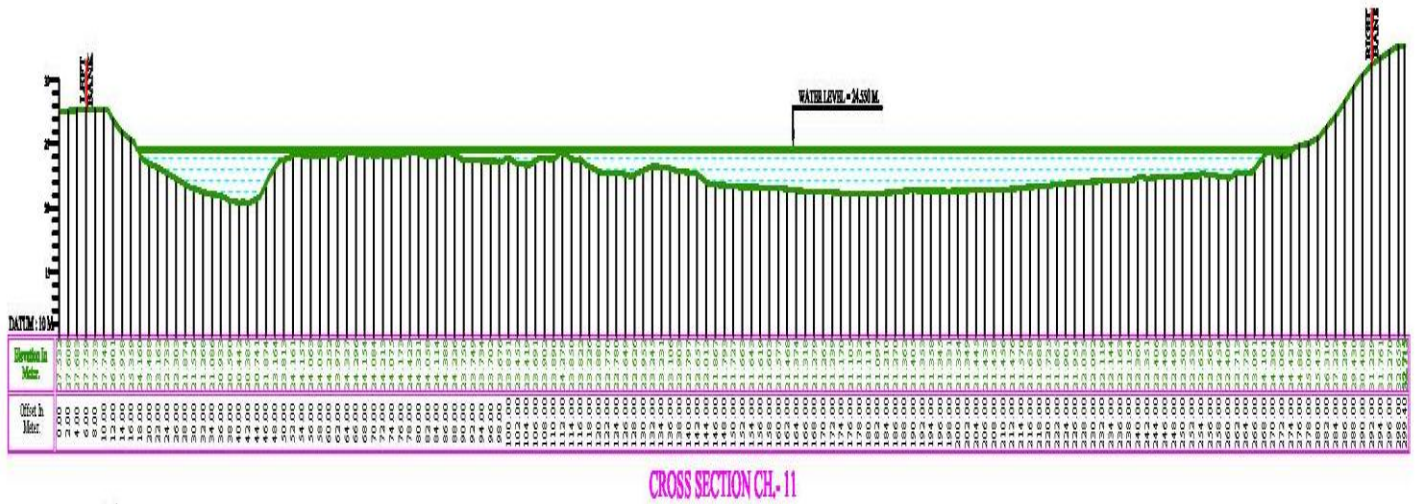


Fig. 6.16 shows the cross-section 11

### 11.1 Discharge Summary Report of CS-11:-

Station Number: 17.04.22medinipore										Meas. No: 0								
Station Name: 1										Date: 04/17/2022								
Party:				Width: 153.4 m				Processed by:										
Boat/Motor:				Area: 820.3 m <sup>2</sup>				Mean Velocity: -0.004 m/s										
Gage Height: 0.000 m				G.H.Change: 0.000 m				Discharge: -3.52 m <sup>3</sup> /s										
Area Method: Avg. Course				ADCP Depth: 0.000 m				Index Vel.: 0.00 m/s		Rating No.: 1								
Nav. Method: Bottom Track				Shore Ens.:10				Adj. Mean Vel: 0.00 m/s		Qm Rating: U								
MagVar Method: None (0.0°)				Bottom Est: Power (0.1667)				Rated Area: 0.000 m <sup>2</sup>		Diff.: 0.000%								
Depth: Composite (BT)				Top Est: Power (0.1667)				Control1: Unspecified										
Discharge Method: None								Control2: Unspecified										
% Correction: 0.00								Control3: Unspecified										
Screening Thresholds:						ADCP:												
BT 3-Beam Solution: YES				Max. Vel.: 1.93 m/s				Type/Freq.: RiverRay / 600 kHz										
WT 3-Beam Solution: YES				Max. Depth: 8.25 m				Serial #: 10209		Firmware: 44.24								
BT Error Vel.: 1.00 m/s				Mean Depth: 5.35 m				Bin Size: 10 cm		Blank: 16 cm								
WT Error Vel.: 10.00 m/s				% Meas.: 75.32				BT Mode: Auto		BT Pings: Dyn								
BT Up Vel.: 10.00 m/s				Water Temp.: None				WT Mode: Auto		WT Pings: Dyn								
WT Up Vel.: 10.00 m/s				ADCP Temp.: 32.7 °C				WZ : 5										
Use Weighted Mean Depth: YES																		
Performed Diag. Test: NO										Project Name: 17.04.22medinipore_0.mmt								
Performed Moving Bed Test: NO										Software: 2.18								
Performed Compass Calibration: NO Evaluation: NO																		
Meas. Location:																		
Tr.#	Edge Distance		#Ens.	Discharge						Width	Area	Time		Mean Vel.		% Bad		
	L	R		Top	Middle	Bottom	Left	Right	Total			Start	End	Boat	Water	Ens.	Bins	
011	R	0.00	0.00	119	-0.232	-2.65	-0.636	0.000	0.000	-3.52	153.4	820.3	04:42	04:44	1.29	-0.00	2	1
<b>Mean</b>		0.00	0.00	119	-0.232	-2.65	-0.636	0.000	0.000	-3.52	153.4	820.3	<b>Total</b>	00:02	1.29	-0.00	2	1
<b>SDev</b>																		
<b>SD/M</b>																		
<b>Remarks:</b>																		



From the bathymetric survey of anicut section, we get the total volume of water stored in the lean period of survey (Table 2). From the tabulated sheet, it is proved that the total volume of anicut is 4736518.369m<sup>3</sup>.

**Table: 6.2 Volume of anicut in Lean period**

C/S NO.	CHAINAGE (m)	C/S AREA (sq.m)	DISTANCE BETWEEN C/S (m)	VOLUME (cu.m)
CS 1	0.000	1075.085	–	0.000
CS 2	527.864	1015.349	527.864	535966.185
CS 3	866.486	1307.639	338.622	442795.333
CS 4	1576.638	1117.826	710.152	793826.370
CS 5	2133.711	956.953	557.073	533092.679
CS 6	2695.138	729.618	561.427	409627.245
CS 7	3197.151	700.704	502.013	351762.517
CS 8	3735.932	791.356	538.781	426367.577
CS 9	4271.375	769.960	535.443	412269.692
CS 10	4815.024	510.745	543.649	277666.009
CS 11	5898.398	510.576	1083.374	553144.763
<b>TOTAL VOLUME</b>				<b>4736518.369</b>

After getting the data from field survey, we calculated the model in HEC-RAS with 1D/2D calibration. From the survey period, per day data is calculated with 1 month volume in per day discharge and storage in 2D. After that, it is calculated as total volume as entered in 2D storage area from river to anicut (**Table 3**). The rainfall has great impact on discharge of the river in this area and calculated graph shows it.

**Table: 6.3 Discharge volumes from River to Anicut**

<b>Date</b>	<b>Rainfall (mm)</b>	<b>Discharge (m<sup>3</sup>/s)</b>
4/23/2022	0	0.770860282
4/24/2022	0	0.770860282
4/25/2022	0	0.770860282
4/26/2022	0	0.770860282
4/27/2022	0	0.770860282
4/28/2022	0	0.770860282
4/29/2022	0	0.770860282
4/30/2022	0	0.770860282
5/1/2022	0.1	0.790510514
5/2/2022	0	0.770860282
5/3/2022	6.8	2.107076023
5/4/2022	1.8	1.124564449
5/5/2022	0.5	0.86911144
5/6/2022	1.5	1.065613755
5/7/2022	1.7	1.104914218
5/8/2022	0	0.770860282
5/9/2022	0.5	0.86911144
5/10/2022	0	0.770860282
5/11/2022	0	0.770860282
5/12/2022	0	0.770860282
5/13/2022	0.3	0.829810977
5/14/2022	0	0.770860282
5/15/2022	0	0.770860282
5/16/2022	0	0.770860282
5/17/2022	7.2	2.185676949
5/18/2022	0.1	0.790510514
5/19/2022	0.6	0.888761671
5/20/2022	0	0.770860282
5/21/2022	0	0.770860282
5/22/2022	0	0.770860282
	<b>Total (m<sup>3</sup>/s)</b>	<b>27.27200731</b>
	<b>Volume (m<sup>3</sup>)</b>	<b>2356301.432</b>
	<b>Monthly volume from Discharge (m<sup>3</sup>)</b>	<b>70689042.95</b>

**Table: 6.4 Calculation of Volume in Lean period (March to May)**

Area	Description	Calculation of Monthly volume in lean period (m <sup>3</sup> )		Water Volume (ML)
River	<b>1 Month Volume for flowing water (I)</b>	70689042.95	70.69×10 <sup>6</sup>	70690
	<b>Evaporation loss (30%) (II)</b>	21206712.89	21.21×10 <sup>6</sup>	21210
	<b>After evaporation loss, total volume (III) = (I)-(II)</b>	49482330.07	49.48×10 <sup>6</sup>	49480
Anicut	<b>Water Storage Capacity</b>	4736518.369	4.74×10 <sup>6</sup>	4740

#### 6.4 Water Sharing among the Stakeholders

Presently, the storage water of Anicut is used for local stakeholders' daily needs or industrial purposes. Kharagpur. The IIT, Kharagpur. The Municipality, Medinipur Municipality and some private industries like Odisha Metallic, Tata Metallic (basically Scrap Iron) are withdrawing water in daily basis. For the calculation we used the river water volume that entered in anicut. Basically, anicut stored water from its establishment, so the capacity of water is usually high there. But we calculated share data based on river discharge entered in anicut (**Table 5**).

**Table: 6.5 Water Sharing Volume**

Stakeholders	Water Withdrawal Per Day(ML/Day)	Water Withdrawal Per Month (ML/Month)
<b>IIT Kharagpur Campus</b>	6.05	181.5
<b>KGP Municipality</b>	56	1680
<b>Midnapore Municipality</b>	25.2	756
<b>Different types of Industries</b>	39	1170
<b>Total Per Day Volume (I)</b>	126.25	3787.5
<b>Unauthorized Withdrawal (UW) (30%)</b>	37.875	1136.25
<b>(I)+(IV)</b>	164.125	4923.75

**Table: 6.6 Distribution of Water as per requirement**

Description	Water volume of river (ML)	Water volume withdrawal by Stakeholder (ML)	Residual Volume of Water (ML)
Per Day	1649.33	164.125	1485.205
Per Month	49480	4923.75	44556.25

**Table: 6.7 Distribution of Water among Stakeholders**

Name of Town/ Industries	Population in 2011	Population Expected in 2021	Water Withdrawal in 2021 (ML/ Months)	Expected in 2026	Water Withdrawal in 2026 (ML/ Months)	Population Expected in 2031	Water Withdrawal in 2031 (ML/Months)
<b>KGP Municipality</b>	293719.00	414790.00	1679.90	502634.00	2035.67	585765.00	2372.35
<b>MDN Municipality</b>	169264.00	186830.00	756.66	195478.00	791.69	206220.00	835.19
<b>IIT KGP</b>	40741.00	44815.00	181.50	47852.00	193.80	49296.00	199.65
<b>Total</b>		<b>646435.00</b>	<b>2618.06</b>	<b>745964.00</b>	<b>3021.15</b>	<b>841281.00</b>	<b>3407.19</b>
<b>Industrial Use</b>			1170.00		1345.50		1521.00
<b>Net Total</b>			<b>3788.06</b>		<b>4366.65</b>		<b>4928.19</b>
<b>UW</b>			1136.42		1310.00		1478.46
<b>Gross-Total</b>			<b>4924.48</b>		<b>5676.65</b>		<b>6406.64</b>

The population is expected based on some calculation in terms of 2021 and 2031. The present population is calculated on 2011's census. The rapid growth of the population measured by population growth analysis. The following calculation proves the expected population on 2011's data,

$$P_n = P_o (1+r/100)^n \quad (23)$$

Where,  $P_o$  is the last year population,  $r$  is the per decade % increase in population,  $P_n$  is the  $P_{2021}$ ,  $P_{2031}$ ,  $P_{2041}$   $n = [(2021-2011)/10] = 10/10 = 1$ . In case of river discharge, the expected value of discharge calculated with the EPR model, the calculation is discussed earlier in this report. The discharge of river in future will decreased due to some climatological factors and decrease in

rainfall. From this equation, the value of expected discharge is analyzed with the expected volume of requirement,

**Table: 6.8 Comparing River Volume with Withdrawal**

<b>Year</b>	<b>Water volume of river (ML/month)</b>	<b>Water volume withdrawal by Stakeholder (ML/month)</b>	<b>Residual Volume of Water (ML/month)</b>
<b>2021</b>	49480	4924.48	44555.52
<b>2026</b>	42058	5676.65	36381.35
<b>2031</b>	35749.3	6406.64	29342.66

## CHAPTER 7

### CONCLUSION

- ❖ Rivers in a plateau region are rich in rainwater for most of the year. Because the source of all these rivers has been unused for a long time, it gradually becomes interesting. Rainfall and water from various small inlets keep these rivers alive.
- ❖ The Kangsabati River, which flows through West Midnapore and Bankura districts, naturally maintains its flow through rain and inlet water. However, over time, settlements along the Kangsabati River have expanded, and water is pumped daily from the river to maintain their day-to-day operations. An anicut dam with an area of 190 ha has been constructed near Medinipur town keeping in view the needs of the people. But now, it is possible to determine the amount of river discharge, keeping in mind the growing population and industrial demand. Although there is no water problem in the region during the monsoon season, the problem increases during the lean period.
- ❖ As a result, measuring the amount of water coming from the river instead of the water stored in the Anicut area gives a good idea of the actual water presence and distribution. Although all the data has been surveyed according to the project from 24th April to 22nd May, we have made all the calculations here by calculating the period from March to May as the lean period.
- ❖ According to the survey, the main flow of the Kangsabati River in the lean period depends on the flow of small tributaries like Tarafeni, Kaalazeera etc. and small inlets coming from the surrounding area. Although the flow of the two tributaries mentioned earlier is constant throughout the year, the flow of inlets is dependent on rainwater. Therefore, when it rains during the lean period, river flow increases by 85%.
- ❖ The flow of the main river is not very visible without an inlet. Measurement of 1D flow along a specific direction along the Kangsabati River and the measurement of two-

dimensional storage in the anicut region of that flow is illustrated in the HEC-RAS 1D / 2D coupled model. The total measurement of river flow along the one-month survey period of the lean period is 70690 ML. During this one month, the amount of water extracted from the river stood at 4924.48 ML. It means that there is enough water in the river to maintain the water supply even if water is pumped during the lean period.

- ❖ Based on the above calculations, water extraction, water use and river discharge are based on the population of 2026 and 2031. Based on population growth, water extraction and use have been highlighted, and it has been observed that water extraction is gradually increasing till 2031. Similarly, the future potential of river discharge has been highlighted through the EPR model and depending on various climatic parameters, and the future water supply has been reduced by about 40%. But the amount of water extraction has increased by more than 25%. In this case, too, it is seen that water abstraction will never overwhelm the water supply in the future, i.e. the water supply is at the right level.
- ❖ It is observed that in the lean period the residual volume of water will decrease day by day. At present, the residual volume of water is 44555.52 ML/month. In the year 2026, the residual volume will be 36381.35 ML/month, and in 2031 it will be 29342.66 ML/month. It is considered that the volume of water present in the Anicut is constant (4740 ML) and the amount of incoming water to the Anicut is equal to the amount of outgoing water from the Anicut.

## **CHAPTER 8**

### **FUTURE SCOPE OF THE STUDY**

In this project, many parameters have been measured to eliminate the water crisis, which has made it possible to eliminate the various water problems, as a result of which the people will benefit to some extent. By studying this subject, it has been learned how much water there is in the river in lean period and how much water demand. We will present the advantages and disadvantages of this project to the government. In the future, more studies will be done on this subject to meet the needs of industry, irrigation and water in people's daily life.

## CHAPTER 9

### 9.1 RECOMMENDATION

- ❖ The above project has highlighted several important issues from all angles. The amount of water carried in the Kangsabati River during the lean period is highlighted here, which can meet the local stakeholders' demand. Even if the river discharge decreases due to future climatic conditions, there is expected to be enough water to meet the demand of stakeholders.
- ❖ The HEC-RAS 1D / 2D coupled model highlights the water balance in the 2D anicut storage area. The Tarafeni and Kaalazeera tributaries are primarily responsible for the water supply during the lean period of the Kangsabati River. Government policy needs to be formulated to maintain the flow of these two rivers in the future.
- ❖ There is a need to be vigilant so that water is not pumped excessively and unnecessarily in the future when the amount of discharge is reduced due to climatic conditions.
- ❖ Above all, proper water use according to the river's capacity will make it possible to keep the river and the anicut region alive in the future for an uninterrupted water supply.

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