DETERMINATION OF WATER USE EFFICIENCY OF THE SELECTED CANALS OF BIRINCHIGURI FLOW IRRIGATION PROJECT

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CANDIDATE DECLARATION

(Session: 2021-2023)

I hereby declare that the work presented in the dissertation entitled "Determination of Water use efficiency of the selected canals of Birinchiguri Flow Irrigation project" in the partial fulfillment of the requirement for the award of the degree of Master of Technology in Civil Engineering with specialization in water Resources Engineering submitted in the Department of Civil Engineering, Assam Engineering College, Jalukbari, Guwahati-13, under Assam Science and Technology University, has been carried out by me under the supervision of Dr. Utpal Kumar Misra**,** Professor, Department of Civil Engineering, Assam Engineering College, Guwahati. Whatever I have presented in this report has not been submitted by me for the award of any other degree or diploma.

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CERTIFICATE OF SUPERVISION

This is to certify that the work contained in the dissertation entitled "Determination of Water use efficiency of the selected canals of Birinchiguri Flow Irrigation project" has been carried out by Dipjyoti Baishya, Roll No: 210620061006, a student of M. Tech 4th semester in the Department of Civil Engineering , Assam Engineering College, Guwahati, under my guidance and supervision and submitted in the partial fulfillment of the requirement for the award of degree of Master of Technology in Civil Engineering with specialization in Water Resources Engineering under Assam Science and Technology University.

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ABSTRACT

Water is the most essential commodity for human beings to be alive and so it is very necessary to make proper use of water without wasting it. Irrigation sector is the biggest consumer of water as more than 80% of available water resources in India is being presently utilized for irrigation purposes. However, the average water use efficiency of irrigation projects in the country is assessed to be only of the order of 30 to 35%. In the north eastern region also, performance of the existing irrigation schemes suffer from low water use efficiency, distribution losses, poor operational maintenance and management and non-availability of water in the tail ends. The region has unique geographical, topographical, climatological settings and sociological characteristics, which are also influencing factors of low water use efficiency. Again, water demand for various purposes namely irrigation, drinking, domestic, power, industrial and other uses is increasing day by day leading to severe seasonal stress on water resources in the region. Its scarcity is more pronounced with increasing population and needs. In the present study, the water use efficiency of the Birinchiguri Flow Irrigation Project is calculated as per methodology given in the guidelines for computing the Water Use Efficiency of the Irrigation Projects, Central Water Commission (CWC), February, 2014.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

NOTATIONS AND ABBREVIATIONS

SYMBOLS	DESCRIPTION
BC	Branch canal
CCA	Cultural command area
CWC	Central water Commission
GCA	Gross Command Area
H/W	Head work
MC	Main canal
NIA	Net irrigable area
R&D	Research and Development
WUE	Water use efficiency
Wc	Conveyance efficiency
W_F	On firm application efficiency
W_p	Water use efficiency
%	Percentage

CHAPTER 1

INTRODUCTION

1.1 GENERAL

Irrigation is the essential input for agricultural development in any country, hence it has received due attention in development programme planning. However, the irrigation sector has not produced the intended benefits and has created certain difficulties of a techno-economic, social, and environmental character that must be addressed on a priority basis if the project is to be implemented on a solid foundation while providing results in a timely way. As a result, there is a significant disparity between irrigation potential created and utilised. This serious issue has drawn the attention of water managers, directing them towards the basic goal of improving water use efficiency through various intervention techniques such as modernization and rehabilitation, irrigation network operation and maintenance, and conjunctive irrigation.

Again, due to constant use, irrigation systems suffer from wear and tear, resulting in a number of irrigation projects in the country operating far below their potential, and the performance of existing irrigation systems suffering from low Water Use Efficiency, distribution losses, poor operation, maintenance, and management, and non-availability of water in the tail ends. As a result, it becomes vital to examine the project's efficiency on a regular basis so that appropriate changes may be done to optimize the system's performance for maximum output from the command area.

In the post-independence era, India has commissioned a vast number of irrigation projects to improve agricultural production and economic development. Water resource development requires a large investment, thus the project is expected to provide many benefits in addition to higher crop yield. Evaluation and impact assessment are required to quantify the project's benefits..It evaluates programme costs and benefits in terms of monetary gains, agricultural output, and socio-economic aspects. Evaluation entails scrutinising the programme implementation process to see how far it contributes to the achievement of the specified goals.

1.2 IRRIGATION EFFICIENCY

The efficient use of irrigation water is a goal shared by all users and planners. Even with the best irrigation system, not all of the water applied during irrigation is stored in the root zone. Irrigation Efficiency is defined as the ratio of the amount of water absorbed by the crop to the amount of water supplied through irrigation. The goal of the efficiency idea is to demonstrate when improvements may be made that will result in more efficient irrigation. The following are the various types of irrigation efficiency:

(i) Water use efficiency.
(ii) Water storage efficiency.
(iii) Water distribution efficiency and
(iv) Consumptive use efficiency.

In this report, only the water use efficiency will be determined.

1.3 WATER USE EFFICIENCY

Water use efficiency has been defined in different ways by many hydrologists, agriculturists and engineers. The value of a particular definition depends on the viewpoint of the author and the context of the hydrological boundary used, beneficial use, soil water storage and effective use of rainfall.

The Central Water Commission (CWC), Ministry of Water Resources, Government of India has provided a guideline for computing the Water Use Efficiency of irrigation projects. CWC, vide the Guideline, carries forward the standardization of the definition of the Water Use Efficiency (W_p) which is broadly divided into the following components:

1. Conveyance Efficiency, W_C
2. On Farm Application Efficiency, W_F

The overall Water Use Efficiency of the project is taken as

$$\mathbf{W_P = W_C \times W_F}$$

This "Guideline for computing water use efficiency of irrigation projects" of CWC - 2014, shall be followed in this project to compute the Water Use Efficiency.

1.4 OBJECTIVES

The main objectives of the present study are:

(i) To determine the present Water Use Efficiency of the selected canals of the Birinchiguri Irrigation Project located in the village Birinchi under Chirang district of Assam.
(ii) To determine the Water Use Efficiency after lining of the whole canals.

CHAPTER 2

LITERATURE REVIEW

A lot of researchers have contributed in the study of Water Use Efficiency in the past years. A brief discussion of a few of them is given below.

Anil Kumar Singh and Rajput T.B.S. (2005) mentioned in their article "Optimizing Water Uses and Recharging of Aquifers" that the dominant method of irrigation practiced in the country is flood irrigation, in which the crop utilizes only one-half of the water released and the rest is lost in conveyance, application, runoff and evaporation. Accordingly, the efficiency of surface irrigation methods is low. In the two decades (1970-1990) ground water irrigated area increased by 105%. However, over the same period the area irrigated by surface water increased by 28% only. They concluded that if the number of overexploited blocks continues to grow at the present rate of 5.5% per annum, by 2018 roughly 36% of India's blocks will face serious problems.

Singh K.K. and Ojha C.S.P. (2005) revealed in their article "Improvement in Irrigation Efficiency Using On-Farm Reservoir and its Efficient Operation" that during irrigation of the crops a huge quantity of water is wasted due to poor efficiencies of irrigation systems. This wastage can be minimized by adopting suitable storing of excess water of irrigation in on-farm reservoir (OFR) and later using this water in a specific way. The study suggests that the use of stored water of OFR invariably increases water irrigation efficiency. However, a particular operation procedure of OFR yields maximum water irrigation efficiency. OFR is a ditch of a particular shape provided in the field, which stores agricultural or rainfall runoff water for later use, thus reducing the demand on the basin-wide system in times of need. It is the most useful and powerful on-farm storage system under suitable conditions. Most recently, OFR and its use has been advocated to augment supplemental irrigation for paddy crop particularly in arid areas from the rainfall-harvested water. OFR can also hold nutrient-laden runoff water from field for reuse and also in preventing degradation of river water quality.

Suresh Pal (2006) pointed out in the article "Resource Use Efficiency, Particularly in Irrigated Area" that efficiency of water use has been increased over time but still remains less than 40 per cent. They argued that with the present price policy regime, there are strong incentives for growing rice and wheat and there is little possibility of large-scale diversification to other crops, which require less water and generate higher income. They also felt that mere withdrawal of subsidy on electricity may not shift incentives in favor of diversification of the cropping system. This will require several other measures like effective direct control on the use of water, participation of farmer organizations in water management, and educating farmers about sustainable use of water resources. India can learn from the Australian experience where long-term farm planning based on suitability of land, pricing and control of water, and farmers' participation in water use, input supply and R & D are found to be very successful.

T. Haque (2006) in his research article "Resource Use Efficiency in Agriculture" pointed out that low irrigation charges encourage farmers not to care about water use efficiency and also cause the problem of rapid depletion of ground water in Punjab and Haryana. He also pointed out that one should keep in mind that the availability of good quality of irrigation water, coupled with flexibility of irrigation and drainage system and appropriate methods of application as well as pricing of irrigation water would be crucial for sustainable use of land and water resources.

Narasaiah (2006) in his book "Agriculture and Water Management" investigated in the Tungabhadra Irrigation Scheme and revealed that the tail-end of a majority distributory commanding 25 per cent of the total area, received approximately 20-40 percent of the targeted discharge while the upper reaches got more than their share. Lack of maintenance has caused many systems to fall into disrepair, further inhibiting performance. Over time, distribution canals have become silted up, increasing the likelihood of breaching, damage to outlets and leading to salt build-up in the soil. According to him successful irrigation in the future will be that which supports much higher levels of agricultural productivity enhances responsiveness to more diversified and dynamic crop markets, stimulates more profitable irrigated agriculture for wide numbers of rural poor farmers, substantially improves water use efficiency and supports the sustainable use of scarce land, biomass and water resources.

Sharda, V.N. (2007) highlighted in the article "Managing Natural Resources" that India envisages a growth rate of 4 per cent per annum in the agriculture sector, so as to achieve a target of over 300 million ton of food grain production by the year 2020. Against the targeted production of 230 metric ton for the X Plan, the actual production has never crossed 212.9 metric ton. Gap between the target and actual production is a matter of serious concern as the growth rate of Indian agriculture during the past decade has sharply decelerated from 3.2 per cent per annum during 1980-81 to 1996-97 to an average rate of only 1.5 per cent thereafter against 4 per cent envisaged in the NAP. India has only about 4 per cent of the world's fresh water resources and occupies only 2.42 per cent of its area to meet the ever increasing demand of food grains, fodder, fuel wood and fibre of its growing populations. The net sown area in the past 30 years has remained static between 138 million ha to 142 million ha, and consequently the size of land holdings is continuously reducing. Between 1971-72 and 2002-03, it declined from 2.2 ha to 1.4 ha. The proportion of small holdings (< 2 ha) in the total number of holdings increased from 68 per cent to 86 per cent, which in actual terms has more than doubled from 38 million to 87 million during this period.

John Briscoe and Malik R.P.S. (2007) explained in their paper "Irrigation Water Use Efficiency" that at the planning stage, irrigation efficiency is assumed as 55 to 60 per cent but in actual practice, the efficiencies obtained on the ground are around 30 per cent or even lower. A recent basin-wise study based on potential evapotranspiration and withdrawals for irrigation shows efficiency in the range of 26 to 27 per cent (Krishna, Godavari, Mahanadi, Cauvery), and 43 to 47 per cent (Indus, Ganga) with overall 37.7 per cent for the country as a whole. Irrigation efficiency is low in the country due to a combination of factors like low water tariff, poor state of canal system due to lack of maintenance, absence of rotational supply, and "use it or lose it" implicit right. Unfortunately no scientific study of overall irrigation efficiency in large systems is available.

Bhagirath (2007) pointed out in his article "Year 2007 Declared as Water Year" that at present the per capita storage capacity in India is only about 207 cubic meters as compared to 1111 cubic meters in China. As a result of growing population, the per capita water availability of India is declining every year and as per an estimate, it will be about 1,341 cubic meters by the year 2025 and about 1,140 cubic meters by the year 2050 which is much below the water-stress threshold of 1,700 cubic meters. Therefore, it is necessary to create infrastructures and adopt appropriate management practices to augment the utilizable water resources and improve the efficiency of the created facilities.

Pandey M.P. and Ghosh A. (2008) in their article on "Challenges to the Future of Agriculture-Global Perspective" pointed out that as per the estimation by the Intergovernmental Panel on Climate Change (IPCC), the average temperature would increase by about 0.3^{O}C per decade over the next century. Consequently, level of sea water could rise by at least 2-4 cm per decade. Therefore, impact of global warming on the entire agricultural growth is apprehended to be worse. Water is becoming a looming crisis. By 2025, scarcity of water would threaten 30 per cent of the human population as 70 per cent of water withdrawals are used in irrigated agriculture globally. Africa and Asia has experienced an increasing shortage in per capita water availability. Irrigation demand is expected to increase keeping pace with the need to increase agriculture production. Irrigated agriculture needs to be increased by 23 million hectares, i.e. 19 per cent over and above the area lost under water logging and salinization. The majority of the areas would fall in South Asia. About 35 per cent of the land under assured irrigation is at risk due to poor management. The most basic of human right is the right of food and nutrition. Farmers ensuring proper drainage and irrigation design can promote efficient use of water. Small-Scale Schemes executed by local government could reduce many problems while backed by national policies that effectively support appropriate technologies, credit, marketing, energy supplies and maintenance of equipment by suitable ecology based cropping program therein.

Arvind Panagariya (2008) stated in his book “India: The Emerging Giant” that bigger the farmer, the larger the amount of water and electricity he uses because of free electricity. According to him the subsidies are distortionary because they lead to highly wasteful use of canal water, ecological degradation from water logging, and excessive use of electricity. The fiscal burden created by free water and electricity has led the states to neglect maintenance of electricity lines and canals. In this respect, the subsidies have been a lose-lose proportion. He suggested that from the efficiency and equity viewpoints, it is desirable to charge farmers for the electricity they use.

Hanumantha Rao C.H. (2008) in his article “Wastages and Inefficiencies in Water Use” pointed out that because of absence of financial accountability on the part of the project authorities and the low rates charged for water, there is a lot of wastage of water and inefficiency in water use. In this context, he quotes a study by Veeraiah and Madankumar which says that out of the water entering upper Ganga Canal, as much as 44 per cent was lost in canal, in distributaries and in village water courses. Of the remaining 56 per cent actually entering the fields, the farmers wasted another 27 per cent in excessive irrigation and thus the water actually used by crops was only 29 per cent. As against this, in the advanced systems of the West as much as 60-70 per cent of the water diverted in large surface system is available for plant use. Another problem is that because of under pricing of surface water, the farmers at the head reaches water their fields intensively, leaving the tail-end farmers with sparse supplies.

Smajstrla et al. (2010) had studied "Efficiencies of Florida Agricultural Irrigation System" pointed out that in Florida seepage losses from reservoirs is the major cause of low Reservoirs storage efficiency. They suggested that seepage losses may be reduced by lining reservoirs with impermeable soils (typically clays) or manmade liners such as plastic sheets, metal, plastic or fiber glass and tanks may be used as reservoirs to eliminate seepage losses. Transpiration losses from reservoirs occur as a result of vegetation growth in and around the reservoir.

N. Bashkaran (2010) in his report on "Lining of Canals can Improve Irrigation Efficiency by over 15 per cent" stated that only around 53 per cent of the water from head reservoirs actually reach farmers' fields the rest represents losses during transit due to percolation and evaporation. He suggested that Plastic or concrete lining of canals can reduce water seepage and percolation losses by 15 per cent or more, thereby significantly improving irrigation efficiency levels. For example Mr. Appalwar's company undertook a study on the Goki Project in the Vidarbha region in collaboration with the Yavatmal Irrigation Division. The study revealed water savings of over 15 per cent arising from lining the distribution canals with woven polypropylene sheets.

Sachin Shah (2012), in "Institutional Reform for Water Use Efficiency in Agriculture" came to the following conclusions:

- The application of hydrologic indicators across regions provides beneficial information on the differences in rainfall variability and relative water availability.
- An important parameter to determine irrigation management calculations such as equity in water distribution is effective rainfall. Irrigation in the winter season, with very little rainfall changes differs from high water demand seasons such as the summer. Therefore, the method used to calculate effective rainfall becomes very important and must be standardized across systems.
- The absence of scientific data greatly compromises efforts to compare across countries, within regions in India because of its variable geographic and agro-climatic zones. These data gaps should be addressed and resolved for comparison purposes and to identify the implications for irrigation management

policy options (such as the way long-term planning for irrigation distribution is calculated).

- Scientific and social indicators are complementary. Application of both types of indicators proved to be useful to gain better understanding of the dynamics of institutional reform and irrigation management by regional managers and farm-level water users.
- To maximize WUE and minimize conflict among water users, water resource management must be conducted along hydrologic boundaries. Matching the administrative (political) boundaries and natural (hydrologic) boundaries is one of the most challenging issues in water resource management. Nevertheless, this system is necessary not only for management purposes but for consistent scientific data collection over time to inform decision-making.

P.B. Jadhav *et al.,* (2014) in their paper, "Conveyance Efficiency Improvement Through Canal Lining and Yield Increment by Adopting Drip Irrigation in Command Area" worked out the conveyance losses from lined and unlined sections of canal irrigation network under existing situation and the scenario for different management strategy to utilize saved water for irrigation in Panchnadi Minor Irrigation Project. They found the overall efficiency of lined, unlined sections of the canal and unlined field channel to be respectively 75%, 52% and 35% and the losses from them were found to be respectively 0.184 Mm^3 , 0.61 Mm^3 and 0.183 Mm^3. They also found that management interventions of converting the unlined canal network sections into lined sections can improve efficiency up to 75% and 0.376 Mm^3 of water can be saved from which about 43 Ha additional areas can be irrigated.

Dr. U.M. Hazarika and Er. R. K. Sinha (2015) in their paper "Water Use Efficiency Of Selected Irrigation Projects Of Northeast: Present Status And Scope Of Improvement", proceedings of Assam Water Conference, conducted a study of five irrigation projects of northeast – 2 medium irrigation projects of Assam and 3 medium irrigation projects of Manipur. They found that conveyance efficiency of the Assam projects are less than 60% and that of Manipur projects are more than 60% which may be due to the land slope or hill topography. The on farm application efficiency varied from 35.5% to 46.8% for all the projects under study. The average conveyance efficiency, on farm application efficiency and overall efficiency of these projects are found as 61.098, 40.38 and 24.84% respectively. Therefore there is an urgent need for increasing the efficiency of the irrigation sector in the region. They also pointed out the various reasons for the low Water Use Efficiency in the region. The unique geographical, topographical, climatological and sociological characteristics, the high rainfall which causes soil loss and thus contributes sediment load to the river from where water is tapped for irrigation, non existence of field channels due to non development of command area and more withdrawal of water by the farmers at the head reaches are some of the reasons. They suggested interventions for improvement of Water Use Efficiency which they divided into technical interventions, social interventions, R&D interventions and policy interventions. Technical interventions include regular maintenance of the canal system, installation of water meters and rehabilitation and restoration of structures. Social interventions include involvement of farmers in the management of irrigation system, formation of water users association, appropriate pricing policy for irrigation water etc. R&D interventions include research programmes on the appropriate areas for diagnosis of deficiencies and to suggest suitable measures for improvement. Policy interventions include policies made by the government.

Syeda Nazmin Sultana *et al.*, (2017), in their paper "Improvement of Water Use Efficiency and Remote Sensing Applications for Surface Soil Moisture Monitoring". They have made studies in the Sukla Irrigation Project. They found that the Conveyance Efficiency of the project based on the selected eight canals was 61.35% and the On Farm Application Efficiency was 54.67%. The overall Water Use Efficiency is thus found was 33.54%. On the basis of the study done on the eight canals it was found that if these canals are lined then 16.04 Mm^3 of water can be saved. Also with very good level maintenance along with providing lining, an amount of 52.76 Mm^3 of water can be saved. With the help of this water, the tail end of the Sukla Irrigation Project can be easily irrigated.

Jerry L. Hatfield and Christian Dold (2019) in their paper "Water-Use Efficiency: Advances and Challenges in a Changing Climate" had studied that the climate change will affect plant growth, but we have opportunities to enhance WUE through crop selection and cultural practices to offset the impact of a changing climate.

K. S. Sujitha , *et al.,* (2020) , in their paper "water use efficiency in different crops cultivation: a study of bore well owning farmers from south India" made an attempt to estimate the water use efficiency of three water-intensive crops namely curry banana, sugarcane and paddy which are cultivated using groundwater irrigation. The study was carried out using field survey data collected from Sivagangai district of Tamil Nadu, India. The study found that irrigation water productivity and water use efficiency were higher for sugarcane crop. But, in terms of profitability and economic water productivity, curry banana crop cultivation seems to be more efficient. Sugarcane seems to be an efficient crop in terms of water productivity, but curry banana appears to be an efficient in terms of economic water productivity.

Tej K. Gautam *et al.,* (2020) in their study "An Evaluation of Irrigation Water Use Efficiency in Crop Production Using a Data Envelopment Analysis Approach: A Case of Louisiana, USA", the primary objective of the study was to estimate and evaluate the technical efficiency of irrigation water use in soybean (Glycine max L.) production in Louisiana, USA. They conducted a farm-level survey to assess information regarding irrigation cost, the volume of water application, and crop yield per acre during the crop year 2016. They used smoothed heterogeneous bootstrapping procedures in conventional data envelopment analysis (DEA) and supplement it with a non radial measure of efficiency known as the Russell measure. The irrigation efficiency scores obtained from both an input- and an output-based DEA approach indicate that producers are over-applying irrigation water by approximately 37 percent. The results provide evidence that an improvement in water management practices can optimize irrigation efficiency, leading to higher profits for the farmers by lowering the other input prices in the production process. The findings should provide a benchmarking tool to formulate an appropriate irrigation policy that enhances water conservation in crop production in regions with similar environmental conditions and soil characteristics.

Vasant P. Gandhi , *et al.,* (2021), in their paper "Improving Water Use Efficiency in India's Agriculture - The Performance and Impact of Micro Irrigation: A Study of the Pradhan Mantri Krishi Sinchayee Yojana (PMKSY) - Per Drop More Crop (PDMC)" made an attempt to study the water use efficiencies of Micro irrigation which includes drip and sprinkler irrigation which are being given substantial importance in India in the recent years to address the objective of improving the water use efficiency given increasing water scarcity, and for enhancing agricultural production and farmer incomes. Micro irrigation is being actively promoted by the government under the Pradhan Mantri Krishi Sinchayee Yojana (PMKSY) - Per Drop More Crop (PDMC) scheme since 2015– 16. The study has examined the performance of the scheme and its impact from the point of view of the agricultural economy, the farmers, and the government. The study was sampled 621 farmers across the five states viz. Andhra Pradesh, Maharashtra, Karnataka, Gujarat and Telangana. The results of the study clearly indicate that micro irrigation technology is highly beneficial in saving water/ reducing water use, and it substantially increases yields, profits and incomes of the farmer. It provides an extremely high return on the investment, including on farmer investment.

Maduri Mallareddy *et al.*, (2023) in their paper "Maximizing Water Use Efficiency in Rice Farming: A Comprehensive Review of Innovative Irrigation Management Technologies" have made an attempt to show the suitability of different water-saving rice production methods. For example, drip-irrigated rice and IOT-based automated irrigation are not feasible for poor farmers due to the high production costs associated with specialized machinery and tools. Similarly, aerobic rice, drip-irrigated rice, and the SRI are labor-intensive, making them unsuitable for areas with a shortage of labor. On the other hand, DSR is suitable for labor-scarce areas, provided herbicides are used to control weeds. In their paper, the suitability of different water-saving rice production methods is reviewed based on factors such as climate, soil type, labor, energy, and greenhouse gas emissions, and their prospects and challenges are evaluated. Additionally, the article examines how cultural practices, such as seed treatment, weed control, and nutrition management, contribute to enhancing water use efficiency in rice production.

David L. Hoover *et al.*, (2023) in their paper "Indicators of water use efficiency across diverse agro ecosystems and spatiotemporal scales", the goals of this review was to evaluate the common indicators of WUE in agricultural production and assess tradeoffs when applying these indicators within and across agro ecosystems amidst a changing climate. They examined three questions: (1) what are the uses and limitations of common WUE indicators, (2) how can WUE indicators be applied within and across agro ecosystems, and (3) how can WUE indicators help adapt agriculture to climate change? Addressing these agricultural challenges required land managers, producers, policy makers, researchers, and consumers to evaluate costs and benefits of practices and innovations of water use in agricultural production.

CHAPTER 3

DETAILS OF BIRINCHIGURI IRRIGATION PROJECT AND METHODOLOGY

3.1 INTRODUCTION

The Birinchiguri Irrigation Project is located at village Birinchiguri in the Chirang district of Assam which is about 30 km away from Bongaigaon town towards West direction under Sidli Development Block. It has its headwork over Birinchi river of Chirang district. The head work of the project is located at latitude of 26.72305556 N and longitude 90.45027778 E. It has been supplying irrigation water to around 3 villages. This project was first operational in the year 2011-12.

Fig: 3.1 Location of the Head Work of the project

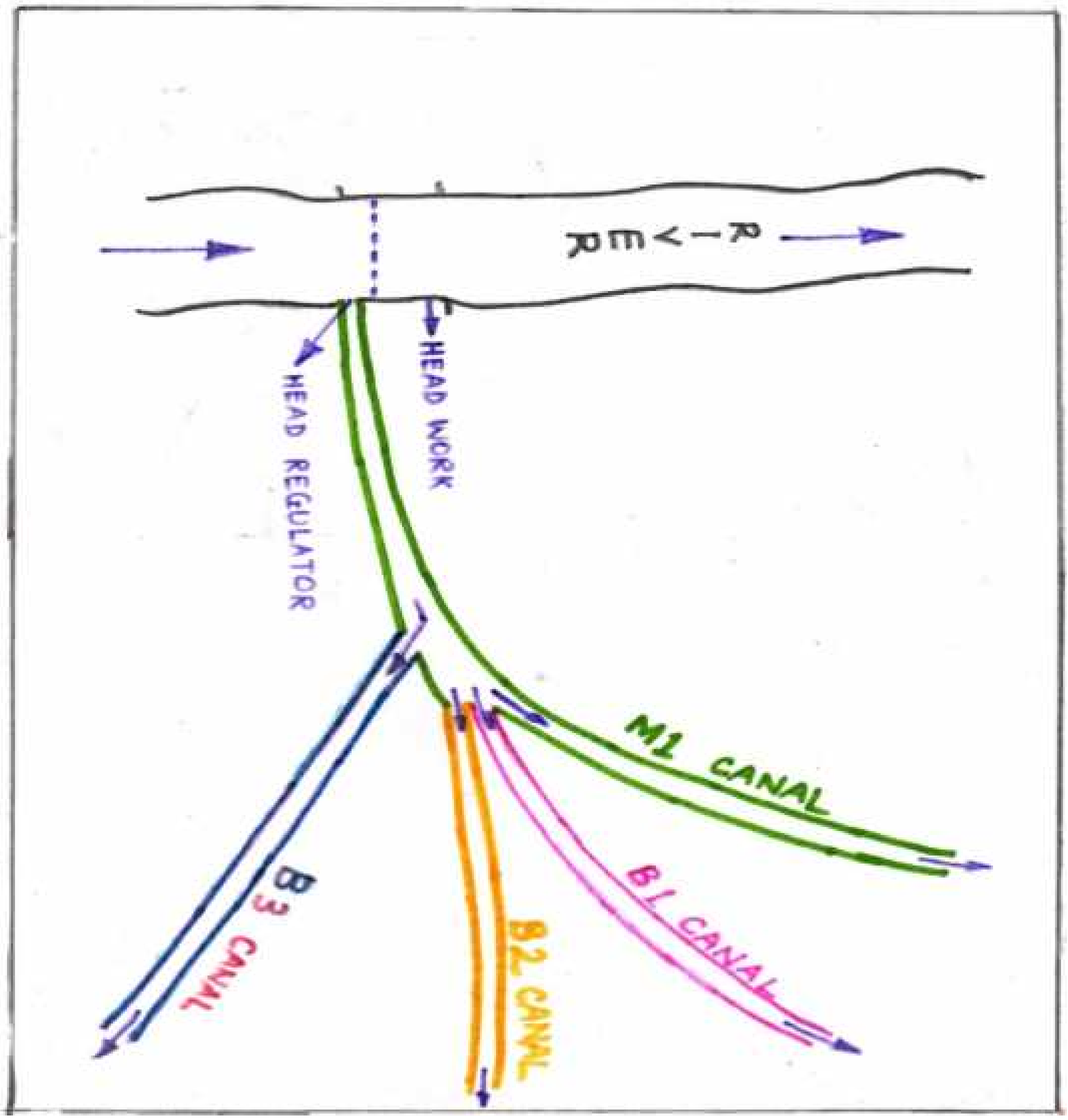


Fig 3.2 Site plan of Birinchiguri Irrigation Project

3.2 DATA COLLECTION

The following data were collected during the study.

Table 3.1 various data collected and its sources

Sl. No.	Name of data	Source
1	Catchment area	Irrigation Department
2	Head works details	
3	Canal network	
4	Design discharge data for the headwork and different canals	
5	Cropping pattern before and after irrigation	DPR of the project

6	Rainfall data	CHRS data portal
7	The area that is presently commanded by the system	Through field visit
8	Number of structures and its condition	
9	Measurement of canal sections	
10	Measurement of inflow and outflow discharges at selected points	By area velocity method

3.3 HYDROLOGY

The source of water for the Birinchiguri Irrigation project is the Birinchi River. The canal system of the irrigation project is only in the right bank of the river. The catchment area of the river up to the headwork is 9.81 square kilometres. The highest annual rainfall in the catchment in the last 19 years is 2409.46 mm. The hydrological details of the Birinchi River are presented in the table below.

Table 3.2 Hydrology of the Birinchi River.

(Source: DPR of the Birinchiguri Irrigation Project)

1	Minimum flow at the headwork site	2.56 cumec
2	Design flood.	60.0 umec

3.4 STATISTICS OF COMMAND AREA

The Gross Command Area (GCA); Culturable Command Area (CCA); Net Irrigable Area (NIA); cropping pattern before and after the introduction of the irrigation scheme is given in the table below.

Table 3.3 Statistics of command area.

(Source: DPR of the Birinchiguri Irrigation Project)

1	Gross Command Area (GCA)	249 Ha
2	Culturable Command Area (CCA)	210 Ha
3	Net Irrigable Area (NIA)	210 Ha
4	Cropping pattern before Introduction of Irrigation	
	Ahu paddy	70 Ha (33.33 %)
	Sali paddy.	100 Ha (47.61 %)
	Jute	15 Ha (7.14 %)
	Mustard	15 Ha (7.14 %)
	Total	**200 Ha**

5	Design Cropping pattern with introduction of Irrigation.	
	Ahu paddy	112 Ha (53.33 %)
	Sali paddy.	160 Ha (76.19 %)
	Jute	24Ha (11.42 %)
	Mustard	24 Ha (11.42 %)
	Total	**320 (152.36%)**

3.5 EXISTING INFRASTRUCTURE OF THE PROJECT

Water is fed into the command area of Birinchiguri Irrigation Project by diverting water of the Birinchi River. The headwork of Birinchiguri Irrigation Project is situated at Birinchi village of Chirang district of Assam. Its latitude and longitude are 26.72305556 N and 90.45027778 E respectively. The headwork consists of a barrage. With the help of cross regulator gates, the normal flow of the river is blocked and as a result of which level of water rises in the upstream side of the headwork and the excess water is diverted into the canal network of the irrigation project. The details of the diversion work are given in the table below.

Table 3.4 Diversion works.

(Source: DPR of Birinchiguri Irrigation Project)

A.	**Barrage:**	
1	Design Discharge	60 cumec
2	Total length of the Barrage	11 m
3	Barrage pier	2 nos. of 1 m width
4	Barrage gates	3 nos. of 3 m width
B.	**Head Regulator:**	
1	Length of Head Regulator	2.2 m
2	Discharge at the inlet of the Head Regulator	2 cumecs

The information about the network of canals supplying irrigation water to the fields is given in the table below.

Table 3.5 Canal and canal structures

(Source: DPR of Birinchiguri Irrigation Project)

1.	**Canal name**	**Length of canal**
	a) Canal M1 (Main canal)	900 m
	b) Canal B1 (Branch canal)	425 m
	c) Canal B2 (Branch canal)	440 m
	d) Canal B3 (Branch canal)	300 m
	e) Field channels	450 m
	Total=	2515 m
2.	**Canal structures in the canals.**	
	a) Canal Regulators	4 Nos.
	b) RCC falls	5 Nos.
	c) RCC Bridge	6 Nos.
	d) Canal pipe outlets for irrigation purpose	70 Nos.
	e) Cross drainage structures.	3 Nos.
	f) Inlets for drainage purpose	12 Nos.

The canals were named as M (Main), B (Branch) and FC (field channels). The canals are operated manually.

Table 3.6 Details of the canal system and its design discharges.

(Source: DPR of Birinchiguri Irrigation Project)

Sl no.	Name of Canal	Chainage (m)		Total length (m)	Bifurcation point (m)	Designed Discharge (Cumec)	CCA (ha)
		From	To				
1	2	3	4	5	6	7	8
1	M1 Canal	0	900	900	0 m at HW	2.0	20
2	B1 Canal	0	425	425	267 m of M1canal	0.5	75
3	B2 Canal	0	440	440	267 m of M1 canal	0.5	59
4	B3 Canal	0	300	300	205 m of M1 canal	0.5	46

3.6 IRRIGATION POTENTIAL CREATED AND UTILIZED

The irrigation project was designed to command a gross area of 249.00 hectare and net irrigable area of 210.00 hectare. The irrigation potential created and utilized in the command area is studied through collection of potential utilisation information from the Irrigation Department, Assam. Though the project was designed to command a gross command area of 249.00 ha, but due to various reasons particularly damage due water pressure, seepage etc. the actual percentage of utilization is quite less. The year wise potential created and potential utilized is shown in the table below.

Table 3.7 Year wise irrigation potential created and irrigation potential utilized (Source: Irrigation Department, Assam)

Year	Irrigation potential created (Ha)	Irrigation potential utilized (Ha)	% utilization
2012-13	249	195	78.31
2013-14	200	135	67.50
2014-15	180	125	69.44
2015-16	175	120	68.57
2016-17	150	115	76.67
2017-18	120	100	83.33
2018-19	80	75	93.75
2019-20	80	70	87.5
2020-21	70	50	71.42
2021-22	60	45	75.00
2022-23	70	65	92.87

It is seen that a hundred percentage of the irrigation potential created is not being utilised by the farmers. Hence, there is an urgent need to increase the Water Use Efficiency so as to reduce the difference between the irrigation potential created and that utilised.

The major portion of canals is earthen and hence there is huge seepage loss of the irrigation water. Also the farmers at the head and at the middle reaches make extensive use of the irrigation water. As a result, the farmers at the tail end are not able to get full benefits from the project.

3.7 METHODOLOGY

The study shall be conducted as per the methodology given in the "Guideline for computing Water Use Efficiency for Irrigation Projects" of CWC-2014. The overall Water Use Efficiency shall be fragmented into two components, (i) Conveyance Efficiency and (ii) On Farm Application Efficiency. Both the efficiencies will be worked out separately and then they will be multiplied to get the overall Water Use Efficiency (WUE).

3.7.1 Conveyance Efficiency

The conveyance efficiency mainly depends on the length of the canals, the soil type or permeability of the canal banks and the condition of the canals. During flowing through the canals, losses like, evaporation, deep percolation, seepage, bund breaks, overtopping of the bunds, runoff in the drain, rat holes in the canal bunds etc. eventually happen. So it is necessary to assess the losses to determine the quantity of water actually delivered to the field in the project area.

So, the Conveyance Efficiency (W_C) = $\frac{\text{W d a tl ii ti tl b o fi}}{\text{W r a tl p he}}$

Water losses in the canal network shall be computed by Inflow - Outflow Method: IS: 9452 (Part-II) of 1980.

3.7.2 On farm application efficiency:

On Farm Application Efficiency is an important and the most critical component of water use efficiency of a project. It depends on the physical condition of field channels / water courses, whether these are lined or unlined, their length and type of strata through which these are laid. The method of application of irrigation water to individual farm plots/ field i.e. by flooding, furrow, drip, sprinkle etc is also an important parameter in determination of on farm application efficiency. On farm application efficiency may be worked out by the ratio of the crop water requirement as per Modified Penman Method for various crops for which irrigation is being provided by the project in each crop season i.e. Kharif, Rabi and hot weather to the quantum of water which is made available to crops from the field outlets of canal system.

3.7.3 The overall water use efficiency of the project:

The overall Water Use Efficiency of the project = (Conveyance efficiency) x (On farm application efficiency)

3.8 SOME IMAGES OF THE PROJECT

Fig 3.3 Headwork

Fig 3.4 Junction point of main and branch canals

Fig 3.5 Cross regulator gates at the Junction point of main and branch canals

Fig. 3.6 Image of the main canal

CHAPTER 4

DETERMINATION OF WATER USE EFFICIENCY

4.1 INTRODUCTION

From the table 3.7 it is seen that all the irrigation potential created is not being utilised by the farmers. Hence, there is an urgent need to increase the Water Use Efficiency so as to reduce the difference between the irrigation potential created and that utilised so that wastage of irrigation potential may be avoided.

This chapter deals with the determination of Water Use Efficiency (WUE) of the Birinchiguri Irrigation Project.

As per the methodology given in the "Guideline for computing Water Use Efficiency for Irrigation Projects" of CWC-2014, the overall Water Use Efficiency is fragmented into two components, (i) Conveyance Efficiency and (ii) On Farm Application Efficiency. Both the efficiencies will be worked out separately and then they will be multiplied to get the overall Water Use Efficiency (WUE).

4.2 CONVEYANCE EFFICIENCY (W_C)

The conveyance efficiency reflects the losses in the conveyance system. It mainly depends on the length of the canals, the soil type or permeability of the canal banks and the condition of the canals. While flowing through the canals, losses like evaporation, deep percolation, seepage, bund breaches, overtopping of the bunds, runoff in the drain, rat holes in the canal bunds etc. eventually happen. So, it is necessary to assess the losses to determine the quantity of water actually delivered to the fields in the project area.

4.2.1 Water losses by Inflow-Outflow Method

Water losses in the canal network have been computed by Inflow-Outflow Method. Inflow-Outflow test was carried out in various sections of the canals. The depth of the various sections of the canals was measured by using a ranging rod. For the measurement of velocity, a ball that floats and to measure the time of travel of the float a stop watch is used. The velocity of the float is equal to the distance between the two cross- sections divided by the time taken by the float to cover the distance. The mean velocity in the vertical is determined as the float velocity multiplied by a coefficient which varies between 0.80 to 0.85. The calculations containing wetted perimeter, inflow and outflow discharges at various cross-sections are shown at Appendix-I, II, III and IV.

Table 4.1 Calculation of seepage losses in canal M1 by Inflow-Outflow method (As per IS: 9452 Part-II, 1980)

Canal Section	Length of reach (m)	Average wetted perimeter (m)	Inflow (Cumec)	Outflow (Cumec)	Loss (Cumec)	Rate of loss in
						m^3/sec per m^3/sec of inflow
I (RCC)	50	3.18	0.765	0.683	0.082	0.108
II (RCC)	50	3.13	0.683	0.601	0.082	0.119
III (RCC)	50	3.07	0.601	0.530	0.071	0.118
IV (RCC)	50	3.00	0.497	0.432	0.065	0.131
V (RCC)	50	2.93	0.432	0.383	0.050	0.115
VI (RCC)	17	2.85	0.383	0.322	0.060	0.158
VII (RCC)	50	2.20	0.242	0.191	0.050	0.208
VIII (RCC)	50	2.05	0.191	0.143	0.048	0.250
IX (RCC)	50	1.95	0.151	0.128	0.023	0.156
X (RCC)	50	1.88	0.128	0.103	0.024	0.190
XI(RCC)	50	1.84	0.103	0.080	0.023	0.227
XII(RCC)	50	1.81	0.080	0.064	0.016	0.201
XIII(RCC)	50	1.80	0.064	0.054	0.010	0.156
XIV(RCC)	50	1.78	0.054	0.041	0.012	0.230
XV(RCC)	33	1.75	0.039	0.034	0.006	0.144
XVI (Earthen)	50	1.30	0.016	0.0062	0.0098	0.61
XVII (Earthen)	50	1.229	0.011	0.0074	0.036	0.32
XVIII (Earthen)	50	1.018	0.0051	0.0049	0.002	0.039
IX (Earthen)	50	1.028	0.0068	0.00455	0.00225	0.33
Total	900					3.810
Average loss						0.20

Table 4.2 Calculation of seepage losses in canal B1 by Inflow-outflow method

(As per IS: 9452 Part-II, 1980)

Canal section	Length of reach (m)	Average wetted perimeter (m)	Inflow (Cumec)	Outflow (Cumec)	Loss (Cumec)	Rate of loss in
						m^3/sec per m^3/sec of inflow
I (RCC)	50	1.66	0.1785	0.13	0.0485	0.27
II (RCC)	25	1.52	0.13	0.935	0.0365	0.28
III (Earthen)	50	1.396	0.08	0.047	0.033	0.41
IV (Earthen)	50	1.332	0.05	0.03	0.02	0.40
V (Earthen)	50	1.372	0.03	0.0231	0.0069	0.23
VI (Earthen)	50	1.372	0.028	0.016	0.012	0.42
VII (Earthen)	50	1.206	0.018	0.0136	0.0044	0.24
VIII (Earthen)	50	1.04	0.0136	0.0098	0.0044	0.27
IX (Earthen)	50	1.04	0.01	0.0054	0.0038	0.94
Total	425				0.00946	3.49
Average loss						0.38

Table 4.3 Calculation of seepage losses in canal B2 by Inflow-outflow method

(As per IS: 9452 Part-II, 1980)

Canal section	Length of reach (m)	Average wetted perimeter (m)	Inflow (Cumec)	Outflow (Cumec)	Loss (Cumec)	Rate of loss in m^3/sec per m^3/sec of inflow
I (RCC)	50	1.66	0.1904	0.13	0.0604	0.31
II (Earthen)	50	1.396	0.084	0.047	0.037	0.44
III (Earthen)	50	1.332	0.0498	0.029	0.0208	0.41
IV (Earthen)	50	1.372	0.03	0.019	0.011	0.36
V (Earthen)	50	1.372	0.028	0.016	0.012	0.42
VI (Earthen)	50	1.206	0.019	0.012	0.007	0.36
VII (Earthen)	50	1.04	0.012	0.0099	0.0021	0.175
VIII (Earthen)	50	1.04	0.0098	0.0057	0.0041	0.41
IX(Earthen)	40	1.04	0.00058	0.00046	0.00012	0.20
Total	440					3.13
Average loss						0.35

Table 4.4 Calculation of seepage losses in canal B3 by Inflow-outflow method
(As per IS: 9452 Part-II, 1980)

Canal section	Length of reach (m)	Average wetted perimeter (m)	Inflow (Cumec)	Outflow (Cumec)	Loss (Cumec)	Rate of loss in m^3/sec per m^3/sec of inflow
I (RCC)	50	1.73	0.246	0.161	0.085	0.34
II (Earthen)	50	1.366	0.10	0.049	0.051	0.51
III (Earthen)	50	1.332	0.047	0.028	0.019	0.40
IV (Earthen)	50	1.226	0.027	0.017	0.01	0.37
V (Earthen)	50	1.372	0.016	0.0126	0.0034	0.21
VI (Earthen)	50	1.206	0.0133	0.0052	0.0081	0.60
Total	300					2.45
Average loss						0.40

Table 4.5 Calculation of Conveyance Efficiency, W_C

Canal no.	Discharge at head, (cumec)	Effective length, (m)	Conveyance loss factor, m^3/sec per m^3/sec of inflow	Total conveyance loss Col. (2) x col.(4)	Delivery at check point Col. (2) – col. (6)	Ratio of col. (6)/col. (2)	Conveyance efficiency Col. 7 x100 %
1	2	3	4	5	6	7	8
M1	0.765	900	0.20	0.153	0.612	0.80	80.00
B1	0.1785	425	0.38	0.067	0.112	0.6246	62.46
B2	0.1904	400	0.35	0.067	0.1234	0.6481	64.81
B3	0.246	300	0.40	0.0984	0.1476	0.60	60.00
						Average =	66.81 %

Therefore, Conveyance Efficiency of the selected canals, W_C = 66.81 %

4.3 ON FARM APPLICATION EFFICIENCY (W_F)

The on farm application efficiency has two components:

(a) W_{F1} known as water courses/field channels efficiency which accounts for the transit losses.

(b) W_{F2} known as on field water application efficiency which accounts for the water loss from the field in deep percolation.

On farm application efficiency,

$$W_F = W_{F1} \times W_{F2}$$

4.3.1 Field Channels Efficiency (W_{F1})

W_{F1} has been determined by the inflow-outflow method.

Hence, W_{F1} = 66.81%

4.3.2 On Field Water Application Efficiency in the Farm (W_{F2})

The On Field Water Application Efficiency in the farm is determined as follows:

Step 1: CLIMWAT 2.0 for CROPWAT software is first downloaded. By opening the CLIMWAT, the nearby ET station from the study area, Dhubri is selected. Then, exported the climatic data of Dhubri and saved.

Step 2: Then, CROPWAT 8.0 software is downloaded. By opening the CROPWAT 8.0 home page is displayed as shown in the figure below.

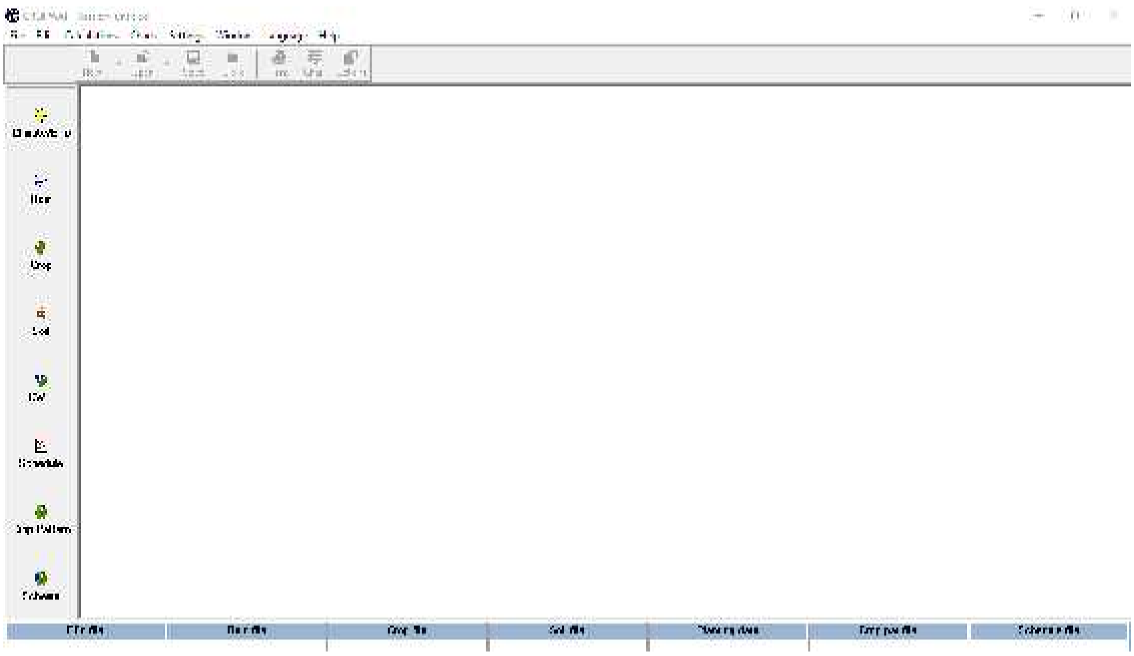


Fig 4.1: Home page of CROPWAT 8.0 software

Then, Reference Evapotranspiration (ETo) is calculated using Modified Penman-Monteith method by importing the climate data for Dhubri station. Reference evapotranspiration (ET_0) values for different months are calculated and given in the following table.

Table 4.6: Reference Evapotranspiration, ET_o , in the command area computed using CROPWAT 8.0 software

Monthly ETo Penman-Monteith E:\M TECH 2021-23\4TH SEM\DISSERTATION PHASE 2\dissert...

Country: Location 12[illegible] Station: DHUBRI

Altitude: 35 m Latitude: [illegible] °N Longitude: [illegible] °E

Month	Min Temp	Max Temp	Humidity	Wind	Sun	Rad	ETo
	°C	°C	%	km/day	hours	MJ/m²/day	mm/day
January	11.7	23.3	86	61	7.8	14.6	2.01
February	13.3	25.5	78	95	8.2	17.2	2.75
March	17.2	30.0	57	121	8.5	20.0	[illegible]
April	[illegible]	30.5	61	156	8.1	[illegible]	[illegible]
May	22.8	30.0	90	138	6.0	19.0	3.87
June	24.4	30.0	90	121	6.0	19.2	3.01
July	25.5	30.0	93	112	5.8	[illegible]	3.86
August	[illegible]	30.0	92	95	5.6	17.8	3.75
September	25.0	29.4	91	95	6.0	17.0	3.49
October	22.8	29.4	93	95	6.9	[illegible]	[illegible]
November	17.8	26.7	95	78	7.9	15.2	2.55
December	12.0	[illegible]	91	[illegible]	0.4	14.0	2.02
Average	20.0	28.2	85	109	7.1	17.6	3.37

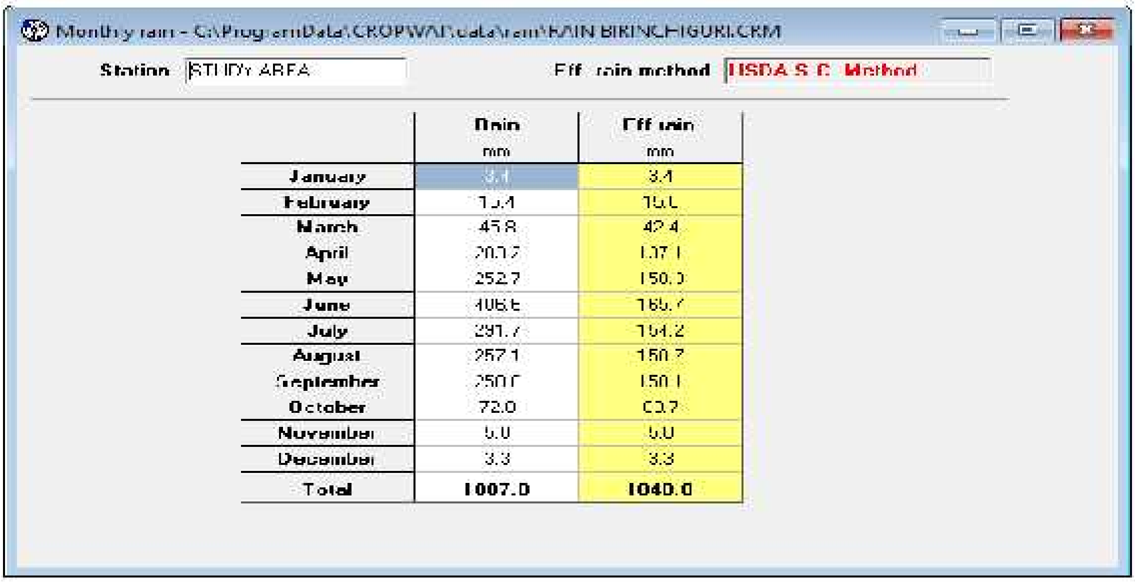
Step 3: Determination of Effective Rainfall

The rainfall data for the command area from 2001-2019 are collected from the Centre for Hydrometeorology and Remote Sensing (CHRS). The Current operational PERSIANN (Precipitation Estimation from Remotely Sensed Information using Artificial Neural Networks) system uses neural network function to compute an estimate of rainfall rate at each 0.25° x 0.25° pixel of the infrared brightness temperature image provided by geostationary satellites. The monthly average rainfall has been calculated. These average monthly rainfall values are put into the CROPWAT software. The effective rainfall is calculated using USDA Soil Conservation Service Method.

Table 4.7: Rainfall data from 2001-2019

YEAR	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
2001	0.5	7.17	50.88	154.94	155.4	267.61	387.04	256.62	304.11	146.39	5.93	7.28
2002	7.04	2.65	67.48	549.2	109.13	380.26	370.89	253.47	326.09	66.06	29.19	3.52
2003	5.81	39.49	115.33	244.48	148.4	323.92	326.42	154.06	233.21	142.63	0.84	22.9
2004	2.86	4.71	36.84	208.91	302.9	338.34	455	309.24	417.97	109.97	1.22	2.07
2005	19.18	1.31	36.24	282.35	464	446.68	262.01	278.29	225.23	143.17	0	15.14
2006	0	0	13.77	109.58	191.22	550.33	314.9	152.12	361.11	86.07	34.42	0
2007	1.99	60.54	10.8	287.03	396.71	291.38	492.7	241.62	204.32	68.34	5.51	0.23
2008	17.54	0	37.17	96.68	58.11	183.32	264.48	329.73	128.92	36.16	0.25	0
2009	0.98	0.9	27.37	82.84	200.61	365.45	239.55	299.89	86.83	140.16	8.68	0
2010	0	9.02	99.31	533.7	363.41	442.21	223.08	239.36	191.78	11.8	0	1.92
2011	0	6.88	5.64	104.21	124.79	270.9	126.19	220.93	105.03	2.44	0	0
2012	2.95	0.27	0.54	198.11	227.77	1023.34	295.96	239.09	458.52	135.51	1.59	0
2013	0	38.26	34.34	169.54	165.71	333.04	153.71	203.28	218.66	62.72	0	0
2014	0.93	4.82	21.36	64.16	200.58	345.54	233.86	275.63	186.93	19.54	0	0.45
2015	2.5	11.05	61.67	114.93	627.2	900.93	248.83	599.32	102.45	10.75	2.83	2.8
2016	0.74	0	93.17	204.88	217.91	285.7	169.93	196.22	220.44	48.84	0	0.51
2017	2.29	0	16.04	234.25	274.32	208.61	260.45	248.78	379.89	77.83	0.77	0.2
2018	0	9.32	53.32	90.19	355.69	295.02	256.8	173.4	471.25	28.66	0	4.88
2019	0	96.83	87.92	130.97	217.97	474.51	461.39	213.79	143.05	31.42	2.86	0.27
TOTAL	65.31	293.22	869.19	3861	4801.83	7727.09	5543.19	4884.84	4765.79	1368.46	94.09	62.17
AV.=	3.44	15.43	45.75	203.21	252.73	406.69	291.75	257.10	250.83	72.02	4.95	3.27

Table 4.8: Effective rainfall (mm) computed by CROPWAT 8.0 software of FAO



	Rain mm	Eff rain mm
January	[illegible]	3.4
February	15.4	15.0
March	45.8	42.4
April	203.2	137.1
May	252.7	150.0
June	406.6	165.7
July	291.7	154.2
August	257.1	150.7
September	250.8	150.1
October	72.0	63.7
November	5.0	5.0
December	3.3	3.3
Total	1007.0	1040.0

Step 4: Input of the Values of Crop Coefficient, K_c

Crop co-efficients (K_c) are required to relate reference evapotranspiration (ET_o) with the crop evapotranspiration (ETcrop) or consumptive use. The K_c value relates to evapotranspiration of a disease free crop grown in a large field under optimum soil water and fertility condition and achieving full production potential under the given growing environment. The K_c value takes into account the crop characteristics, time of planning or sowing stages of crop development and general climatic conditions. The K_c values for different stages of crop development and different climatic conditions are given below in the table. The four stages of crop development are as follows:-

(i) 1st stage (nursery and initial) – Germination and initial growth

(ii) 2nd stage (development stage) – From end of initial stage to attainment of effective full ground cover.

(iii) 3rd stage (mid stage) – From attainment of effective full ground cover to time of start of maturing.

(iv) 4th stage (late stage) – From end of mid-season stage until full maturity or harvest.

Table 4.9: Values of K_c

Source: Sultana Syeda Nazmin et al (2017)

Name of crop	Stage	Number of days	K_c
Sali paddy	1st stage	20	1.10
	2nd stage	30	1.08
	3rd stage	80	1.05
	4th stage	20	0.95

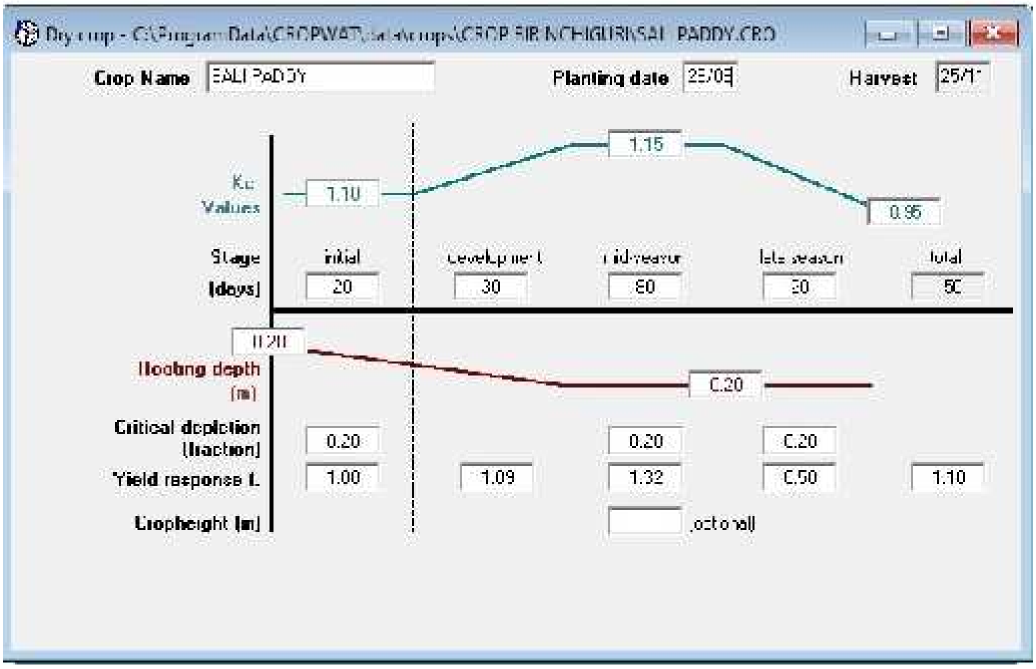


Fig 4.2: Window of CROPWAT for feeding the various inputs relating to the crop Sali paddy

Step 5: Determination of soil type and percolation losses in the paddy fields of the study area

The soil type in the study area is determined by preparing the soil map by using the ArcGIS software. Some steps are-

(i) Country "India" is selected from the digital soil map of the world.

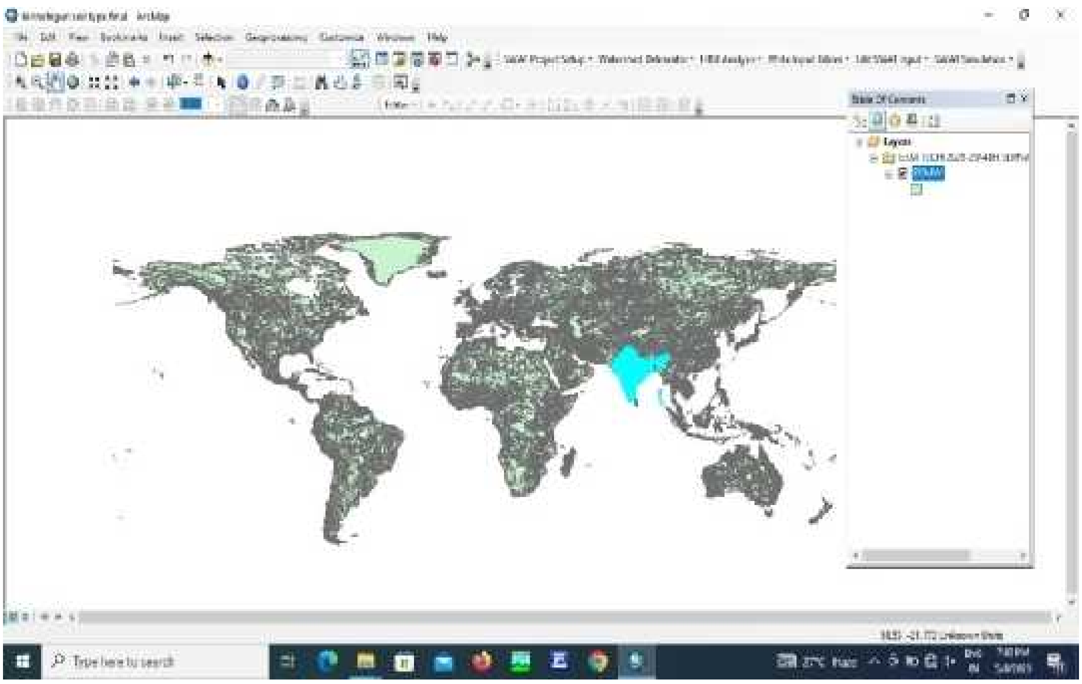


Fig 4.3: Digital soil map of world

(ii) India shape file of districts is added.

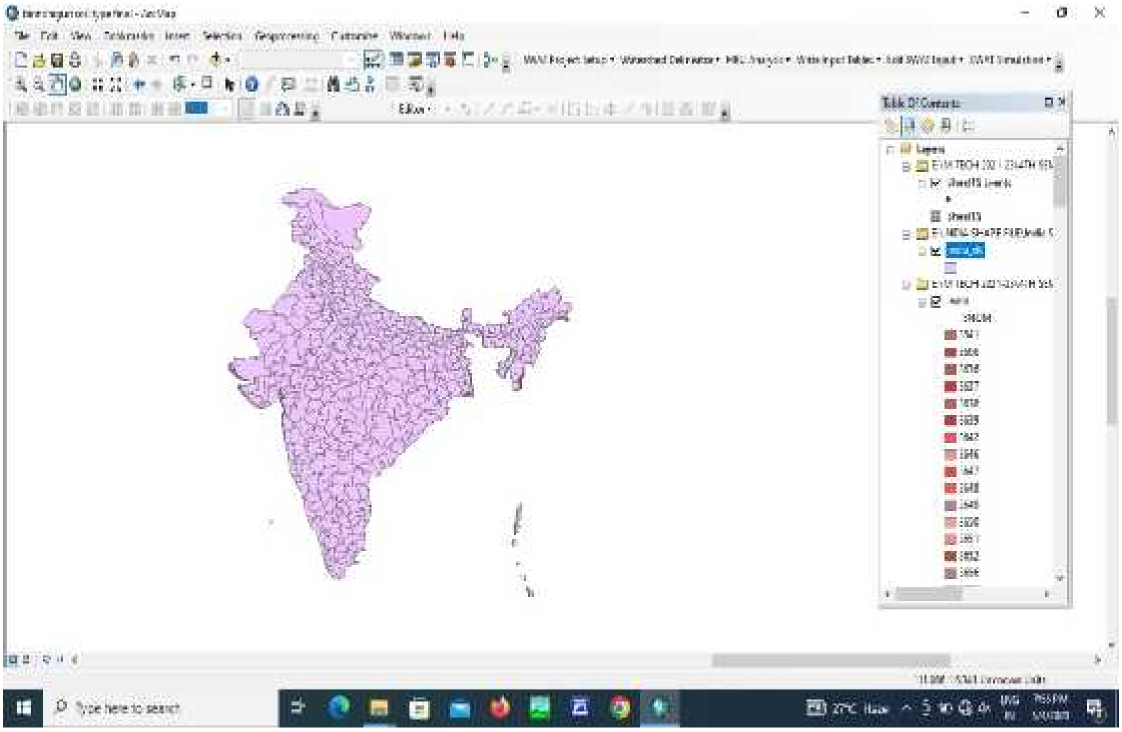


Fig 4.4: Shape file of India (districts)

(iii) Geoprocessing

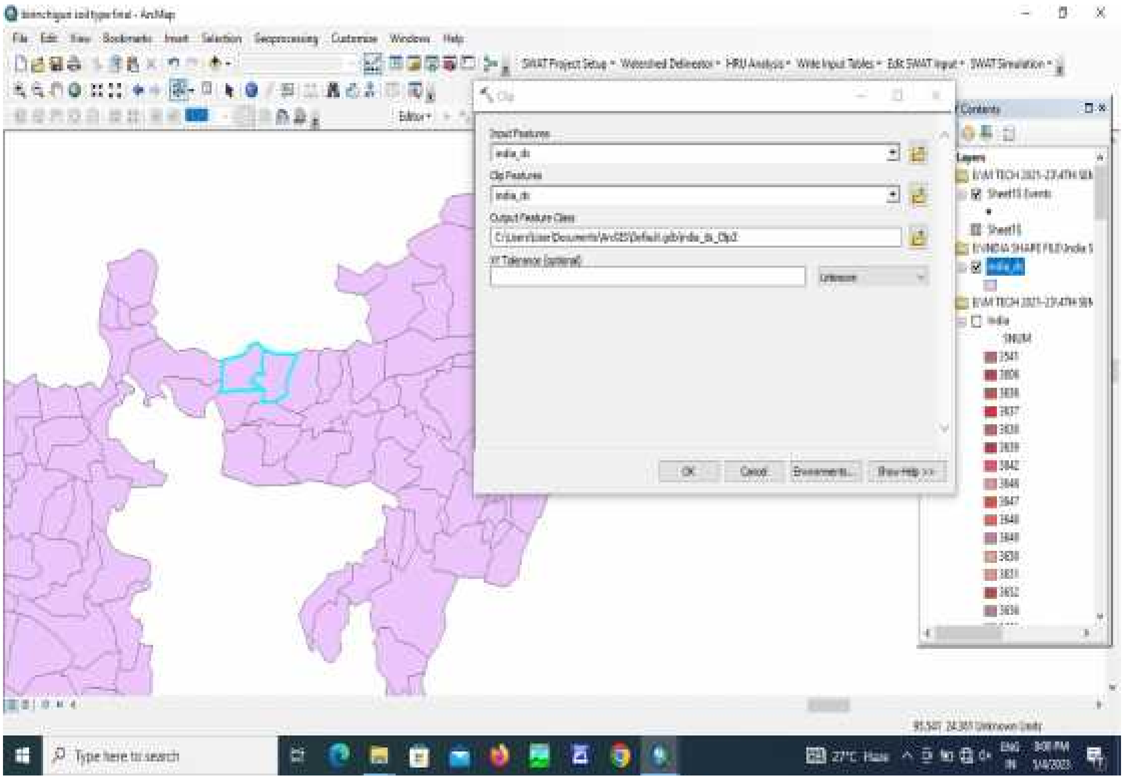


Fig 4.5: Geoprocessing in Arc GIS

(iv) Soil mapping of North East and nearby states.

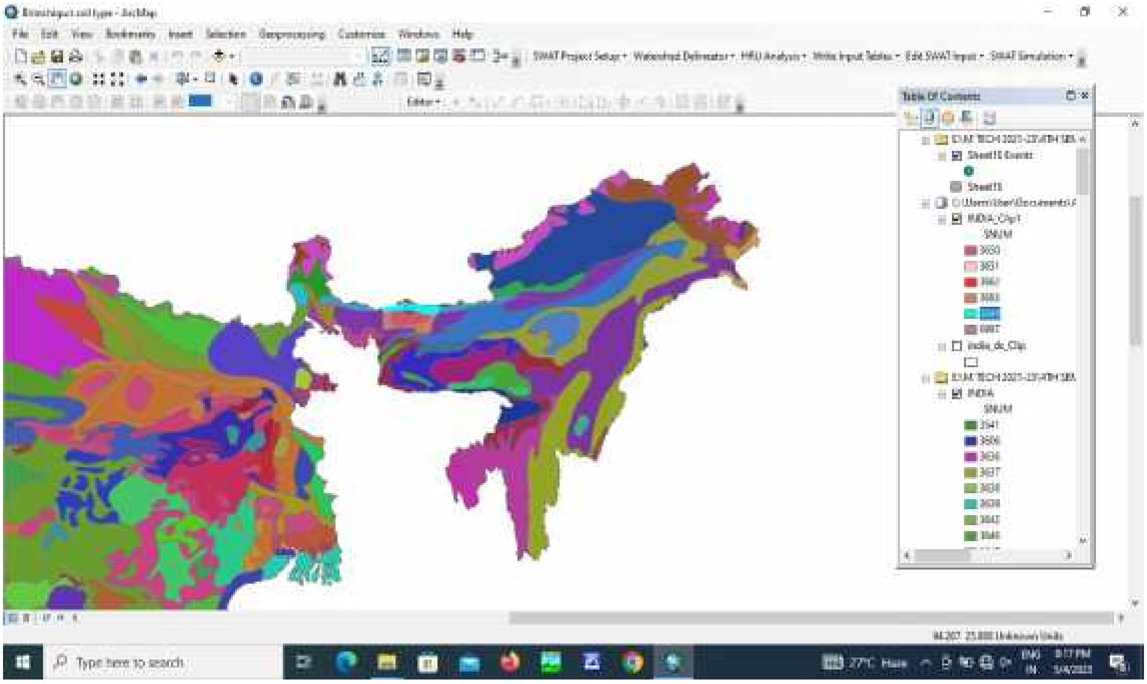


Fig 4.6: Soil mapping of North East and nearby states.

(v) Soil type boundary of the study area.

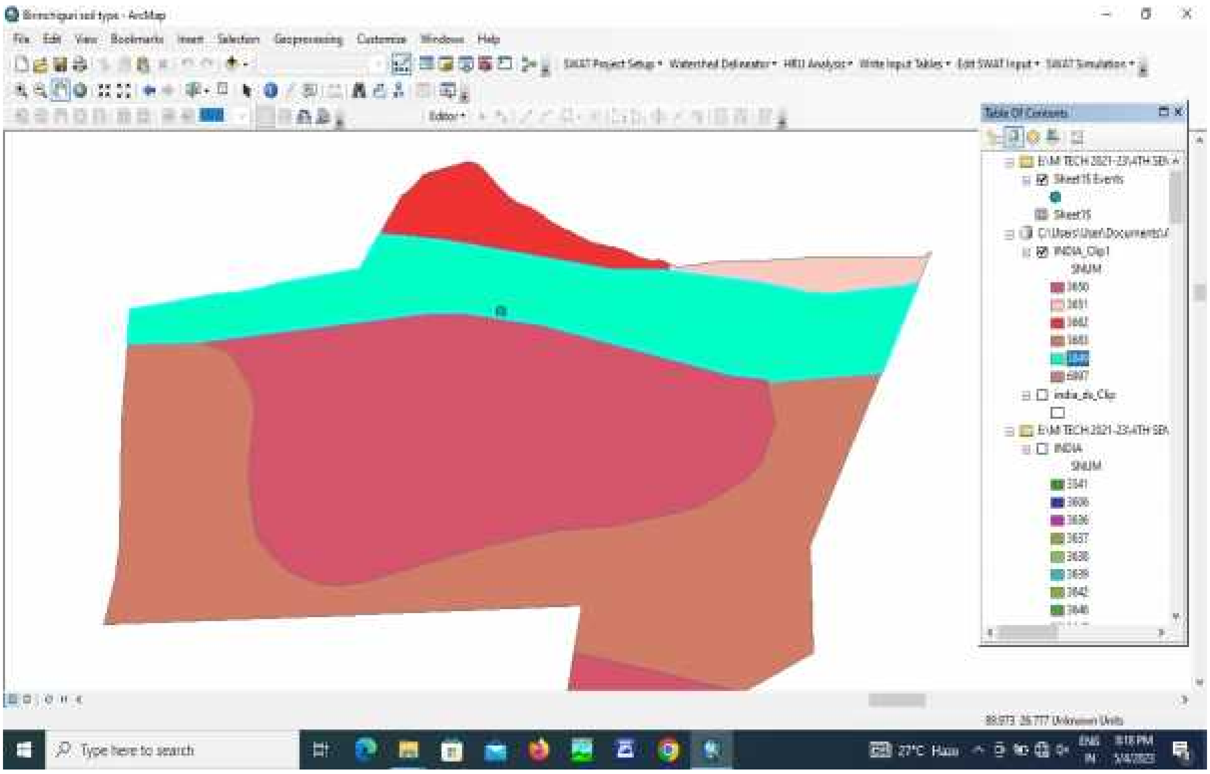


Fig 4.7: Soil Map of the study area determined in Arc GIS

(vi) Determination of type of soil by SNUM.

The soil number (SNUM) located in the study area is found as 3849.

Then, the number is searched in the file SWAT 2012 and found that the soil type available in the study area is Sandy Loam type of soil.

(vii) Then, the soil name is inserted in the CROPWAT window and the soil data is found as shown in the figure below.

Fig 4.8: Window of CROPWAT for feeding the various inputs related to the soil

Step 6: Determination of Crop Water Requirement

The amount of water required to compensate the evapotranspiration loss from the cropped field is defined as crop water requirement. Generally, the values for Crop evapotranspiration under standard conditions (ET_c) and crop water requirement are identical. Crop water requirement refers to the amount of water that needs to be supplied to the roots of plants, while crop evapotranspiration refers to the amount of water that is lost through evapotranspiration. As there is still a considerable lack of information for different crops, the Penman-Monteith method is used for the estimation of the Reference evapotranspiration (ET_0). Experimentally determined ratios of ET_c/ET_0, called Crop coefficient (K_c), are used to relate ET_c to ET_0. Therefore, we can express crop evapotranspiration as $ET_c = K_c * ET_0$. This is known as the crop coefficient approach to calculate crop evapotranspiration. Due to variations in the crop characteristics throughout its growing season, K_c for a given crop changes from sowing till harvest. For the calculations of the Crop Water Requirements (CWR), the crop coefficient approach is used. Crop water requirements are then calculated as the difference between crop evapotranspiration and effective rainfall.

Table 4.10: Crop water requirement for Sali paddy

Crop Water Requirements

ETo station: DHUBR
Rain station: STUDY AREA
Crop: SALI PADDY
Planting date: 29/06

Month	Decade	Stage	Kc	ETc	ETc	Eff rain	Irr. Req.
			coeff	mm/day	mm/dec	mm/dec	mm/dec
Jun	3	Init	1.10	4.2[illegible]	5.4	1[illegible]	8.4
Jul	1	Init	1.10	4.23	42.3	32.4	0.0
Jul	2	Deve	1.10	4.25	42.5	[illegible]	0.0
Jul	3	Deve	1.11	4.26	46.8	50.3	0.0
Aug	1	Deve	1.13	4.28	42.8	50.3	0.0
Aug	2	Mid	1.15	4.30	43.0	50.1	0.0
Aug	3	Mid	1.15	[illegible]	[illegible]	[illegible]	0.0
Sep	1	Mid	1.15	4.12	41.2	[illegible]	0.0
Sep	2	Mid	1.15	4.02	40.2	34.1	0.0
Sep	3	Mid	1.15	3.89	38.9	43.1	0.0
Oct	1	Mid	1.15	3.75	37.5	30.0	7.5
Oct	2	Mid	1.15	3.62	36.2	19.9	16.3
Oct	3	Mid	1.15	3.39	37.3	13.[illegible]	23.5
Nov	1	Late	1.0[illegible]	3.12	31.2	4.0	26.4
Nov	2	Late	[illegible]	[illegible]	[illegible]	0.0	[illegible]
Nov	3	Late	[illegible]	2.30	11.5	0.1	11.4
					572.0	534.7	120.1

Step 7: Determination of Net Irrigation Requirement (NIR) :

After clicking on the schedule, the Net Irrigation Requirement (NIR) is displayed as shown in the table below.

Table 4.11: Net irrigation requirement (NIR) for Sali paddy

Crop irrigation schedule

ETo station: DHUBRI
Rain station: STUDY AREA
Crop: SALI PADDY
Soil: SANDY LOAM
Planting date: 29/06
Harvest date: 25/11
Yield red.: 0.3 %

Table format:
- Irrigation schedule
- Daily soil moisture balance

Timing: Irrigate at critical depletion
Application: Refill soil to field capacity
Field eff. 70 %

Date	Day	Stage	Rain	Ks	Eta	Depl	Net Irr	Deficit	Loss	Gr. Irr	Flow
			mm	fract.	%	%	mm	mm	mm	mm	l/s/ha
29 Jun	1	Init	0.0	0.63	63	57	22.6	0.0	0.0	32.3	3.74
1 Jul	3	Init	0.0	1.00	100	[illegible]	8.4	0.0	0.0	12.1	[illegible]
4 Jul	5	Init	0.0	1.00	100	[illegible]	0.5	0.0	0.0	[illegible]	0.47
6 Jul	8	Init	0.0	1.00	100	[illegible]	8.5	0.0	0.0	12.1	[illegible]
8 Jul	10	Init	0.0	1.00	100	[illegible]	8.5	0.0	0.0	12.1	[illegible]
10 Jul	12	Init	0.0	1.00	100	[illegible]	0.5	0.0	0.0	[illegible]	[illegible]
12 Jul	14	Init	0.0	1.00	100	[illegible]	8.5	0.0	0.0	[illegible]	[illegible]

Totals

Total gross irrigation	784.1	mm	Total rainfall	876.8	mm
Total net irrigation	548.9	mm	Effective rainfall	40.1	mm
Total irrigation losses	0.0	mm	Total rain loss	836.7	mm
Actual water use by crop	568.9	mm	Moist deficit at harvest	0.0	mm
Potential water use by crop	570.5	mm	Actual irrigation requirement	530.4	mm
Efficiency irrigation schedule	100.0	%	Efficiency rain	4.6	%
Deficiency irrigation schedule	0.3	%			

Yield reductions

Therefore, NIR = 548.90 mm

Step 8: Calculations for determining the on farm application efficiency

We know that Field Irrigation Requirement (FIR) = $\frac{N}{W\ \ 1} = \frac{5\quad .9}{0.6}$ = 821.52 mm

Actual supply = Gross Irrigation Requirement (GIR) + Effective Rainfall

GIR = $\frac{F}{0.7} = \frac{8\quad .5}{0.7}$= 1173.60 mm

Actual supply = 1173.60 + 40.10

= 1213.70 mm

On field water application efficiency, $WF_2 = \frac{F}{A\qquad s} = \frac{8\quad .5}{1\quad\ .7}$ x 100 = 67.68 %

Hence, On Farm Application Efficiency, $W_F = \frac{6\ .8}{1}$ x $\frac{6\ .6}{1}$ x 100 = 44.54 %

Therefore, overall Water Use Efficiency $W_P = W_C$ x $W_F = \frac{6\ .8}{1}$ x $\frac{4\ .5}{1}$ x 100 = 29.75 %

Thus it is seen that the Water Use Efficiency is very low.

CHAPTER 5

IMPROVEMENT OF CONVEYANCE EFFICIENCY BY CANAL LINING

5.1 INTRODUCTION

As seen in the previous chapter, the conveyance efficiency of the Birinchiguri Irrigation Project is only 66.81% which is very low. This is mainly because the canal network is not fully lined and this causes huge seepage losses. The seepage loss in the canals accounts for major portion of water conveyance loss. Now, as per the "Guideline for computing water use efficiency (WUE) of irrigation projects" put forward by CWC, Ministry of Water Resources, Government of India, the Conveyance Efficiency can be improved and can be brought up to at least 75%. If the level of maintenance is very good, this value can be further improved and can be brought up to 95%. In this chapter, the probable quantity of water that may be saved from seepage loss and the additional area that can be brought under irrigation by converting the canals into lined canals have been attempted to be determined.

5.2 IMPROVING CONVEYANCE EFFICIENCY THROUGH LINING OF CANALS

In the Birinchiguri Irrigation Project, the canal network is lined only up to some distance. The other parts of the project are unlined canals.

Now, if it is considered that the canal network is fully lined, then the seepage loss will reduce to a great extent. The probable water saving and predicted additional area that can be brought under irrigation after converting unlined sections of main canal and branch canals into lined sections are given below.

Table 5.1: Water that may be saved from seepage and additional area that can be irrigated after converting unlined canals into lined canals

Canal no.	Conveyance efficiency before lining %	Conveyance efficiency after lining %	Discharge at head m^3/sec	Delivery at check point before lining m^3/sec	Delivery at check point after lining m^3/sec	Total loss before lining m^3/sec	Total loss after lining m^3/sec	Water that may be saved from seepage		Predicted additional area to be irrigated Ha (Col.10/0.009)
								m^3/sec (col.7-col.8)	Mm^3 Col.9X 60X60 X24X 110/10^6	
1	2	3	4	5	6	7	8	9	10	11
M1	80									
B1	62.46	75	0.1785	0.112	0.13	0.0665	0.048	0.018	0.171	19.008
B2	64.81	75	0.1904	0.1234	0.142	0.067	0.048	0.0186	0.177	19.6416
B3	60	75	0.246	0.1476	0.185	0.0984	0.061	0.0374	0.355	39.4944
						Total=		0.074	0.703	78.144

Table 5.2: Water that may be saved from seepage and additional area that can be irrigated after converting unlined canals into lined canals and very good level of maintenance.

Canal no.	Conveyance efficiency before lining %	Conveyance efficiency after lining %	Discharge at head m^3/sec	Delivery at check point before lining m^3/sec	Delivery at check point after lining m^3/sec	Total loss before lining m^3/sec	Total loss after lining m^3/sec	Water that may be saved from seepage		Predicted additional area to be irrigated Ha (Col.10/0.009)
								m^3/sec (col.7-col.8)	Mm^3 Col.9X 60X60 X24X 110/10^6	
1	2	3	4	5	6	7	8	9	10	11
M1	80	95	0.765	0.612	0.727	0.153	0.038	0.058	0.55	61.62
B_1	62.46	95	0.1785	0.112	0.170	0.0665	0.008	0.057	0.55	60.70
B_2	64.81	95	0.1904	0.1234	0.181	0.067	0.010	0.086	0.82	90.92
B3	60	95	0.246	0.1476	0.234	0.0984	0.012	0.086	0.82	90.92
							Total=	0.288	2.18	242.54

Thus, it is seen from table 5.1 that a total volume of 0.0703 Mm^3 can be saved if the whole canal system is lined. With the help of this water an additional area of 78.144 Ha can be irrigated. Again, from table 5.2 it is found that if the whole canal network is lined and the maintenance level is also very good then 2.18 Mm^3 of water can be saved which can irrigate an additional area of 242.54 ha. Thus, the tail end of the project, which at present does not receive much benefit from it, can easily be irrigated if the canals are lined.

The increase in the Conveyance Efficiency will also lead to an increase in the Water Use Efficiency.

i. If Conveyance Efficiency is increased to 75%, then,

Field Irrigation Requirement (FIR) = $\frac{N}{W\ \ 1}$ = $\frac{5\ \ \ .9}{C.7}$ = 731.87 mm

Actual supply = Gross Irrigation Requirement (GIR) + Effective Rainfall

GIR = $\frac{F}{C.7}$ = $\frac{7\ \ \ .8}{C.7}$= 1045.52 mm

Actual supply = 1045.52 + 40.10

= 1085.62 mm

On field water application efficiency, W_{F2} = $\frac{F}{A\ \ \ \ s}$

= $\frac{7\ \ \ .8}{1\ \ \ .6}$ x 100 = 67.41 %

Hence, On Farm Application Efficiency, W_F = $\frac{7}{1}$ x $\frac{6\ .4}{1}$ x 100 = 50.56 %

Therefore, overall Water Use Efficiency W_P= W_C x W_F

$= \frac{7}{1} \times \frac{5\ .5}{1} \times 100 = 37.92\ \%$

ii. If Conveyance Efficiency is increased to 95%, then

Field Irrigation Requirement (FIR) = $\frac{N}{W\ \ 1} = \frac{5\ \ \ .9}{C.9} = 577.78$ mm

Actual supply = Gross Irrigation Requirement (GIR) + Effective Rainfall

GIR = $\frac{F}{C.7} = \frac{5\ \ \ .7}{C.7} = 825.40$ mm

Actual supply = 825.40 + 40.10

= 865.50 mm

On field water application efficiency, $WF_2 = \frac{F}{A\ \ \ \ s}$

$= \frac{8\ \ \ .4}{8\ \ \ .5} \times 100 = 95.36\ \%$

Hence, On Farm Application Efficiency, $W_F = \frac{9}{1} \times \frac{9\ .3}{1} \times 100 = 90.59\ \%$

Therefore, overall Water Use Efficiency $W_P = W_C \times W_F$

$= \frac{9}{1} \times \frac{9\ .5}{1} \times 100 = 90.81\ \%$

Thus, it is seen that under practical achievable limits, the Water Use Efficiency can be increased up to 37.92 % by lining the whole canal network. With very good level of maintenance, it can be increased up to 90.81 %. As a result, wastage of water can be avoided along with providing irrigation facilities to a larger area.

CHAPTER 6

SUMMARY, CONCLUSION AND SCOPE FOR FUTURE STUDIES

6.1 SUMMARY

Irrigation Efficiency is the ratio of the amount of water consumed by the crop to the amount of water supplied through irrigation. Irrigation Efficiency is of various types. In this project, the Water Use Efficiency of the Birinchiguri Irrigation Project has been determined. The Water Use Efficiency of the Birinchiguri Irrigation Project has been calculated as per the "Guideline for computing water use efficiency of irrigation projects" of CWC – 2014.

The Water Use Efficiency can be fragmented into two components, i.e., (i) Conveyance Efficiency and (ii) On Farm Application Efficiency. Conveyance Efficiency is the ratio of water delivery at the inlet of fields to the water released at the project head work. The conveyance efficiency of canals is found as **66.81 %.**

As per the CWC guideline, the Conveyance Efficiency can be increased to a maximum of 75% by fully lining the canals. But the canals of the Birinchiguri irrigation Project are not fully lined. If the canals are converted to fully lined canals, then the seepage loss would reduce to a great extent.

The On Farm Application Efficiency consists of two components, i.e., Field Channels Efficiency and on field water application efficiency in the farm. The field channel efficiency accounts for the transit losses which have been calculated using the Inflow – Outflow method and is found to be 66.81%. The on field water application efficiency in the farm accounts for the water loss from the field in deep percolation.

In order to calculate the on field water application efficiency, a number of parameters like Reference Evapotranspiration, Effective Rainfall, Soil Type, Infiltration Rate, Crop Water Requirement and Net Irrigation Requirement were determined by using the CROPWAT 8.0 software. First, the Reference Evapotranspiration has been determined. After that, the average monthly rainfall was calculated from rainfall data of 19 years collected from CHRS data portal. These values were then used to calculate the Effective Rainfall. The USDA soil conservation service method was used to calculate the Effective Rainfall.

In the next step, feed the crop coefficient values, period of each stage, rooting depth, critical depletion factor and yield response.

The soil type was determined by preparing the soil map for the study area by using the software Arc GIS and it was concluded that the soil of the study area is of sandy loam type. This data was then fed into the CROPWAT software to get the initial available soil moisture.

Using all these parameters, the software then calculated the Crop Water Requirement for Sali paddy.

After that the Net Irrigation Requirement is calculated and it was found as 548.90 mm.

Using these data, the On Farm Application Efficiency is then calculated and is found to be 44.54 %. The Water Use Efficiency is then found by multiplying the Conveyance Efficiency and the On Farm Application Efficiency and it comes to be 29.75 %. Thus it is seen that the Water Use Efficiency is very low.

As per the CWC guideline, the Conveyance Efficiency can be increased to a maximum of 75% by fully lining the canals. But the canals of the Birinchiguri irrigation Project are not fully lined. If the canals are converted to fully lined canals, then the seepage loss would reduce to a great extent. The amount of water that can be saved from seepage in this manner and the additional area that be irrigated with this saved water has been determined. It was found that if the canals are fully lined and the Conveyance Efficiency is assumed to be 75% then a huge amount of water, i.e., 0.703 Mm^3 can be saved. An area of 78.144 Ha can be irrigated with the help of this water. Again, if the maintenance level is very good then the Conveyance Efficiency can be increased up to 95%. In this case, 2.18 Mm^3 of water can be saved which can irrigate an additional area of 242.54 Ha. The tail end of the project will also receive much benefit from it. This would help to reduce the gap between the irrigation potential created and that utilized. As a result there would be less wastage of water.

6.2 CONCLUSION

From the present study, it can be concluded that the water supplied through the canals is not fully utilized to the paddy field. It may be due to losses due to seepage, leakages in the canals, evaporation losses etc. Though evaporation loss cannot be reduced but Seepage loss can be reduced by lining of the canals and we can get a better efficiency than the present condition.

6.3 SCOPE FOR FUTURE STUDIES

There is vast scope for improvement of performance through various water management techniques. Further works are necessary for appropriate water distribution in the command area. On Farm Application Efficiency is also another factor for low overall Water Use Efficiency. On Farm Application Efficiency is low due to poor performance of water application through field channels, for which studies are necessary. Conjunctive use of water not yet been planned in the command area. But, there is scope for development of irrigation based on conjunctive use, which is to be studied. Application of new technology like canal automation may add new dimension to project which may be introduced on pilot command.

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APPENDIX -I

Calculation of average wetted perimeter and cross-sectional area of inflow and outflow of canal M1 with the help of ranging rod, float and stop watch.

Section I (Ch. 0.00 m to 50.00 m):
(a) Inflow (At ch. 0.00 m):

Width = 2.00 m

Depth of flow= 0.60 m

Wetted perimeter = 2 x 0.60 + 2.00 = 3.20 m

Distance travelled (s) = 9.00 m

Time taken (t) = 12 sec

Velocity (v) = s/t = 9/12 = 0.75 m/s

The mean velocity in the vertical is determined as the float velocity multiplied by a coefficient which varies between 0.80 and 0.85. Here, we have considered it as 0.85.

Hence, mean velocity (V_m) = 0.85 x 0.75 = 0.63 m/s

Inflow Discharge (Q) = A. V_m

= (2 x 0.60) x 0.63

= 0.765 m^3/s

(b) **Outflow (At ch. 50.00 m):**

Width = 2.00 m

Depth of flow= 0.58 m

Wetted perimeter = 2 x 0.58 + 2.00 = 3.16 m

Distance travelled (s) = 9.00 m

Time taken (t) = 13 sec

Velocity (v) = s/t = 9/13 = 0.692 m/s

The mean velocity in the vertical is determined as the float velocity multiplied by a coefficient which varies between 0.80 and 0.85. Here, we have considered it as 0.85.

Hence, mean velocity (V_m) = 0.85 x 0.692 = 0.588 m/s

Outflow Discharge (Q) = A. V_m

= (2 x 0.58) x 0.588

= 0.683 m^3/s

Average wetted perimeter = (3.2+3.16)/2
= 3.18 m

Section II (Ch. 50.00 m to 100.00 m):

(a) Inflow (At ch. 50.00 m):

Width = 2.00 m

Depth of flow= 0.58 m

Wetted perimeter = 2 x 0.58 + 2.00 = 3.16 m

Distance travelled (s) = 9.00 m

Time taken (t) = 13 sec

Velocity (v) = s/t = 9/13 = 0.692 m/s

The mean velocity in the vertical is determined as the float velocity multiplied by a coefficient which varies between 0.80 and 0.85. Here, we have considered it as 0.85.

Hence, mean velocity (V_m) = 0.85 x 0.692 = 0.588 m/s

Inflow Discharge (Q) = A. V_m

= (2 x 0.58) x 0.588

= 0.683 m^3/s

(b) Outflow (At ch. 100.00 m):

Width = 2.00 m

Depth of flow= 0.55 m

Wetted perimeter = 2 x 0.55 + 2.00 = 3.10 m

Distance travelled (s) = 9.00 m

Time taken (t) = 14 sec

Velocity (v) = s/t = 9/14 = 0.643 m/s

The mean velocity in the vertical is determined as the float velocity multiplied by a coefficient which varies between 0.80 and 0.85. Here, we have considered it as 0.85.

Hence, mean velocity (V_m) = 0.85 x 0.643 = 0.546 m/s

Outflow Discharge (Q) = A. V_m

= (2 x 0.55) x 0.546

= 0.601 m^3/s

Average wetted perimeter = (3.16+3.1)/2

= 3.13 m

Section III (Ch. 100.00 m to 150.00 m):

(a) Inflow (At ch. 100.00 m):

Width = 2.00 m

Depth of flow= 0.55 Wetted perimeter = 2 x 0.55 + 2.00 = 3.10 m

Distance travelled (s) = 9.00 m

Time taken (t) = 14 sec

Velocity (v) = s/t = 9/14 = 0.643 m/s

The mean velocity in the vertical is determined as the float velocity multiplied by a coefficient which varies between 0.80 and 0.85. Here, we have considered it as 0.85.

Hence, mean velocity (V_m) = 0.85 x 0.643 = 0.546 m/s

Inflow Discharge (Q) = A. V_m

= (2 x 0.55) x 0.546

= 0.601 m^3/s

(b) **Outflow (At ch. 150.00 m):**

Width = 2.00 m

Depth of flow= 0.52 m

Wetted perimeter = 2 x 0.52 + 2.00 = 3.04 m

Distance travelled (s) = 9.00 m

Time taken (t) = 15 sec

Velocity (v) = s/t = 9/15 = 0.6 m/s

The mean velocity in the vertical is determined as the float velocity multiplied by a coefficient which varies between 0.80 and 0.85. Here, we have considered it as 0.85.

Hence, mean velocity (V_m) = 0.85 x 0.60 = 0.510 m/s

Outflow Discharge (Q) = A. V_m

= (2 x 0.52) x 0.510

= 0.530 m^3/s

Average wetted perimeter = (3.10+3.04)/2

= 3.07 m

Section IV (Ch. 150.00 m to 200.00 m):

(a) Inflow (At ch. 150.00 m):

Width = 2.00 m

Depth of flow= 0.52 m

Wetted perimeter = 2 x 0.52 + 2.00 = 3.04 m

Distance travelled (s) = 9.00 m

Time taken (t) = 16 sec

Velocity (v) = s/t = 9/16 = 0.56 m/s

The mean velocity in the vertical is determined as the float velocity multiplied by a coefficient which varies between 0.80 and 0.85. Here, we have considered it as 0.85.

Hence, mean velocity (V_m) = 0.85 x 0.56 = 0.478 m/s

Inflow Discharge (Q) = A. V_m

= (2 x 0.52) x 0.478

= 0.497 m^3/s

(b) **Outflow (At ch. 200.00 m):**

Width = 2.00 m

Depth of flow= 0.48 m

Wetted perimeter = 2 x 0.48 + 2.00 = 2.96 m

Distance travelled (s) = 9.00 m

Time taken (t) = 17 sec

Velocity (v) = s/t = 9/17 = 0.529 m/s

The mean velocity in the vertical is determined as the float velocity multiplied by a coefficient which varies between 0.80 and 0.85. Here, we have considered it as 0.85.

Hence, mean velocity (V_m) = 0.85 x 0.529 = 0.450 m/s

Outflow Discharge (Q) = A. V_m

= (2 x 0.48) x 0.450

= 0.432 m^3/s

Average wetted perimeter = (3.04+2.96)/2

= 3.00 m

Section V (Ch. 200.00 m to 250.00 m):

(a) Inflow (At ch. 200.00 m):

Width = 2.00 m

Depth of flow= 0.48 m

Wetted perimeter = 2 x 0.48 + 2.00 = 2.96 m

Distance travelled (s) = 9.00 m

Time taken (t) = 17 sec

Velocity (v) = s/t = 9/17 = 0.529 m/s

The mean velocity in the vertical is determined as the float velocity multiplied by a coefficient which varies between 0.80 and 0.85. Here, we have considered it as 0.85.

Hence, mean velocity (V_m) = 0.85 x 0.529 = 0.450 m/s

Inflow Discharge (Q) = A. V_m

$= (2 \times 0.48) \times 0.450$

$= 0.432\ m^3/s$

(b) **Outflow (At ch. 250.00 m):**

Width = 2.00 m

Depth of flow= 0.45 m

Wetted perimeter = 2 x 0.45 + 2.00 = 2.90 m

Distance travelled (s) = 9.00 m

Time taken (t) = 18 sec

Velocity (v) = s/t = 9/18 = 0.50 m/s

The mean velocity in the vertical is determined as the float velocity multiplied by a coefficient which varies between 0.80 and 0.85. Here, we have considered it as 0.85.

Hence, mean velocity (V_m) = 0.85 x 0.50 = 0.425 m/s

Outflow Discharge (Q) = A. V_m

$= (2 \times 0.45) \times 0.425$

$= 0.383\ m^3/s$

Average wetted perimeter = (2.96+2.90)/2
= 2.93 m

Section VI (Ch. 250.00 m to 267.00 m):
(a) Inflow (At ch. 250.00 m):

Width = 2.00 m

Depth of flow = 0.45 m

Wetted perimeter = 2 x 0.45 + 2.00 = 2.90 m

Distance travelled (s) = 9.00 m

Time taken (t) = 18 sec

Velocity (v) = s/t = 9/18 = 0.50 m/s

The mean velocity in the vertical is determined as the float velocity multiplied by a coefficient which varies between 0.80 and 0.85. Here, we have considered it as 0.85.

Hence, mean velocity (V_m) = 0.85 x 0.50 = 0.425 m/s

Inflow Discharge (Q) = A. V_m

$= (2 \times 0.45) \times 0.425$

$= 0.383\ m^3/s$

(b) **Outflow (At ch. 267.00 m):**

Width = 2.00 m

Depth of flow= 0.40 m

Wetted perimeter = 2 x 0.40 + 2.00 = 2.80 m

Distance travelled (s) = 9.00 m

Time taken (t) = 19 sec

Velocity (v) = s/t = 9/19 = 0.474 m/s

The mean velocity in the vertical is determined as the float velocity multiplied by a coefficient which varies between 0.80 and 0.85. Here, we have considered it as 0.85.

Hence, mean velocity (V_m) = 0.85 x 0.474 = 0.403 m/s

Outflow Discharge (Q) = A. V_m

= (2 x 0.40) x 0.403

= 0.322 m^3/s

Average wetted perimeter = (2.90+2.80)/2

= 2.85 m

Section VII (Ch. 267.00 m to 317.00 m):

(a) Inflow (At ch. 267.00 m):

Width = 1.50 m

Depth of flow= 0.40 m

Wetted perimeter = 2 x 0.40 + 1.50 = 2.30 m

Distance travelled (s) = 9.00 m

Time taken (t) = 19 sec

Velocity (v) = s/t = 9/19 = 0.474 m/s

The mean velocity in the vertical is determined as the float velocity multiplied by a coefficient which varies between 0.80 and 0.85. Here, we have considered it as 0.85.

Hence, mean velocity (V_m) = 0.85 x 0.474 = 0.403 m/s

Inflow Discharge (Q) = A. V_m

= (1.50 x 0.40) x 0.403

= 0.242 m^3/s

(b) **Outflow (At ch. 317.00 m):**

Width = 1.50 m

Depth of flow= 0.30 m

Wetted perimeter = 2 x 0.30 + 1.50 = 2.1 m

Distance travelled (s) = 9.00 m

Time taken (t) = 18 sec

Velocity (v) = s/t = 9/18 = 0.50 m/s

The mean velocity in the vertical is determined as the float velocity multiplied by a coefficient which varies between 0.80 and 0.85. Here, we have considered it as 0.85.

Hence, mean velocity (V_m) = 0.85 x 0.50 = 0.425 m/s

Outflow Discharge (Q) = A. V_m

= (1.5 x 0.30) x 0.425

= 0.191 m^3/s

Average wetted perimeter = (2.30+2.10)/2

= 2.20 m

Section VIII (Ch. 317.00 m to 367.00 m):

(a) Inflow (At ch. 317.00 m):

Width = 1.50 m

Depth of flow= 0.30 m

Wetted perimeter = 2 x 0.30 + 1.50 = 2.1 m

Distance travelled (s) = 9.00 m

Time taken (t) = 18 sec

Velocity (v) = s/t = 9/18 = 0.50 m/s

The mean velocity in the vertical is determined as the float velocity multiplied by a coefficient which varies between 0.80 and 0.85. Here, we have considered it as 0.85.

Hence, mean velocity (V_m) = 0.85 x 0.50 = 0.425 m/s

Inflow Discharge (Q) = A. V_m

= (1.5 x 0.30) x 0.425

= 0.191 m^3/s

(b) **Outflow (At ch. 367.00 m):**

Width = 1.50 m

Depth of flow= 0.25 m

Wetted perimeter = 2 x 0.25 + 1.5 = 2.00 m

Distance travelled (s) = 9.00 m

Time taken (t) = 20 sec

Velocity (v) = s/t = 9/20 = 0.450 m/s

The mean velocity in the vertical is determined as the float velocity multiplied by a coefficient which varies between 0.80 and 0.85. Here, we have considered it as 0.85.

Hence, mean velocity (V_m) = 0.85 x 0.450 = 0.383 m/s

Outflow Discharge (Q) = A. V_m

= (1.50 x 0.25) x 0.383

= 0.143 m^3/s

Average wetted perimeter = (2.10+2.00)/2
= 2.05 m

Section IX (Ch. 367.00 m to 417.00 m):
(a) Inflow (At ch. 367.00 m):

Width = 1.50 m

Depth of flow= 0.25 m

Wetted perimeter = 2 x 0.25 + 1.5 = 2.00 m

Distance travelled (s) = 9.00 m

Time taken (t) = 19 sec

Velocity (v) = s/t = 9/19 = 0.474 m/s

The mean velocity in the vertical is determined as the float velocity multiplied by a coefficient which varies between 0.80 and 0.85. Here, we have considered it as 0.85.

Hence, mean velocity (V_m) = 0.85 x 0.474 = 0.403 m/s

Inflow Discharge (Q) = A. V_m

= (1.50 x 0.25) x 0.403

= 0.151 m^3/s

(b) **Outflow (At ch. 417.00 m):**

Width = 1.50 m

Depth of flow= 0.20 m

Wetted perimeter = 2 x 0.20 + 1.5 = 1.90 m

Distance travelled (s) = 9.00 m

Time taken (t) = 18 sec

Velocity (v) = s/t = 9/18 = 0.50 m/s

The mean velocity in the vertical is determined as the float velocity multiplied by a coefficient which varies between 0.80 and 0.85. Here, we have considered it as 0.85.

Hence, mean velocity (V_m) = 0.85 x 0.50 = 0.425 m/s

Outflow Discharge (Q) = A. V_m

= (1.50 x 0.20) x 0.425

= 0.128 m^3/s

Average wetted perimeter = (2.00+1.90)/2

= 1.95 m

Section X (Ch. 417.00 m to 467.00 m):
(a) Inflow (At ch. 417.00 m):

Width = 1.50 m

Depth of flow= 0.20 m

Wetted perimeter = 2 x 0.20 + 1.5 = 1.90 m

Distance travelled (s) = 9.00 m

Time taken (t) = 18 sec

Velocity (v) = s/t = 9/18 = 0.50 m/s

The mean velocity in the vertical is determined as the float velocity multiplied by a coefficient which varies between 0.80 and 0.85. Here, we have considered it as 0.85.

Hence, mean velocity (V_m) = 0.85 x 0.50 = 0.425 m/s

Inflow Discharge (Q) = A. V_m

= (1.50 x 0.20) x 0.425

= 0.128 m^3/s

(b) **Outflow (At ch. 467.00 m):**

Width = 1.50 m

Depth of flow= 0.18 m

Wetted perimeter = 2 x 0.18 + 1.5 = 1.86 m

Distance travelled (s) = 9.00 m

Time taken (t) = 120 sec

Velocity (v) = s/t = 9/20 = 0.450 m/s

The mean velocity in the vertical is determined as the float velocity multiplied by a coefficient which varies between 0.80 and 0.85. Here, we have considered it as 0.85.

Hence, mean velocity (V_m) = 0.85 x 0.450 = 0.383 m/s

Outflow Discharge (Q) = A. V_m

= (1.50 x 0.18) x 0.383

= 0.103 m^3/s

Average wetted perimeter = (1.90+1.86)/2

= 1.88 m

Section XI (Ch. 467.00 m to 517.00 m):
(a) Inflow (At ch. 467.00 m):

Width = 1.50 m

Depth of flow= 0.18 m

Wetted perimeter = 2 x 0.18 + 1.5 = 1.86 m

Distance travelled (s) = 9.00 m

Time taken (t) = 20 sec

Velocity (v) = s/t = 9/20 = 0.450 m/s

The mean velocity in the vertical is determined as the float velocity multiplied by a coefficient which varies between 0.80 and 0.85. Here, we have considered it as 0.85.

Hence, mean velocity (V_m) = 0.85 x 0.450 = 0.383 m/s

Inflow Discharge (Q) = A. V_m

= (1.50 x 0.18) x 0.383

= 0.103 m^3/s

(b) **Outflow (At ch. 517.00 m):**

Width = 1.50 m

Depth of flow= 0.16 m

Wetted perimeter = 2 x 0.16 + 1.5 = 1.82 m

Distance travelled (s) = 9.00 m

Time taken (t) = 23 sec

Velocity (v) = s/t = 9/23 = 0.391 m/s

The mean velocity in the vertical is determined as the float velocity multiplied by a coefficient which varies between 0.80 and 0.85. Here, we have considered it as 0.85.Hence, mean velocity (V_m) = 0.85 x 0.391 = 0.333 m/s

Outflow Discharge (Q) = A. V_m

= (1.50 x 0.16) x 0.333

= 0.080 m^3/s

Average wetted perimeter = (1.86+1.82)/2

= 1.84 m

Section XII (Ch. 517.00 m to 567.00 m):

(a) Inflow (At ch. 517.00 m):

Width = 1.50 m

Depth of flow= 0.16 m

Wetted perimeter = 2 x 0.16 + 1.5 = 1.82 m

Distance travelled (s) = 9.00 m

Time taken (t) = 23 sec

Velocity (v) = s/t = 9/23 = 0.391 m/s

The mean velocity in the vertical is determined as the float velocity multiplied by a coefficient which varies between 0.80 and 0.85. Here, we have considered it as 0.85.

Hence, mean velocity (V_m) = 0.85 x 0.391 = 0.333 m/s

Inflow Discharge (Q) = A. V_m

= (1.50 x 0.16) x 0.333

= 0.080 m^3/s

(b) **Outflow (At ch. 567.00 m):**

Width = 1.50 m

Depth of flow= 0.15 m

Wetted perimeter = 2 x 0.15 + 1.5 = 1.80 m

Distance travelled (s) = 9.00 m

Time taken (t) = 27 sec

Velocity (v) = s/t = 9/27 = 0.333 m/s

The mean velocity in the vertical is determined as the float velocity multiplied by a coefficient which varies between 0.80 and 0.85. Here, we have considered it as 0.85.

Hence, mean velocity (V_m) = 0.85 x 0.333 = 0.283 m/s

Outflow Discharge (Q) = A. V_m

= (1.50 x 0.15) x 0.283

= 0.064 m^3/s

Average wetted perimeter = (1.82+1.8)/2

= 1.81 m

Section XIII (Ch. 567.00 m to 617.00 m):

(a) Inflow (At ch. 567.00 m):

Width = 1.50 m

Depth of flow= 0.15 m

Wetted perimeter = 2 x 0.15 + 1.5 = 1.80 m

Distance travelled (s) = 9.00 m

Time taken (t) = 27 sec

Velocity (v) = s/t = 9/27 = 0.333 m/s

The mean velocity in the vertical is determined as the float velocity multiplied by a coefficient which varies between 0.80 and 0.85. Here, we have considered it as 0.85.

Hence, mean velocity (V_m) = 0.85 x 0.333 = 0.283 m/s

Inflow Discharge (Q) = A. V_m

= (1.50 x 0.15) x 0.283

= 0.064 m^3/s

(b) **Outflow (At ch. 617.00 m):**

Width = 1.50 m

Depth of flow= 0.15 m

Wetted perimeter = 2 x 0.15 + 1.5 = 1.80 m

Distance travelled (s) = 9.00 m

Time taken (t) = 32 sec

Velocity (v) = s/t = 9/32 = 0.281 m/s

The mean velocity in the vertical is determined as the float velocity multiplied by a coefficient which varies between 0.80 and 0.85. Here, we have considered it as 0.85.

Hence, mean velocity (V_m) = 0.85 x 0.281 = 0.239 m/s

Outflow Discharge (Q) = A. V_m

= (1.50 x 0.15) x 0.239

= 0.054 m^3/s

Average wetted perimeter = (1.8+1.8)/2

= 1.8 m

Section XIV (Ch. 617.00 m to 667.00 m):

(a) Inflow (At ch. 617.00 m):

Width = 1.50 m

Depth of flow= 0.15 m

Wetted perimeter = 2 x 0.15 + 1.5 = 1.80 m

Distance travelled (s) = 9.00 m

Time taken (t) = 32 sec

Velocity (v) = s/t = 9/32 = 0.281 m/s

The mean velocity in the vertical is determined as the float velocity multiplied by a coefficient which varies between 0.80 and 0.85. Here, we have considered it as 0.85.

Hence, mean velocity (V_m) = 0.85 x 0.281 = 0.239 m/s

Inflow Discharge (Q) = A. V_m

= (1.50 x 0.15) x 0.239

= 0.054 m^3/s

(b) **Outflow (At ch. 667.00 m):**

Width = 1.50 m

Depth of flow= 0.13 m

Wetted perimeter = 2 x 0.13 + 1.5 = 1.76 m

Distance travelled (s) = 9.00 m

Time taken (t) = 36 sec

Velocity (v) = s/t = 9/36 = 0.250 m/s

The mean velocity in the vertical is determined as the float velocity multiplied by a coefficient which varies between 0.80 and 0.85. Here, we have considered it as 0.85.

Hence, mean velocity (V_m) = 0.85 x 0.250 = 0.213 m/s

Outflow Discharge (Q) = A. V_m

= (1.50 x 0.13) x 0.213

= 0.041 m^3/s

Average wetted perimeter = (1.80+1.76)/2

= 1.78 m

Section XV (Ch. 667.00 m to 700.00 m):

(a) Inflow (At ch. 667.00 m):

Width = 1.50 m

Depth of flow= 0.13 m

Wetted perimeter = 2 x 0.13 + 1.5 = 1.76 m

Distance travelled (s) = 9.00 m

Time taken (t) = 36 sec

Velocity (v) = s/t = 9/36 = 0.250 m/s

The mean velocity in the vertical is determined as the float velocity multiplied by a coefficient which varies between 0.80 and 0.85. Here, we have considered it as 0.85.

Hence, mean velocity (V_m) = 0.85 x 0.250 = 0.213 m/s

Inflow Discharge (Q) = A. V_m

= (1.50 x 0.13) x 0.213

= 0.041 m^3/s

(b) **Outflow (At ch. 700.00 m):**

Width = 1.50 m

Depth of flow= 0.12 m

Wetted perimeter = 2 x 0.12 + 1.5 = 1.74 m

Distance travelled (s) = 9.00 m

Time taken (t) = 41 sec

Velocity (v) = s/t = 9/41 = 0.220 m/s

The mean velocity in the vertical is determined as the float velocity multiplied by a coefficient which varies between 0.80 and 0.85. Here, we have considered it as 0.85.

Hence, mean velocity (V_m) = 0.85 x 0.220 = 0.187 m/s

Outflow Discharge (Q) = A. V_m

= (1.50 x 0.12) x 0.187

= 0.034 m^3/s

Average wetted perimeter = (1.76+1.74)/2

= 1.75 m

Section XVI (Ch. 700.00 m to 750.00 m):

(a) Inflow (At ch. 700.00 m):

Sl. No.	Distance in meter (B_n)	Depth of flow at distance (d_n) (m)	Intermediate distance b_n (B_{n+1}- B_n) (m)	Depth difference (d_{n+1}- d_n) (m)	Average depth $\frac{dn+1+dn}{2}$ (m)	Intermediate wetted perimeter $\sqrt{Col.4^2 + Col.5^2}$ (m)	Intermediate cross-sectional area (Col. 4 x Col. 6) sqm
1	2	3	4	5	6	7	8
1	0	0					
2	0.7	0.15	0.7	0.15	0.075	0.71	0.0525
3	1.4	0	0.7	0.15	0.075	0.71	0.0525
				Grand Total		1.42	0.105

Distance travelled (s) = 9.00 m

Time taken (t) = 50 sec

Velocity (v) = s/t = 9/50 = 0.18 m/s

The mean velocity in the vertical is determined as the float velocity multiplied by a coefficient which varies between 0.80 and 0.85. Here, we have considered it as 0.85.

Hence, mean velocity (V_m) = 0.85 x 0.18 = 0.153 m/s

Inflow Discharge (Q) = A. V_m

= 0.105 x 0.153

= 0.016 m^3/s

(b) Outflow (At ch. 750.00 m)

Sl. No.	Distance in meter (B_n)	Depth of flow at distance (d_n) (m)	Intermediate distance b_n (B_{n+1}- B_n) (m)	Depth difference (d_{n+1}- d_n) (m)	Average depth $\frac{dn+1+dn}{2}$ (m)	Intermediate wetted perimeter $\sqrt{Col.4^2 + Col.5^2}$ (m)	Intermediate cross-sectional area (Col. 4 x Col. 6) sqm
1	2	3	4	5	6	7	8
1	0	0					
2	0.5	0.10	0.5	0.10	0.05	0.509	0.025
3	1.0	0	0.5	0.10	0.05	0.509	0.025
				Grand Total		1.18	0.05

Distance travelled (s) = 9.00 m

Time taken (t) = 59 sec

Velocity (v) = s/t = 9/59 = 0.15 m/s

The mean velocity in the vertical is determined as the float velocity multiplied by a coefficient which varies between 0.80 and 0.85. Here, we have considered it as 0.85.

Hence, mean velocity (V_m) = 0.85 x 0.15= 0.123 m/s

Outflow Discharge (Q) = A. V_m

= 0.05 x 0.123

= 0.0062 m^3/s

Average wetted perimeter = (1.42+1.18)/2
= 1.30 m

Section XVII (Ch. 750.00 m to 800.00 m):
(a) Inflow (At ch. 750.00 m)

Sl. No.	Distance in meter (B_n)	Depth of flow at distance (d_n) (m)	Intermediate distance b_n (B_{n+1}- B_n) (m)	Depth difference (d_{n+1}- d_n) (m)	Average depth $\frac{dn+1+dn}{2}$ (m)	Intermediate wetted perimeter $\sqrt{Col.4^2 + Col.5^2}$ (m)	Intermediate cross-sectional area (Col. 4 x Col. 6) sqm
1	2	3	4	5	6	7	8
1	0	0					
2	0.7	0.15	0.7	0.15	0.075	0.71	0.0525
3	1.4	0	0.7	0.15	0.075	0.71	0.0525
				Grand Total		1.42	0.105

Distance travelled (s) = 9.00 m

Time taken (t) = 72 sec

Velocity (v) = s/t = 9/72 = 0.125 m/s

The mean velocity in the vertical is determined as the float velocity multiplied by a coefficient which varies between 0.80 and 0.85. Here, we have considered it as 0.85.

Hence, mean velocity (V_m) = 0.85 x 0.125 = 0.106 m/s

Inflow Discharge (Q) = A. V_m

= 0.105 x 0.106

= 0.011 m^3/s

(b) Outflow (At ch. 800.00 m)

Sl. No.	Distance in meter (B_n)	Depth of flow at distance (d_n) (m)	Intermediate distance b_n (B_{n+1}- B_n) (m)	Depth difference (d_{n+1}- d_n) (m)	Average depth $\frac{dn+1+dn}{2}$ (m)	Intermediate wetted perimeter $\sqrt{Col.4^2+Col.5^2}$ (m)	Intermediate cross-sectional area (Col. 4 x Col. 6) sqm
1	2	3	4	5	6	7	8
1	0	0					
2	0.5	0.14	0.5	0.14	0.07	0.519	0.035
3	1.0	0	0.5	0.14	0.07	0.519	0.035
				Grand Total		1.038	0.07

Distance travelled (s) = 9.00 m

Time taken (t) = 71 sec

Velocity (v) = s/t = 9/71 = 0.126 m/s

The mean velocity in the vertical is determined as the float velocity multiplied by a coefficient which varies between 0.80 and 0.85. Here, we have considered it as 0.85.

Hence, mean velocity (V_m) = 0.85 x 0.126= 0.1071 m/s

Outflow Discharge (Q) = A. V_m

= 0.07 x 0.1071

= 0.0074 m^3/s

Average wetted perimeter = (1.42+1.038)/2
= 1.229 m

Section XVIII (Ch. 800.00 m to 850.00 m):

(a) Inflow (At ch. 800.00 m):

Sl. No.	Distance in meter (B_n)	Depth of flow at distance (d_n) (m)	Intermediate distance b_n (B_{n+1}- B_n) (m)	Depth difference (d_{n+1}- d_n) (m)	Average depth $\frac{dn+1+dn}{2}$ (m)	Intermediate wetted perimeter $\sqrt{Col.4^2+Col.5^2}$ (m)	Intermediate cross-sectional area (Col. 4 x Col. 6) sqm
1	2	3	4	5	6	7	8
1	0	0					
2	0.5	0.10	0.5	0.10	0.05	0.509	0.025
3	1.0	0	0.5	0.10	0.05	0.509	0.025
				Grand Total		1.018	0.05

Distance travelled (s) = 9.00 m

Time taken (t) = 75 sec

Velocity (v) = s/t = 9/75 = 0.12 m/s

The mean velocity in the vertical is determined as the float velocity multiplied by a coefficient which varies between 0.80 and 0.85. Here, we have considered it as 0.85.

Hence, mean velocity (V_m) = 0.85 x 0.12 = 0.102 m/s

Inflow Discharge (Q) = A. V_m

= 0.05 x 0.102

= 0.0051 m^3/s

(b) Outflow (At ch. 850.00 m)

Sl. No.	Distance in meter (B_n)	Depth of flow at distance (d_n) (m)	Intermediate distance b_n (B_{n+1}- B_n) (m)	Depth difference (d_{n+1}- d_n) (m)	Average depth $\frac{dn+1+dn}{2}$ (m)	Intermediate wetted perimeter $\sqrt{Col.4^2+Col.5^2}$ (m)	Intermediate cross-sectional area (Col. 4 x Col. 6) sqm
1	2	3	4	5	6	7	8
1	0	0					
2	0.5	0.10	0.5	0.10	0.05	0.509	0.025
3	1.0	0	0.5	0.10	0.05	0.509	0.025
				Grand Total		1.018	0.05

Distance travelled (s) = 9.00 m

Time taken (t) = 78 sec

Velocity (v) = s/t = 9/78 = 0.115 m/s

The mean velocity in the vertical is determined as the float velocity multiplied by a coefficient which varies between 0.80 and 0.85. Here, we have considered it as 0.85.

Hence, mean velocity (V_m) = 0.85 x 0.115 = 0.098 m/s

Outflow Discharge (Q) = A. V_m

= 0.05 x 0.098

= 0.0049 m^3/s

Average wetted perimeter = (1.018+1.018)/2
= 1.018 m

Section XIX (Ch. 850.00 m to 900.00 m):
(a) Inflow (At ch. 850.00 m)

Sl. No.	Distance in meter (B_n)	Depth of flow at distance (d_n) (m)	Intermediate distance b_n (B_{n+1}- B_n) (m)	Depth difference (d_{n+1}- d_n) (m)	Average depth $\frac{dn+1+dn}{2}$ (m)	Intermediate wetted perimeter $\sqrt{Col.4^2+Col.5^2}$ (m)	Intermediate cross-sectional area (Col. 4 x Col. 6) sqm
1	2	3	4	5	6	7	8
1	0	0					
2	0.5	0.14	0.5	0.14	0.07	0.519	0.035
3	1.0	0	0.5	0.14	0.07	0.519	0.035
				Grand Total		1.038	0.07

Distance travelled (s) = 9.00 m

Time taken (t) = 78 sec

Velocity (v) = s/t = 9/78 = 0.115 m/s

The mean velocity in the vertical is determined as the float velocity multiplied by a coefficient which varies between 0.80 and 0.85. Here, we have considered it as 0.85.

Hence, mean velocity (V_m) = 0.85 x 0.115 = 0.098 m/s

Inflow Discharge (Q) = A. V_m

= 0.07 x 0.098

= 0.0068 m^3/s

(b) **Outflow (At ch. 900.00 m)**

Sl. No.	Distance in meter (B_n)	Depth of flow at distance (d_n) (m)	Intermediate distance b_n (B_{n+1}- B_n) (m)	Depth difference (d_{n+1}- d_n) (m)	Average depth $\frac{dn+1+dn}{2}$ (m)	Intermediate wetted perimeter $\sqrt{Col.4^2+Col.5^2}$ (m)	Intermediate cross-sectional area (Col. 4 x Col. 6) sqm
1	2	3	4	5	6	7	8
1	0	0					
2	0.5	0.10	0.5	0.10	0.05	0.509	0.025
3	1.0	0	0.5	0.10	0.05	0.509	0.025
				Grand Total		1.018	0.05

Distance travelled (s) = 9.00 m

Time taken (t) = 83 sec

Velocity (v) = s/t = 9/83 = 0.108 m/s

The mean velocity in the vertical is determined as the float velocity multiplied by a coefficient which varies between 0.80 and 0.85. Here, we have considered it as 0.85.

Hence, mean velocity (V_m) = 0.85 x 0.108 = 0.091 m/s

Outflow Discharge (Q) = A. V_m

= 0.05 x 0.091

= 0.00455 m^3/s

Average wetted perimeter = (1.038+1.018)/2

= 1.028 m

APPENDIX-II

Calculation of average wetted perimeter and cross-sectional area of inflow and outflow of canal B1 with the help of ranging rod, float and stop watch.

Section I (Ch. 0.00 m to 50.00 m):
(a) Inflow (At ch. 0.00 m):

Width = 1.00 m

Depth of flow= 0.35 m

Wetted perimeter = 2 x 0.35 + 1.00 = 1.70 m

Distance travelled (s) = 9.00 m

Time taken (t) = 15 sec

Velocity (v) = s/t = 9/15 = 0.6 m/s

The mean velocity in the vertical is determined as the float velocity multiplied by a coefficient which varies between 0.80 and 0.85. Here, we have considered it as 0.85.

Hence, mean velocity (V_m) = 0.85 x 0.60 = 0.51 m/s

Inflow Discharge (Q) = A. V_m

= (1.0 x 0.35) x 0.51

= 0.1785 m^3/s

(b)Outflow (At ch. 50.00 m):

Width = 1.00 m

Depth of flow= 0.31 m

Wetted perimeter = 2 x 0.31 + 1.00 = 1.62 m

Distance travelled (s) = 9.00 m

Time taken (t) = 17 sec

Velocity (v) = s/t = 9/17 = 0.52 m/s

The mean velocity in the vertical is determined as the float velocity multiplied by a coefficient which varies between 0.80 and 0.85. Here,we have considered it as 0.85.

Hence, mean velocity (V_m) = 0.85 x 0.52 = 0.442 m/s

Outflow Discharge (Q) = A. V_m

= (1.0 x 0.31) x 0.442

= 0.13 m^3/s

Average wetted perimeter = (1.70+1.62)/2
= 1.66 m

Section II (Ch. 50.00 m to 75.00 m):

(a) Inflow (At ch. 50.00 m):

Width = 1.00 m

Depth of flow= 0.30 m

Wetted perimeter = 2 x 0.30 + 1.00 = 1.6 m

Distance travelled (s) = 9.00 m

Time taken (t) = 17 sec

Velocity (v) = s/t = 9/17 = 0.52 m/s

The mean velocity in the vertical is determined as the float velocity multiplied by a coefficient which varies between 0.80 and 0.85. Here,we have considered it as 0.85.

Hence, mean velocity (V_m) = 0.85 x 0.52 = 0.442 m/s

Inflow Discharge (Q) = A. V_m

= (1.0 x 0.30) x 0.442

= 0.13 m^3/s

(b) Outflow (At ch. 75.00 m):

Width = 1.00 m

Depth of flow= 0.22 m

Wetted perimeter = 2 x 0.22 + 1.00 = 1.44 m

Distance travelled (s) = 9.00 m

Time taken (t) = 18 sec

Velocity (v) = s/t = 9/18 = 0.5 m/s

The mean velocity in the vertical is determined as the float velocity multiplied by a coefficient which varies between 0.80 and 0.85. Here, we have considered it as 0.85.

Hence, mean velocity (V_m) = 0.85 x 0.50 = 0.425 m/s

Outflow Discharge (Q) = A. V_m

= (1.0 x 0.22) x 0.425

= 0.0935 m^3/s

Average wetted perimeter = (1.60+1.44)/2

= 1.52 m

Section III (Ch. 75.00 m to 125.00 m):
(a)Inflow (At ch. 75.00 m):

Sl. No.	Distance in meter (B_n)	Depth of flow at distance (d_n) (m)	Intermediate distance b_n (B_{n+1}- B_n) (m)	Depth difference (d_{n+1}- d_n) (m)	Average depth $\frac{dn+1+dn}{2}$ (m)	Intermediate wetted perimeter $\sqrt{Col.4^2 + Col.5^2}$ (m)	Intermediate cross-sectional area (Col. 4 x Col. 6) sqm
1	2	3	4	5	6	7	8
1	0	0					
2	0.7	0.27	0.7	0.27	0.135	0.75	0.0945
3	1.4	0	0.7	0.27	0.135	0.75	0.0945
				Grand Total		1.50	0.189

Distance travelled (s) = 9.00 m

Time taken (t) = 18 sec

Velocity (v) = s/t = 9/18 = 0.50 m/s

The mean velocity in the vertical is determined as the float velocity multiplied by a coefficient which varies between 0.80 and 0.85. Here, we have considered it as 0.85.

Hence, mean velocity (V_m) = 0.85 x 0.50 = 0.425 m/s

Inflow Discharge (Q) = A. V_m

= 0.189 x 0.425

= 0.080 m^3/s

(b) Outflow (At ch. 125.00 m)

Sl. No.	Distance in meter (B_n)	Depth of flow at distance (d_n) (m)	Intermediate distance b_n (B_{n+1}- B_n) (m)	Depth difference (d_{n+1}- d_n) (m)	Average depth $\frac{dn+1+dn}{2}$ (m)	Intermediate wetted perimeter $\sqrt{Col.4^2 + Col.5^2}$ (m)	Intermediate cross-sectional area (Col. 4 x Col. 6) sqm
1	2	3	4	5	6	7	8
1	0	0					
2	0.6	0.24	0.60	0.24	0.12	0.646	0.072
3	1.2	0	0.60	0.24	0.12	0.646	0.072
				Grand Total		1.292	0.144

Distance travelled (s) = 9.00 m

Time taken (t) = 23 sec

Velocity (v) = s/t = 9/23 = 0.391 m/s

The mean velocity in the vertical is determined as the float velocity multiplied by a coefficient which varies between 0.80 and 0.85. Here, we have considered it as 0.85.

Hence, mean velocity (V_m) = 0.85 x 0.391 = 0.332 m/s

Outflow Discharge (Q) = A. V_m

= 0.144 x 0.332

= 0.047 m^3/s

Average wetted perimeter = (1.5+1.292)/2

= 1.396 m

Section IV (Ch. 125.00 m to 175.00 m):
(a)Inflow (At ch. 125.00 m)

Sl. No.	Distance in meter (B_n)	Depth of flow at distance (d_n) (m)	Intermediate distance b_n (B_{n+1}- B_n) (m)	Depth difference (d_{n+1}- d_n) (m)	Average depth $\frac{dn+1+dn}{2}$ (m)	Intermediate wetted perimeter $\sqrt{Col.4^2+Col.5^2}$ (m)	Intermediate cross-sectional area (Col. 4 x Col. 6) sqm
1	2	3	4	5	6	7	8
1	0	0					
2	0.6	0.24	0.60	0.24	0.12	0.646	0.072
3	1.2	0	0.60	0.24	0.12	0.646	0.072
				Grand Total		1.292	0.144

Distance travelled (s) = 9.00 m

Time taken (t) = 22 sec

Velocity (v) = s/t = 9/22 = 0.409 m/s

The mean velocity in the vertical is determined as the float velocity multiplied by a coefficient which varies between 0.80 and 0.85. Here, we have considered it as 0.85.

Hence, mean velocity (V_m) = 0.85 x 0.409 = 0.348 m/s

Inflow Discharge (Q) = A. V_m

= 0.144 x 0.348

= 0.050 m^3/s

(b)Outflow (At ch. 175.00 m)

Sl. No.	Distance in meter (B_n)	Depth of flow at distance (d_n) (m)	Intermediate distance b_n (B_{n+1}- B_n) (m)	Depth difference (d_{n+1}- d_n) (m)	Average depth $\frac{dn+1+dn}{2}$ (m)	Intermediate wetted perimeter $\sqrt{Col.4^2+Col.5^2}$ (m)	Intermediate cross-sectional area (Col. 4 x Col. 6) sqm
1	2	3	4	5	6	7	8
1	0	0					
2	0.5	0.22	0.50	0.22	0.11	0.686	0.055
3	1.0	0	0.50	0.22	0.11	0.686	0.055
				Grand Total		1.372	0.11

Distance travelled (s) = 9.00 m

Time taken (t) = 27 sec

Velocity (v) = s/t = 9/27 = 0.33 m/s

The mean velocity in the vertical is determined as the float velocity multiplied by a coefficient which varies between 0.80 and 0.85. Here, we have considered it as 0.85.

Hence, mean velocity (V_m) = 0.85 x 0.33 = 0.28 m/s

Outflow Discharge (Q) = A. V_m

= 0.11 x 0.28

= 0.030 m^3/s

Average wetted perimeter = (1.292+1.372)/2

= 1.332 m

Section V (Ch. 175.00 m to 225.00 m):
(a)Inflow (At ch. 175.00 m)

Sl. No.	Distance in meter (B_n)	Depth of flow at distance (d_n) (m)	Intermediate distance b_n (B_{n+1}- B_n) (m)	Depth difference (d_{n+1}- d_n) (m)	Average depth $\frac{dn+1+dn}{2}$ (m)	Intermediate wetted perimeter $\sqrt{Col.4^2+Col.5^2}$ (m)	Intermediate cross-sectional area (Col. 4 x Col. 6) sqm
1	2	3	4	5	6	7	8
1	0	0					
2	0.5	0.22	0.50	0.22	0.11	0.686	0.055
3	1.0	0	0.50	0.22	0.11	0.686	0.055
				Grand Total		1.372	0.11

Distance travelled (s) = 9.00 m

Time taken (t) = 27 sec

Velocity (v) = s/t = 9/27 = 0.33 m/s

The mean velocity in the vertical is determined as the float velocity multiplied by a coefficient which varies between 0.80 and 0.85. Here, we have considered it as 0.85.

Hence, mean velocity (V_m) = 0.85 x 0.33 = 0.28 m/s

Inflow Discharge (Q) = A. V_m

= 0.11 x 0.28

= 0.030 m^3/s

(b)Outflow (At ch. 225.00 m)

Sl. No.	Distance in meter (B_n)	Depth of flow at distance (d_n) (m)	Intermediate distance b_n (B_{n+1}- B_n) (m)	Depth difference (d_{n+1}- d_n) (m)	Average depth $\frac{dn+1+dn}{2}$ (m)	Intermediate wetted perimeter $\sqrt{Col.4^2+Col.5^2}$ (m)	Intermediate cross-sectional area (Col. 4 x Col. 6) sqm
1	2	3	4	5	6	7	8
1	0	0					
2	0.5	0.22	0.50	0.22	0.11	0.686	0.055
3	1.0	0	0.50	0.22	0.11	0.686	0.055
				Grand Total		1.372	0.11

Distance travelled (s) = 9.00 m

Time taken (t) = 37 sec

Velocity (v) = s/t = 9/37 = 0.243 m/s

The mean velocity in the vertical is determined as the float velocity multiplied by a coefficient which varies between 0.80 and 0.85. Here, we have considered it as 0.85.

Hence, mean velocity (V_m) = 0.85 x 0.243 = 0.21 m/s

Outflow Discharge (Q) = A. V_m

= 0.11 x 0.21

= 0.0231 m^3/s

Average wetted perimeter = (1.372+1.372)/2

= 1.372 m

Section VI (Ch. 225.00 m to 275.00 m):

(a) Inflow (At ch. 225.00 m)

Sl. No.	Distance in meter (B_n)	Depth of flow at distance (d_n) (m)	Intermediate distance b_n (B_{n+1}- B_n) (m)	Depth difference (d_{n+1}- d_n) (m)	Average depth $\frac{dn+1+dn}{2}$ (m)	Intermediate wetted perimeter $\sqrt{Col.4^2+Col.5^2}$ (m)	Intermediate cross-sectional area (Col. 4 x Col. 6) sqm
1	2	3	4	5	6	7	8
1	0	0					
2	0.5	0.22	0.50	0.22	0.11	0.686	0.055
3	1.0	0	0.50	0.22	0.11	0.686	0.055
				Grand Total		1.372	0.11

Distance travelled (s) = 9.00 m

Time taken (t) = 30 sec

Velocity (v) = s/t = 9/30 = 0.30 m/s

The mean velocity in the vertical is determined as the float velocity multiplied by a coefficient which varies between 0.80 and 0.85. Here, we have considered it as 0.85.

Hence, mean velocity (V_m) = 0.85 x 0.30 = 0.255 m/s

Inflow Discharge (Q) = A. V_m

= 0.11 x 0.255

= 0.028 m^3/s

(b) Outflow (At ch. 275.00 m):

Sl. No.	Distance in meter (B_n)	Depth of flow at distance (d_n) (m)	Intermediate distance b_n (B_{n+1}- B_n) (m)	Depth difference (d_{n+1}- d_n) (m)	Average depth $\frac{dn+1+dn}{2}$ (m)	Intermediate wetted perimeter $\sqrt{Col.4^2+Col.5^2}$ (m)	Intermediate cross-sectional area (Col. 4 x Col. 6) sqm
1	2	3	4	5	6	7	8
1	0	0					
2	0.5	0.18	0.50	0.18	0.09	0.53	0.045
3	1.0	0	0.50	0.18	0.09	0.53	0.045
				Grand Total		1.372	0.09

Distance travelled (s) = 9.00 m

Time taken (t) = 42 sec

Velocity (v) = s/t = 9/42 = 0.214 m/s

The mean velocity in the vertical is determined as the float velocity multiplied by a coefficient which varies between 0.80 and 0.85. Here, we have considered it as 0.85.

Hence, mean velocity (V_m) = 0.85 x 0.214 = 0.181 m/s

Outflow Discharge (Q) = A. V_m

= 0.09 x 0.181

= 0.016 m^3/s

Average wetted perimeter = (1.372+1.372)/2

= 1.372 m

Section VII (Ch. 275.00 m to 325.00 m):

(a) Inflow (At ch. 275.00 m)

Sl. No.	Distance in meter (B_n)	Depth of flow at distance (d_n) (m)	Intermediate distance b_n (B_{n+1}- B_n) (m)	Depth difference (d_{n+1}- d_n) (m)	Average depth $\frac{d_{n+1}+d_n}{2}$ (m)	Intermediate wetted perimeter $\sqrt{Col.4^2+Col.5^2}$ (m)	Intermediate cross-sectional area (Col. 4 x Col. 6) sqm
1	2	3	4	5	6	7	8
1	0	0					
2	0.5	0.18	0.50	0.18	0.09	0.53	0.045
3	1.0	0	0.50	0.18	0.09	0.53	0.045
				Grand Total		1.372	0.09

Distance travelled (s) = 9.00 m

Time taken (t) = 38 sec

Velocity (v) = s/t = 9/38 = 0.23 m/s

The mean velocity in the vertical is determined as the float velocity multiplied by a coefficient which varies between 0.80 and 0.85. Here, we have considered it as 0.85.

Hence, mean velocity (V_m) = 0.85 x 0.23 = 0.20 m/s

Inflow Discharge (Q) = A. V_m

= 0.09 x 0.20

= 0.018 m^3/s

(b) Outflow (At ch. 325.00 m)

Sl. No.	Distance in meter (B_n)	Depth of flow at distance (d_n) (m)	Intermediate distance b_n (B_{n+1}- B_n) (m)	Depth difference (d_{n+1}- d_n) (m)	Average depth $\frac{dn+1+dn}{2}$ (m)	Intermediate wetted perimeter $\sqrt{Col.4^2+Col.5^2}$ (m)	Intermediate cross-sectional area (Col. 4 x Col. 6) sqm
1	2	3	4	5	6	7	8
1	0	0					
2	0.5	0.16	0.50	0.16	0.08	0.52	0.04
3	1.0	0	0.50	0.16	0.08	0.52	0.04
				Grand Total		1.04	0.08

Distance travelled (s) = 9.00 m

Time taken (t) = 45 sec

Velocity (v) = s/t = 9/45= 0.2 m/s

The mean velocity in the vertical is determined as the float velocity multiplied by a coefficient which varies between 0.80 and 0.85. Here, we have considered it as 0.85.

Hence, mean velocity (V_m) = 0.85 x 0.2 = 0.17 m/s

Outflow Discharge (Q) = A. V_m

= 0.08 x 0.17

= 0.0136 m^3/s

Average wetted perimeter = (1.372+1.04)/2

= 1.206 m

Section VIII (Ch. 325.00 m to 375.00 m):

(a) Inflow (At ch. 325.00 m)

Sl. No.	Distance in meter (B_n)	Depth of flow at distance (d_n) (m)	Intermediate distance b_n (B_{n+1}- B_n) (m)	Depth difference (d_{n+1}- d_n) (m)	Average depth $\frac{dn+1+dn}{2}$ (m)	Intermediate wetted perimeter $\sqrt{Col.4^2+Col.5^2}$ (m)	Intermediate cross-sectional area (Col. 4 x Col. 6) sqm
1	2	3	4	5	6	7	8
1	0	0					
2	0.5	0.16	0.50	0.16	0.08	0.52	0.04
3	1.0	0	0.50	0.16	0.08	0.52	0.04
				Grand Total		1.04	0.08

Distance travelled (s) = 9.00 m

Time taken (t) = 45 sec

Velocity (v) = s/t = 9/45= 0.2 m/s

The mean velocity in the vertical is determined as the float velocity multiplied by a coefficient which varies between 0.80 and 0.85. Here, we have considered it as 0.85.

Hence, mean velocity (V_m) = 0.85 x 0.2 = 0.17 m/s

Inflow Discharge (Q) = A. V_m

= 0.08 x 0.17

= 0.0136 m^3/s

(b) Outflow (At ch. 375.00 m)

Sl. No.	Distance in meter (B_n)	Depth of flow at distance (d_n) (m)	Intermediate distance b_n (B_{n+1}- B_n) (m)	Depth difference (d_{n+1}- d_n) (m)	Average depth $\frac{dn+1+dn}{2}$ (m)	Intermediate wetted perimeter $\sqrt{Col.4^2 + Col.5^2}$ (m)	Intermediate cross-sectional area (Col. 4 x Col. 6) sqm
1	2	3	4	5	6	7	8
1	0	0					
2	0.5	0.16	0.50	0.16	0.08	0.52	0.04
3	1.0	0	0.50	0.16	0.08	0.52	0.04
				Grand Total		1.04	0.08

Distance travelled (s) = 9.00 m

Time taken (t) = 60 sec

Velocity (v) = s/t = 9/60= 0.15 m/s

The mean velocity in the vertical is determined as the float velocity multiplied by a coefficient which varies between 0.80 and 0.85. Here, we have considered it as 0.85.

Hence, mean velocity (V_m) = 0.85 x 0.15 = 0.123 m/s

Outflow Discharge (Q) = A. V_m

= 0.08 x 0.123

= 0.0098 m^3/s

Average wetted perimeter = (1.04+1.04)/2
= 1.04 m

Section VIII (Ch. 375.00 m to 425.00 m):

(a) Inflow (At ch. 375.00 m)

Sl. No.	Distance in meter (B_n)	Depth of flow at distance (d_n) (m)	Intermediate distance b_n (B_{n+1}- B_n) (m)	Depth difference (d_{n+1}- d_n) (m)	Average depth $\frac{dn+1+dn}{2}$ (m)	Intermediate wetted perimeter $\sqrt{Col.4^2+Col.5^2}$ (m)	Intermediate cross-sectional area (Col. 4 x Col. 6) sqm
1	2	3	4	5	6	7	8
1	0	0					
2	0.5	0.10	0.50	0.10	0.05	0.51	0.04
3	1.0	0	0.50	0.10	0.05	0.51	0.04
				Grand Total		1.0	0.08

Distance travelled (s) = 9.00 m

Time taken (t) = 60 sec

Velocity (v) = s/t = 9/60= 0.15 m/s

The mean velocity in the vertical is determined as the float velocity multiplied by a coefficient which varies between 0.80 and 0.85. Here, we have considered it as 0.85.

Hence, mean velocity (V_m) = 0.85 x 0.15 = 0.123 m/s

Inflow Discharge (Q) = A. V_m

= 0.08 x 0.123

= 0.0098 m^3/s

(b) Outflow (At ch. 425.00 m)

Sl. No.	Distance in meter (B_n)	Depth of flow at distance (d_n) (m)	Intermediate distance b_n (B_{n+1}- B_n) (m)	Depth difference (d_{n+1}- d_n) (m)	Average depth $\frac{dn+1+dn}{2}$ (m)	Intermediate wetted perimeter $\sqrt{Col.4^2+Col.5^2}$ (m)	Intermediate cross-sectional area (Col. 4 x Col. 6) sqm
1	2	3	4	5	6	7	8
1	0	0					
2	0.5	0.16	0.50	0.16	0.08	0.52	0.04
3	1.0	0	0.50	0.16	0.08	0.52	0.04
				Grand Total		1.04	0.08

Distance travelled (s) = 9.00 m

Time taken (t) = 112 sec

Velocity (v) = s/t = 9/112= 0.080m/s

The mean velocity in the vertical is determined as the float velocity multiplied by a coefficient which varies between 0.80 and 0.85. Here, we have considered it as 0.85.

Hence, mean velocity (V_m) = 0.85 x 0.080 = 0.068 m/s

Outflow Discharge (Q) = A. V_m

= 0.08 x 0.068

= 0.00054 m^3/s

Average wetted perimeter = (1.04+1.04)/2

= 1.04 m

APPENDIX-III

Calculation of average wetted perimeter and cross-sectional area of inflow and outflow of canal B2 with the help of ranging rod, float and stop watch.

Section I (Ch. 0.00 m to 50.00 m):
(a) Inflow (At ch. 0.00 m):

Width = 1.00 m

Depth of flow= 0.35 m

Wetted perimeter = 2 x 0.35 + 1.00 = 1.70 m

Distance travelled (s) = 9.00 m

Time taken (t) = 14 sec

Velocity (v) = s/t = 9/14 = 0.64 m/s

The mean velocity in the vertical is determined as the float velocity multiplied by a coefficient which varies between 0.80 and 0.85. Here, we have considered it as 0.85.

Hence, mean velocity (V_m) = 0.85 x 0.64 = 0.544 m/s

Inflow Discharge (Q) = A. V_m

= (1.0 x 0.35) x 0.544

= 0.1904 m^3/s

(b) Outflow (At ch. 50.00 m):

Width = 1.00 m

Depth of flow= 0.31 m

Wetted perimeter = 2 x 0.31 + 1.00 = 1.62 m

Distance travelled (s) = 9.00 m

Time taken (t) = 17 sec

Velocity (v) = s/t = 9/17 = 0.52 m/s

The mean velocity in the vertical is determined as the float velocity multiplied by a coefficient which varies between 0.80 and 0.85. Here, we have considered it as 0.85.

Hence, mean velocity (V_m) = 0.85 x 0.52 = 0.442 m/s

Outflow Discharge (Q) = A. V_m

= (1.0 x 0.31) x 0.442

= 0.13 m^3/s

Average wetted perimeter = (1.70+1.62)/2
= 1.66 m

Section II (Ch. 50.00 m to 100.00 m):

(a) Inflow (At ch. 50.00 m):

Sl. No.	Distance in meter (B_n)	Depth of flow at distance (d_n) (m)	Intermediate distance b_n (B_{n+1}- B_n) (m)	Depth difference (d_{n+1}- d_n) (m)	Average depth $\frac{dn+1+dn}{2}$ (m)	Intermediate wetted perimeter $\sqrt{Col.4^2+Col.5^2}$ (m)	Intermediate cross-sectional area (Col. 4 x Col. 6) sqm
1	2	3	4	5	6	7	8
1	0	0					
2	0.7	0.27	0.7	0.27	0.135	0.75	0.0945
3	1.4	0	0.7	0.27	0.135	0.75	0.0945
				Grand Total		1.50	0.189

Distance travelled (s) = 9.00 m

Time taken (t) = 17 sec

Velocity (v) = s/t = 9/17 = 0.529 m/s

The mean velocity in the vertical is determined as the float velocity multiplied by a coefficient which varies between 0.80 and 0.85. Here, we have considered it as 0.85.

Hence, mean velocity (V_m) = 0.85 x 0.529 = 0.449 m/s

Inflow Discharge (Q) = A. V_m

= 0.189 x 0.449

= 0.084 m^3/s

(b) Outflow (At ch. 100.00 m)

Sl. No.	Distance in meter (B_n)	Depth of flow at distance (d_n) (m)	Intermediate distance b_n (B_{n+1}- B_n) (m)	Depth difference (d_{n+1}- d_n) (m)	Average depth $\frac{dn+1+dn}{2}$ (m)	Intermediate wetted perimeter $\sqrt{Col.4^2+Col.5^2}$ (m)	Intermediate cross-sectional area (Col. 4 x Col. 6) sqm
1	2	3	4	5	6	7	8
1	0	0					
2	0.6	0.24	0.60	0.24	0.12	0.646	0.072
3	1.2	0	0.60	0.24	0.12	0.646	0.072
				Grand Total		1.292	0.144

Distance travelled (s) = 9.00 m

Time taken (t) = 23 sec

Velocity (v) = s/t = 9/23 = 0.391 m/s

The mean velocity in the vertical is determined as the float velocity multiplied by a coefficient which varies between 0.80 and 0.85. Here, we have considered it as 0.85.

Hence, mean velocity (V_m) = 0.85 x 0.391 = 0.332 m/s

Outflow Discharge (Q) = A. V_m

= 0.144 x 0.332

= 0.047 m^3/s

Average wetted perimeter = (1.5+1.292)/2

= 1.396 m

Section III (Ch. 100.00 m to 150.00 m):

(a) Inflow (At ch. 100.00 m)

Sl. No.	Distance in meter (B_n)	Depth of flow at distance (d_n) (m)	Intermediate distance b_n (B_{n+1}- B_n) (m)	Depth difference (d_{n+1}- d_n) (m)	Average depth $\frac{d_{n+1}+d_n}{2}$ (m)	Intermediate wetted perimeter $\sqrt{Col.4^2+Col.5^2}$ (m)	Intermediate cross-sectional area (Col. 4 x Col. 6) sqm
1	2	3	4	5	6	7	8
1	0	0					
2	0.6	0.25	0.60	0.24	0.125	0.646	0.075
3	1.2	0	0.60	0.24	0.125	0.646	0.075
				Grand Total		1.292	0.150

Distance travelled (s) = 9.00 m

Time taken (t) = 23 sec

Velocity (v) = s/t = 9/23 = 0.391 m/s

The mean velocity in the vertical is determined as the float velocity multiplied by a coefficient which varies between 0.80 and 0.85. Here, we have considered it as 0.85.

Hence, mean velocity (V_m) = 0.85 x 0.391 = 0.332 m/s

Inflow Discharge (Q) = A. V_m

= 0.150 x 0.332

= 0.0498 m^3/s

(b) Outflow (At ch. 150.00 m)

Sl. No.	Distance in meter (B_n)	Depth of flow at distance (d_n) (m)	Intermediate distance b_n (B_{n+1}- B_n) (m)	Depth difference (d_{n+1}- d_n) (m)	Average depth $\frac{dn+1+dn}{2}$ (m)	Intermediate wetted perimeter $\sqrt{Col.4^2+Col.5^2}$ (m)	Intermediate cross-sectional area (Col. 4 x Col. 6) sqm
1	2	3	4	5	6	7	8
1	0	0					
2	0.5	0.22	0.50	0.22	0.11	0.686	0.055
3	1.0	0	0.50	0.22	0.11	0.686	0.055
				Grand Total		1.372	0.11

Distance travelled (s) = 9.00 m

Time taken (t) = 29 sec

Velocity (v) = s/t = 9/29 = 0.31 m/s

The mean velocity in the vertical is determined as the float velocity multiplied by a coefficient which varies between 0.80 and 0.85. Here, we have considered it as 0.85.

Hence, mean velocity (V_m) = 0.85 x 0.31 = 0.26 m/s

Outflow Discharge (Q) = A. V_m

= 0.11 x 0.26

= 0.029 m^3/s

Average wetted perimeter = (1.292+1.372)/2

= 1.332 m

Section IV (Ch. 150.00 m to 200.00 m):

(a) Inflow (At ch. 150.00 m):

Sl. No.	Distance in meter (B_n)	Depth of flow at distance (d_n) (m)	Intermediate distance b_n (B_{n+1}- B_n) (m)	Depth difference (d_{n+1}- d_n) (m)	Average depth $\frac{dn+1+dn}{2}$ (m)	Intermediate wetted perimeter $\sqrt{Col.4^2+Col.5^2}$ (m)	Intermediate cross-sectional area (Col. 4 x Col. 6) sqm
1	2	3	4	5	6	7	8
1	0	0					
2	0.5	0.22	0.50	0.22	0.11	0.686	0.055
3	1.0	0	0.50	0.22	0.11	0.686	0.055
				Grand Total		1.372	0.11

Distance travelled (s) = 9.00 m

Time taken (t) = 27 sec

Velocity (v) = s/t = 9/27 = 0.33 m/s

The mean velocity in the vertical is determined as the float velocity multiplied by a coefficient which varies between 0.80 and 0.85. Here, we have considered it as 0.85.

Hence, mean velocity (V_m) = 0.85 x 0.33 = 0.28 m/s

Inflow Discharge (Q) = A. V_m

= 0.11 x 0.28

= 0.030 m^3/s

(b) Outflow (At ch. 200.00 m)

Sl. No.	Distance in meter (B_n)	Depth of flow at distance (d_n) (m)	Intermediate distance b_n (B_{n+1}- B_n) (m)	Depth difference (d_{n+1}- d_n) (m)	Average depth $\frac{dn+1+dn}{2}$ (m)	Intermediate wetted perimeter $\sqrt{Col.4^2 + Col.5^2}$ (m)	Intermediate cross-sectional area (Col. 4 x Col. 6) sqm
1	2	3	4	5	6	7	8
1	0	0					
2	0.5	0.22	0.50	0.22	0.11	0.686	0.055
3	1.0	0	0.50	0.22	0.11	0.686	0.055
				Grand Total		1.372	0.11

Distance travelled (s) = 9.00 m

Time taken (t) = 42 sec

Velocity (v) = s/t = 9/42 = 0.214 m/s

The mean velocity in the vertical is determined as the float velocity multiplied by a coefficient which varies between 0.80 and 0.85. Here, we have considered it as 0.85.

Hence, mean velocity (V_m) = 0.85 x 0.214 = 0.181 m/s

Outflow Discharge (Q) = A. V_m

= 0.11 x 0.181

= 0.019 m^3/s

Average wetted perimeter = (1.372+1.372)/2
= 1.372 m

Section V (Ch. 200.00 m to 250.00 m):

(a) Inflow (At ch. 200.00 m)

Sl. No.	Distance in meter (B_n)	Depth of flow at distance (d_n) (m)	Intermediate distance b_n (B_{n+1}- B_n) (m)	Depth difference (d_{n+1}- d_n) (m)	Average depth $\frac{dn+1+dn}{2}$ (m)	Intermediate wetted perimeter $\sqrt{Col.4^2+Col.5^2}$ (m)	Intermediate cross-sectional area (Col. 4 x Col. 6) sqm
1	2	3	4	5	6	7	8
1	0	0					
2	0.5	0.22	0.50	0.22	0.11	0.686	0.055
3	1.0	0	0.50	0.22	0.11	0.686	0.055
				Grand Total		1.372	0.11

Distance travelled (s) = 9.00 m

Time taken (t) = 30 sec

Velocity (v) = s/t = 9/30 = 0.30 m/s

The mean velocity in the vertical is determined as the float velocity multiplied by a coefficient which varies between 0.80 and 0.85. Here, we have considered it as 0.85.

Hence, mean velocity (V_m) = 0.85 x 0.30 = 0.255 m/s

Inflow Discharge (Q) = A. V_m

= 0.11 x 0.255

= 0.028 m^3/s

(b) Outflow (At ch. 250.00 m)

Sl. No.	Distance in meter (B_n)	Depth of flow at distance (d_n) (m)	Intermediate distance b_n (B_{n+1}- B_n) (m)	Depth difference (d_{n+1}- d_n) (m)	Average depth $\frac{dn+1+dn}{2}$ (m)	Intermediate wetted perimeter $\sqrt{Col.4^2+Col.5^2}$ (m)	Intermediate cross-sectional area (Col. 4 x Col. 6) sqm
1	2	3	4	5	6	7	8
1	0	0					
2	0.5	0.18	0.50	0.18	0.09	0.53	0.045
3	1.0	0	0.50	0.18	0.09	0.53	0.045
				Grand Total		1.372	0.09

Distance travelled (s) = 9.00 m

Time taken (t) = 42 sec

Velocity (v) = s/t = 9/42 = 0.214 m/s

The mean velocity in the vertical is determined as the float velocity multiplied by a coefficient which varies between 0.80 and 0.85. Here, we have considered it as 0.85.

Hence, mean velocity (V_m) = 0.85 x 0.214 = 0.181 m/s

Outflow Discharge (Q) = A. V_m

= 0.09 x 0.181

= 0.016 m^3/s

Average wetted perimeter = (1.372+1.372)/2

= 1.372 m

Section VI (Ch. 250.00 m to 300.00 m):

(a) Inflow (At ch. 250.00 m):

Sl. No.	Distance in meter (B_n)	Depth of flow at distance (d_n) (m)	Intermediate distance b_n (B_{n+1}- B_n) (m)	Depth difference (d_{n+1}- d_n) (m)	Average depth $\frac{dn+1+dn}{2}$ (m)	Intermediate wetted perimeter $\sqrt{Col.4^2 + Col.5^2}$ (m)	Intermediate cross-sectional area (Col. 4 x Col. 6) sqm
1	2	3	4	5	6	7	8
1	0	0					
2	0.5	0.19	0.50	0.19	0.095	0.534	0.0475
3	1.0	0	0.50	0.19	0.095	0.534	0.0475
				Grand Total		1.372	0.095

Distance travelled (s) = 9.00 m

Time taken (t) = 38 sec

Velocity (v) = s/t = 9/38 = 0.23 m/s

The mean velocity in the vertical is determined as the float velocity multiplied by a coefficient which varies between 0.80 and 0.85. Here, we have considered it as 0.85.

Hence, mean velocity (V_m) = 0.85 x 0.23 = 0.20 m/s

Inflow Discharge (Q) = A. V_m

= 0.095 x 0.20

= 0.019 m^3/s

(b) Outflow (At ch. 300.00 m)

Sl. No.	Distance in meter (B_n)	Depth of flow at distance (d_n) (m)	Intermediate distance b_n (B_{n+1}- B_n) (m)	Depth difference (d_{n+1}- d_n) (m)	Average depth $\frac{dn+1+dn}{2}$ (m)	Intermediate wetted perimeter $\sqrt{Col.4^2 + Col.5^2}$ (m)	Intermediate cross-sectional area (Col. 4 x Col. 6) sqm
1	2	3	4	5	6	7	8
1	0	0					
2	0.5	0.16	0.50	0.16	0.08	0.52	0.04
3	1.0	0	0.50	0.16	0.08	0.52	0.04
				Grand Total		1.04	0.08

Distance travelled (s) = 9.00 m

Time taken (t) = 50 sec

Velocity (v) = s/t = 9/50= 0.18 m/s

The mean velocity in the vertical is determined as the float velocity multiplied by a coefficient which varies between 0.80 and 0.85. Here, we have considered it as 0.85.

Hence, mean velocity (V_m) = 0.85 x 0.18 = 0.153 m/s

Outflow Discharge (Q) = A. V_m

= 0.08 x 0.153

= 0.012 m^3/s

Average wetted perimeter = (1.372+1.04)/2

= 1.206 m

Section VII (Ch. 300.00 m to 350.00 m):
(a) Inflow (At ch. 300.00 m):

Sl. No.	Distance in meter (B_n)	Depth of flow at distance (d_n) (m)	Intermediate distance b_n (B_{n+1}- B_n) (m)	Depth difference (d_{n+1}- d_n) (m)	Average depth $\frac{dn+1+dn}{2}$ (m)	Intermediate wetted perimeter $\sqrt{Col.4^2 + Col.5^2}$ (m)	Intermediate cross-sectional area (Col. 4 x Col. 6) sqm
1	2	3	4	5	6	7	8
1	0	0					
2	0.5	0.16	0.50	0.16	0.08	0.52	0.04
3	1.0	0	0.50	0.16	0.08	0.52	0.04
				Grand Total		1.04	0.08

Distance travelled (s) = 9.00 m

Time taken (t) = 50 sec

Velocity (v) = s/t = 9/50= 0.18 m/s

The mean velocity in the vertical is determined as the float velocity multiplied by a coefficient which varies between 0.80 and 0.85. Here, we have considered it as 0.85.

Hence, mean velocity (V_m) = 0.85 x 0.18 = 0.153 m/s

Inflow Discharge (Q) = A. V_m

= 0.08 x 0.153

= 0.012 m^3/s

(b) Outflow (At ch. 350.00 m)

Sl. No.	Distance in meter (B_n)	Depth of flow at distance (d_n) (m)	Intermediate distance b_n (B_{n+1}- B_n) (m)	Depth difference (d_{n+1}- d_n) (m)	Average depth $\frac{dn+1+dn}{2}$ (m)	Intermediate wetted perimeter $\sqrt{Col.4^2+Col.5^2}$ (m)	Intermediate cross-sectional area (Col. 4 x Col. 6) sqm
1	2	3	4	5	6	7	8
1	0	0					
2	0.5	0.16	0.50	0.16	0.08	0.52	0.04
3	1.0	0	0.50	0.16	0.08	0.52	0.04
				Grand Total		1.04	0.08

Distance travelled (s) = 9.00 m

Time taken (t) = 61 sec

Velocity (v) = s/t = 9/61= 0.147 m/s

The mean velocity in the vertical is determined as the float velocity multiplied by a coefficient which varies between 0.80 and 0.85. Here, we have considered it as 0.85.

Hence, mean velocity (V_m) = 0.85 x 0.147 = 0. 124 m/s

Outflow Discharge (Q) = A. V_m

= 0.08 x 0.124

= 0.0099 m^3/s

Average wetted perimeter = (1.04+1.04)/2

= 1.04 m

Section VIII (Ch. 350.00 m to 400.00 m):

(a) Inflow (At ch. 350.00 m)

Sl. No.	Distance in meter (B_n)	Depth of flow at distance (d_n) (m)	Intermediate distance b_n (B_{n+1}- B_n) (m)	Depth difference (d_{n+1}- d_n) (m)	Average depth $\frac{dn+1+dn}{2}$ (m)	Intermediate wetted perimeter $\sqrt{Col.4^2 + Col.5^2}$ (m)	Intermediate cross-sectional area (Col. 4 x Col. 6) sqm
1	2	3	4	5	6	7	8
1	0	0					
2	0.5	0.10	0.50	0.10	0.05	0.51	0.04
3	1.0	0	0.50	0.10	0.05	0.51	0.04
				Grand Total		1.0	0.08

Distance travelled (s) = 9.00 m

Time taken (t) = 60 sec

Velocity (v) = s/t = 9/60= 0.15 m/s

The mean velocity in the vertical is determined as the float velocity multiplied by a coefficient which varies between 0.80 and 0.85. Here, we have considered it as 0.85.

Hence, mean velocity (V_m) = 0.85 x 0.15 = 0.123 m/s

Inflow Discharge (Q) = A. V_m

= 0.08 x 0.123

= 0.0098 m^3/s

(b) Outflow (At ch. 400.00 m):

Sl. No.	Distance in meter (B_n)	Depth of flow at distance (d_n) (m)	Intermediate distance b_n (B_{n+1}- B_n) (m)	Depth difference (d_{n+1}- d_n) (m)	Average depth $\frac{dn+1+dn}{2}$ (m)	Intermediate wetted perimeter $\sqrt{Col.4^2 + Col.5^2}$ (m)	Intermediate cross-sectional area (Col. 4 x Col. 6) sqm
1	2	3	4	5	6	7	8
1	0	0					
2	0.5	0.16	0.50	0.16	0.08	0.52	0.04
3	1.0	0	0.50	0.16	0.08	0.52	0.04
				Grand Total		1.04	0.08

Distance travelled (s) = 9.00 m

Time taken (t) = 105 sec

Velocity (v) = s/t = 9/105= 0.085 m/s

The mean velocity in the vertical is determined as the float velocity multiplied by a coefficient which varies between 0.80 and 0.85. Here, we have considered it as 0.85.

Hence, mean velocity (V_m) = 0.85 x 0.085 = 0.072 m/s

Outflow Discharge (Q) = A. V_m

= 0.08 x 0.072

= 0.0057 m^3/s

Average wetted perimeter = (1.04+1.04)/2
= 1.04 m

Section IX (Ch. 400.00 m to 440.00 m):
(a) Inflow (At ch. 400.00 m):

Sl. No.	Distance in meter (B_n)	Depth of flow at distance (d_n) (m)	Intermediate distance b_n (B_{n+1}- B_n) (m)	Depth difference (d_{n+1}- d_n) (m)	Average depth $\frac{dn+1+dn}{2}$ (m)	Intermediate wetted perimeter $\sqrt{Col.4^2+Col.5^2}$ (m)	Intermediate cross-sectional area (Col. 4 x Col. 6) sqm
1	2	3	4	5	6	7	8
1	0	0					
2	0.5	0.10	0.50	0.10	0.05	0.51	0.04
3	1.0	0	0.50	0.10	0.05	0.51	0.04
				Grand Total		1.0	0.08

Distance travelled (s) = 9.00 m

Time taken (t) = 110 sec

Velocity (v) = s/t = 9/110= 0.081 m/s

The mean velocity in the vertical is determined as the float velocity multiplied by a coefficient which varies between 0.80 and 0.85. Here, we have considered it as 0.85.

Hence, mean velocity (V_m) = 0.85 x 0.081 = 0.069 m/s

Inflow Discharge (Q) = A. V_m

= 0.08 x 0.069

= 0.00052 m^3/s

(b) Outflow (At ch. 440.00 m)

Sl. No.	Distance in meter (B_n)	Depth of flow at distance (d_n) (m)	Intermediate distance b_n (B_{n+1}- B_n) (m)	Depth difference (d_{n+1}- d_n) (m)	Average depth $\frac{dn+1+dn}{2}$ (m)	Intermediate wetted perimeter $\sqrt{Col.4^2+Col.5^2}$ (m)	Intermediate cross-sectional area (Col. 4 x Col. 6) sqm
1	2	3	4	5	6	7	8
1	0	0					
2	0.5	0.09	0.50	0.09	0.045	0.50	0.0225
3	1.0	0	0.50	0.09	0.045	0.50	0.0225
				Grand Total		1.00	0.045

Distance travelled (s) = 9.00 m

Time taken (t) = 130 sec

Velocity (v) = s/t = 9/130= 0.069 m/s

The mean velocity in the vertical is determined as the float velocity multiplied by a coefficient which varies between 0.80 and 0.85. Here, we have considered it as 0.85.

Hence, mean velocity (V_m) = 0.85 x 0.069 = 0.058 m/s

Outflow Discharge (Q) = A. V_m

= 0.08 x 0.058

= 0.00046 m^3/s

Average wetted perimeter = (1.04+1.04)/2

= 1.04 m

APPENDIX-IV

Calculation of average wetted perimeter and cross-sectional area of inflow and outflow of canal B3 with the help of ranging rod, float and stop watch.

Section I (Ch. 0.00 m to 50.00 m):
(a) Inflow (At ch. 0.00 m):

Width = 1.00 m

Depth of flow= 0.39 m

Wetted perimeter = 2 x 0.39 + 1.00 = 1.78 m

Distance travelled (s) = 9.00 m

Time taken (t) = 12 sec

Velocity (v) = s/t = 9/12 = 0.75 m/s

The mean velocity in the vertical is determined as the float velocity multiplied by a coefficient which varies between 0.80 and 0.85. Here, we have considered it as 0.85.

Hence, mean velocity (V_m) = 0.85 x 0.75 = 0.63m/s

Inflow Discharge (Q) = A. V_m

= (1.0 x 0.39) x 0.63

= 0.246 m^3/s

(b) Outflow (At ch. 50.00 m):

Width = 1.00 m

Depth of flow= 0.34 m

Wetted perimeter = 2 x 0.31 + 1.00 = 1.68 m

Distance travelled (s) = 9.00 m

Time taken (t) = 16 sec

Velocity (v) = s/t = 9/16 = 0.56 m/s

The mean velocity in the vertical is determined as the float velocity multiplied by a coefficient which varies between 0.80 and 0.85. Here,we have considered it as 0.85.

Hence, mean velocity (V_m) = 0.85 x 0.56 = 0.476 m/s

Outflow Discharge (Q) = A. V_m

= (1.0 x 0.34) x 0.476

= 0.161 m^3/s

Average wetted perimeter = (1.78+1.68)/2

= 1.73 m

Section II (Ch. 50.00 m to 100.00 m):

(a) Inflow (At ch. 50.00 m)

Sl. No.	Distance in meter (B_n)	Depth of flow at distance (d_n) (m)	Intermediate distance b_n (B_{n+1}- B_n) (m)	Depth difference (d_{n+1}- d_n) (m)	Average depth $\frac{dn+1+dn}{2}$ (m)	Intermediate wetted perimeter $\sqrt{Col.4^2 + Col.5^2}$ (m)	Intermediate cross-sectional area (Col. 4 x Col. 6) sqm
1	2	3	4	5	6	7	8
1	0	0					
2	0.7	0.32	0.7	0.32	0.16	0.77	0.112
3	1.4	0	0.7	0.32	0.16	0.77	0.112
				Grand Total		1.44	0.224

Distance travelled (s) = 9.00 m

Time taken (t) = 17 sec

Velocity (v) = s/t = 9/17 = 0.529 m/s

The mean velocity in the vertical is determined as the float velocity multiplied by a coefficient which varies between 0.80 and 0.85. Here, we have considered it as 0.85.

Hence, mean velocity (V_m) = 0.85 x 0.529 = 0.449 m/s

Inflow Discharge (Q) = A. V_m

= 0.224 x 0.449

= 0.10 m^3/s

(b) Outflow (At ch. 100.00 m)

Sl. No.	Distance in meter (B_n)	Depth of flow at distance (d_n) (m)	Intermediate distance b_n (B_{n+1}- B_n) (m)	Depth difference (d_{n+1}- d_n) (m)	Average depth $\frac{dn+1+dn}{2}$ (m)	Intermediate wetted perimeter $\sqrt{Col.4^2 + Col.5^2}$ (m)	Intermediate cross-sectional area (Col. 4 x Col. 6) sqm
1	2	3	4	5	6	7	8
1	0	0					
2	0.6	0.24	0.60	0.24	0.12	0.646	0.072
3	1.2	0	0.60	0.24	0.12	0.646	0.072
				Grand Total		1.292	0.144

Distance travelled (s) = 9.00 m

Time taken (t) = 22 sec

Velocity (v) = s/t = 9/22 = 0.409 m/s

The mean velocity in the vertical is determined as the float velocity multiplied by a coefficient which varies between 0.80 and 0.85. Here, we have considered it as 0.85.

Hence, mean velocity (V_m) = 0.85 x 0.409 = 0.347 m/s

Outflow Discharge (Q) = A. V_m

= 0.144 x 0.347

= 0.049 m^3/s

Average wetted perimeter = (1.44+1.292)/2

= 1.366 m

Section III (Ch. 100.00 m to 150.00 m):

(a) Inflow (At ch. 100.00 m):

Sl. No.	Distance in meter (B_n)	Depth of flow at distance (d_n) (m)	Intermediate distance b_n (B_{n+1}- B_n) (m)	Depth difference (d_{n+1}- d_n) (m)	Average depth $\frac{dn+1+dn}{2}$ (m)	Intermediate wetted perimeter $\sqrt{Col.4^2 + Col.5^2}$ (m)	Intermediate cross-sectional area (Col. 4 x Col. 6) sqm
1	2	3	4	5	6	7	8
1	0	0					
2	0.6	0.25	0.60	0.24	0.125	0.646	0.075
3	1.2	0	0.60	0.24	0.125	0.646	0.075
				Grand Total		1.292	0.150

Distance travelled (s) = 9.00 m

Time taken (t) = 24 sec

Velocity (v) = s/t = 9/24 = 0.375 m/s

The mean velocity in the vertical is determined as the float velocity multiplied by a coefficient which varies between 0.80 and 0.85. Here, we have considered it as 0.85.

Hence, mean velocity (V_m) = 0.85 x 0.375 = 0.319 m/s

Inflow Discharge (Q) = A. V_m

= 0.150 x 0.319

= 0.047 m^3/s

(b) Outflow (At ch. 150.00 m)

Sl. No.	Distance in meter (B_n)	Depth of flow at distance (d_n) (m)	Intermediate distance b_n (B_{n+1}- B_n) (m)	Depth difference (d_{n+1}- d_n) (m)	Average depth $\frac{dn+1+dn}{2}$ (m)	Intermediate wetted perimeter $\sqrt{Col.4^2 + Col.5^2}$ (m)	Intermediate cross-sectional area (Col. 4 x Col. 6) sqm
1	2	3	4	5	6	7	8
1	0	0					
2	0.5	0.22	0.50	0.22	0.11	0.686	0.055
3	1.0	0	0.50	0.22	0.11	0.686	0.055
				Grand Total		1.372	0.11

Distance travelled (s) = 9.00 m

Time taken (t) = 30 sec

Velocity (v) = s/t = 9/30 = 0.30 m/s

The mean velocity in the vertical is determined as the float velocity multiplied by a coefficient which varies between 0.80 and 0.85. Here, we have considered it as 0.85.

Hence, mean velocity (V_m) = 0.85 x 0.30 = 0.255 m/s

Outflow Discharge (Q) = A. V_m

= 0.11 x 0.255

= 0.028 m^3/s

Average wetted perimeter = (1.292+1.372)/2

= 1.332 m

Section IV (Ch. 150.00 m to 200.00 m):

(a) Inflow (At ch. 150.00 m):

Sl. No.	Distance in meter (B_n)	Depth of flow at distance (d_n) (m)	Intermediate distance b_n (B_{n+1}- B_n) (m)	Depth difference (d_{n+1}- d_n) (m)	Average depth $\frac{dn+1+dn}{2}$ (m)	Intermediate wetted perimeter $\sqrt{Col.4^2 + Col.5^2}$ (m)	Intermediate cross-sectional area (Col. 4 x Col. 6) sqm
1	2	3	4	5	6	7	8
1	0	0					
2	0.5	0.21	0.50	0.21	0.105	0.54	0.0525
3	1.0	0	0.50	0.21	0.105	0.54	0.0525
				Grand Total		1.08	0.105

Distance travelled (s) = 9.00 m

Time taken (t) = 29 sec

Velocity (v) = s/t = 9/29 = 0.31 m/s

The mean velocity in the vertical is determined as the float velocity multiplied by a coefficient which varies between 0.80 and 0.85. Here, we have considered it as 0.85.

Hence, mean velocity (V_m) = 0.85 x 0.31 = 0.26 m/s

Inflow Discharge (Q) = A. V_m

= 0.105 x 0.26

= 0.027 m^3/s

(b) Outflow (At ch. 200.00 m)

Sl. No.	Distance in meter (B_n)	Depth of flow at distance (d_n) (m)	Intermediate distance b_n (B_{n+1}- B_n) (m)	Depth difference (d_{n+1}- d_n) (m)	Average depth $\frac{dn+1+dn}{2}$ (m)	Intermediate wetted perimeter $\sqrt{Col.4^2 + Col.5^2}$ (m)	Intermediate cross-sectional area (Col. 4 x Col. 6) sqm
1	2	3	4	5	6	7	8
1	0	0					
2	0.5	0.22	0.50	0.22	0.11	0.686	0.055
3	1.0	0	0.50	0.22	0.11	0.686	0.055
				Grand Total		1.372	0.11

Distance travelled (s) = 9.00 m

Time taken (t) = 47 sec

Velocity (v) = s/t = 9/47 = 0.19 m/s

The mean velocity in the vertical is determined as the float velocity multiplied by a coefficient which varies between 0.80 and 0.85. Here, we have considered it as 0.85.

Hence, mean velocity (V_m) = 0.85 x 0.19 = 0.16 m/s

Outflow Discharge (Q) = A. V_m

= 0.11 x 0.16

= 0.017 m^3/s

Average wetted perimeter = (1.08+1.372)/2

= 1.226 m

Section V (Ch. 200.00 m to 250.00 m):

(a) Inflow (At ch. 200.00 m)

Sl. No.	Distance in meter (B_n)	Depth of flow at distance (d_n) (m)	Intermediate distance b_n (B_{n+1}- B_n) (m)	Depth difference (d_{n+1}- d_n) (m)	Average depth $\frac{dn+1+dn}{2}$ (m)	Intermediate wetted perimeter $\sqrt{Col.4^2 + Col.5^2}$ (m)	Intermediate cross-sectional area (Col. 4 x Col. 6) sqm
1	2	3	4	5	6	7	8
1	0	0					
2	0.5	0.22	0.50	0.22	0.11	0.686	0.055
3	1.0	0	0.50	0.22	0.11	0.686	0.055
				Grand Total		1.372	0.11

Distance travelled (s) = 9.00 m

Time taken (t) = 48 sec

Velocity (v) = s/t = 9/48 = 0.18 m/s

The mean velocity in the vertical is determined as the float velocity multiplied by a coefficient which varies between 0.80 and 0.85. Here, we have considered it as 0.85.

Hence, mean velocity (V_m) = 0.85 x 0.18 = 0.153 m/s

Inflow Discharge (Q) = A. V_m

= 0.11 x 0.153

= 0.016 m^3/s

(b) Outflow (At ch. 250.00 m)

Sl. No.	Distance in meter (B_n)	Depth of flow at distance (d_n) (m)	Intermediate distance b_n (B_{n+1}- B_n) (m)	Depth difference (d_{n+1}- d_n) (m)	Average depth $\frac{dn+1+dn}{2}$ (m)	Intermediate wetted perimeter $\sqrt{Col.4^2 + Col.5^2}$ (m)	Intermediate cross-sectional area (Col. 4 x Col. 6) sqm
1	2	3	4	5	6	7	8
1	0	0					
2	0.5	0.18	0.50	0.18	0.09	0.53	0.045
3	1.0	0	0.50	0.18	0.09	0.53	0.045
				Grand Total		1.372	0.09

Distance travelled (s) = 9.00 m

Time taken (t) = 52 sec

Velocity (v) = s/t = 9/52 = 0.17 m/s

The mean velocity in the vertical is determined as the float velocity multiplied by a coefficient which varies between 0.80 and 0.85. Here, we have considered it as 0.85.

Hence, mean velocity (V_m) = 0.85 x 0.17 = 0.14 m/s

Outflow Discharge (Q) = A. V_m

= 0.09 x 0.14

= 0.0126 m^3/s

Average wetted perimeter = (1.372+1.372)/2

= 1.372 m

Section VI (Ch. 250.00 m to 300.00 m):

(a) Inflow (At ch. 250.00 m)

Sl. No.	Distance in meter (B_n)	Depth of flow at distance (d_n) (m)	Intermediate distance b_n (B_{n+1}- B_n) (m)	Depth difference (d_{n+1}- d_n) (m)	Average depth $\frac{dn+1+dn}{2}$ (m)	Intermediate wetted perimeter $\sqrt{Col.4^2 + Col.5^2}$ (m)	Intermediate cross-sectional area (Col. 4 x Col. 6) sqm
1	2	3	4	5	6	7	8
1	0	0					
2	0.5	0.19	0.50	0.19	0.095	0.534	0.0475
3	1.0	0	0.50	0.19	0.095	0.534	0.0475
				Grand Total		1.372	0.095

Distance travelled (s) = 9.00 m

Time taken (t) = 52 sec

Velocity (v) = s/t = 9/52 = 0.17 m/s

The mean velocity in the vertical is determined as the float velocity multiplied by a coefficient which varies between 0.80 and 0.85. Here, we have considered it as 0.85.

Hence, mean velocity (V_m) = 0.85 x 0.17 = 0.14 m/s

Inflow Discharge (Q) = A. V_m

= 0.095 x 0.14

= 0.0133 m^3/s

(b) Outflow (At ch. 300.00 m)

Sl. No.	Distance in meter (B_n)	Depth of flow at distance (d_n) (m)	Intermediate distance b_n (B_{n+1}- B_n) (m)	Depth difference (d_{n+1}- d_n) (m)	Average depth $\frac{dn+1+dn}{2}$ (m)	Intermediate wetted perimeter $\sqrt{Col.4^2+Col.5^2}$ (m)	Intermediate cross-sectional area (Col. 4 x Col. 6) sqm
1	2	3	4	5	6	7	8
1	0	0					
2	0.5	0.10	0.50	0.10	0.05	0.51	0.025
3	1.0	0	0.50	0.10	0.05	0.51	0.025
				Grand Total		1.04	0.05

Distance travelled (s) = 9.00 m

Time taken (t) = 73 sec

Velocity (v) = s/t = 9/73= 0.123 m/s

The mean velocity in the vertical is determined as the float velocity multiplied by a coefficient which varies between 0.80 and 0.85. Here, we have considered it as 0.85.

Hence, mean velocity (V_m) = 0.85 x 0.123 = 0.104 m/s

Outflow Discharge (Q) = A. V_m

= 0.05 x 0.104

= 0.0052 m^3/s

Average wetted perimeter = (1.372+1.04)/2

= 1.206 m