MINI PROJECT ON

EVALUATION OF ADEQUACY OF THE EXISTING DRAINAGE SYSTEM OF MALIGAON AREA USING RATIONAL METHOD AND GEOGRAPHIC INFORMATION SYSTEM

Submitted in partial fulfilment for 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

SESSION: 2023-2025

Submitted By

SABNAM AKHTAR RAHMAN

Roll No: 230620061015

ASTU Registration: 161703118

Under the guidance of

DR. BIBHASH SARMA

Professor

Department of Civil Engineering

ASSAM ENGINEERING COLLEGE

JALUKBARI, GUWAHATI-781013, ASSAM

DEPARTMENT OF CIVIL ENGINEERING

ASSAM ENGINEERING COLLEGE

JALUKBARI, GUWAHATI-781013

ASSAM, INDIA

CANDIDATE'S DECLARATION

I hereby declare that **"EVALUATION OF ADEQUACY OF THE EXISTING DRAINAGE SYSTEM OF MALIGAON AREA USING RATIONAL METHOD AND GEOGRAPHIC INFORMATION SYSTEM"** is a report prepared by me in partial fulfillment for the requirement of the award of the degree of Masters of Technology in Civil Engineering with specialization in Water Resources Engineering submitted in the Department of Civil Engineering, Assam Engineering College, Jalukbari, Guwahati-781013 under Assam Science and Technology University under the supervision and guidance of Dr. Bibhash Sarma, Professor, Department of Civil Engineering, AssamEngineering College, Jalukbari, Guwahati-781013.

The matter embodied in this dissertation has not been submitted by me for the award of any other degree.

Place: Guwahati

Date:

Sabnam Akhtar Rahman

M. Tech. 3rd Semester

Roll No-230620061015

College Roll NO- PG/C/23/34

Department of Civil Engineering

Assam Engineering College

Jalukbari, Guwahati-781013

DEPARTMENT OF CIVIL ENGINEERING

ASSAM ENGINEERING COLLEGE

JALUKBARI, GUWAHATI-781013

ASSAM, INDIA

CERTIFICATE OF SUPERVISION
SESSION (2023-2025)

This is to certify that the project work entitled **"EVALUATION OF ADEQUACY OF THE EXISTING DRAINAGE SYSTEM OF MALIGAON AREA USING RATIONAL METHOD AND GEOGRAPHIC INFORMATION SYSTEM"** is a project report prepared by Sabnam Akhtar Rahman, Roll No- 230620061015, a student of MTech. 3rd semester, Department of Civil Engineering (Water Resources Engineering), Assam Engineering College under my guidance and supervision and submitted in partial fulfilment of the requirement for the award of the Degree of Master of Technology in Civil Engineering with specialization in Water Resources Engineering under Assam Science and Technology University.

Place: Guwahati

Date:

Dr. Bibhash Sarma

Professor

Department of Civil Engineering

Assam Engineering College

Jalukbari, Guwahati-781013

DEPARTMENT OF CIVIL ENGINEERING

ASSAM ENGINEERING COLLEGE

JALUKBARI, GUWAHATI-781013

ASSAM, INDIA

CERTIFICATE OF APPROVAL
SESSION (2023-2025)

This is to certify that Sabnam Akhtar Rahman, Roll no- 230620061015**,** a student of MTech, 3rd Semester of Civil Engineering Department (Water Resources Engineering), Assam Engineering College, has submitted the project entitled **"EVALUATION OF ADEQUACY OF THE EXISTING DRAINAGE SYSTEM OF MALIGAON AREA USING RATIONAL METHOD AND GEOGRAPHIC INFORMATION SYSTEM"** in partial fulfilment for the requirement of the award of the Degree of Master of Technology in Civil Engineering with specialization in Water Resources Engineering under Assam Science and Technology University.

Place: Guwahati

Date:

Dr. Jayanta Pathak

Professor and Head of the Department

Department of Civil Engineering

Assam Engineering College

Jalukbari, Guwahati-781013

ACKNOWLEDGEMENT

I would like to express my sincere appreciation to my supervisor Dr. Bibhash Sarma, Department of Civil Engineering of Assam Engineering College for his extensive support, and encouragement throughout the project work. I am highly indebted for his constant guidance and supervision as well as for providing full co- operation throughout the study and preparing the finalized dissertation. Working under him has indeed been a great experience and inspiration for me.

I express my gratitude to Dr. Jayanta Pathak, Professor and Head of Department of Civil Engineering of Assam Engineering College and also towards the entire fraternity of the Department of Civil Engineering of Assam Engineering College.

I cannot help myself without thanking Assam Engineering College, which provided us the required infrastructure and comforts all throughout this course and my project in particular. I also thank all the faculty members and staff of Department of Civil Engineering, Assam Engineering College for their free exchange of idea and lending their helping hand whenever I needed them.

I also express profound gratitude to God for his guidance, strength, and blessings that have illuminated my path and enabled me to overcome challenges during this endeavor. His grace has been a constant source of inspiration and motivation.

Lastly, I thank all my classmate and well-wishers for their constant encouragement, valuable advice and inspiration during the course of my study.

Name: Sabnam Akhtar Rahman
College Roll No: PG-C-23-34
ASTU Roll No- 230620061015
ASTU Registration No: 161703118

CONTENTS

LIST OF FIGURES

LIST OF TABLES

NOTATIONS

Q	Discharge
V	Velocity of flow
C	Coefficient of runoff
i	Rainfall intensity
B	Bottom width of channel
f	Free board
S	Channel bed slope
A	Cross sectional area without freeboard
Y	Effective depth of flow
P	Wetted perimeter
R	Hydraulic radius
n	Manning's Roughness Coefficient
1: Z (V:H)	Side slope of trapezoidal channel

ABSTRACT

Urban waterlogging causes serious problem in urban areas affecting daily activities of the residents. Water Logging has become a severe issue in all metropolitan region. With the increase of the high-rise buildings and rapid urbanization has made the land congested and disrupted the natural drainage of the cities.

Drainage is a very important consideration in planning a city to avoid damage due to surface runoff and waterlogging or flooding. A drainage system must be properly designed to efficiently and safely convey the runoff to a disposal site. Drainage network study is essential to understand surface hydrology of a particular area. Guwahati city is surrounded by hillocks and surface runoff drains towards the plain areas causing waterlogging in some parts. This study focuses on analyzing the performance of the existing drainage capacity in the Maligaon area of Guwahati, Assam.

Using GIS based approach the Catchment area has been delineated. The runoff generated in the catchment has been estimated by using Rational Method. Manning's equation has been used to compute the velocity in the cross section, and discharge capacity. This study aims to compare the efficiency of existing drainage system in the study area with the discharge of the main disposal site.

The study revealed that out of ten (10) cross-sectional drains, one was inadequate to convey the corresponding runoff.

Keywords: Waterlogging, Maligaon Area, Guwahati, Catchment, Runoff, Rational Method, Drainage efficiency.

CHAPTER 1

INTRODUCTION

1.1 PROLOGUE

Urban waterlogging is a worldwide problem that is very widely known. Waterlogging takes place when cities experience uninterrupted or intense rainfall within a short period of time, which exceeds the capacity of their drainage systems (Bisht et al., 2016; Ning et al., 2017a; Basnet et al., 2020; Duan et al., 2022). In recent years, rainfall-induced water-logging has become a common hazard in the Urbanized areas (Mulik. N. M. et al., 2021). Waterlogging problem causes serious limitation in the sustainable development of cities.

Urban water logging is increasingly threatened by climate change, population growth, and aging of urban drainage systems; thus, urban waterlogging has emerged as one of the significant challenges the world is facing in the 21st century (Zeng et al., 2021).

Urban drainage systems are broadly designed to drain out the surface runoff from the urban areas during storm events. However, if storm exceeds the drainage capacity of storm water, it can flood the area causing road interruption, economic loss as well as health problems. Increasing imperviousness of land cover will tend to produce more surface flow, increase the rate at which runoff concentrates, as well as peak flow. Therefore, there is a growing requirement to enhance drainage capacity so that flooding in rapidly urbanizing-areas may be reduced (Mi Pale Kyi et al.,2017).

1.2 CAUSES OF URBAN WATER LOGGING

1.2.1 Meteorological factor

Over the last decades the climatic condition of the Earth is changing rapidly. Extreme weather, especially the extreme rainfall has occurred around the world. According to scientists these trends of climatic changes will continue (Boyu Jiang, 2022). According to research, rainstorm can be considered as the main and most direct factor for urban waterlogging. Also, most of the cities are located in the plain area, the stormwater gets accumulated as it cannot be drained in time thus, threatening the safety of residents in the cities (C Xi and N Sakai, 2023).

1.2.2 Urbanization factor

The rapid urbanization is an important cause of water logging disasters for it changes the natural hydrological conditions and even destroys the natural water cycle process. The increasing impermeable areas like pavements, squares and roads in the city weakens the soil infiltration performance, causes increasing surface runoff, and make flood hydrograph in a sharp and steep way, which all increase the pressure of city flood prevention and control system (Qiangqiang Li et al.,2016). With urbanization, the city's impervious surface area grows at a steady rate, but storage facilities such as huge paddy fields and fishponds shrink, resulting in a higher runoff coefficient (Boyu Jiang,2022).

1.2.3 Disappearance of natural drainage system

The disappearance of the natural drainage system is one of main causes for water logging. Rapid population growth and unplanned land filling to develop new residential areas, uncontrolled and haphazard disposal of solid wastes and garbage into the existing drainage system (M. Mujibor Rahman et al.,2009).

1.2.4 Poor Drainage system

Drainage pipelines features aging problem, low standard in design, small diameter, and limited drainage ability, thus being easy to cause the water logging problem in the low-lying areas and the higher drainage pressure for these pipeline (Qiangqiang Li et al.,2016). Poor drainage design, with inadequate or nonexistent drainage systems, prevents excess water from draining away and leads to waterlogging (Khalil et al., 2021; Klimov and Klimova, 2022).

1.3 IMPACTS OF WATER LOGGING

Waterlogging disrupts normal life, traffic movement, causes damage to roads, houses, as well as hamper the education system (Md. Shiblur Rahaman et al.,2020).

Water stagnation sources increase the mosquito population, which eventually leads to a rise in vector-borne diseases such as dengue and malaria (Ar. Chandresh Sahu et al., 2024).

Water logging of the ground contributes to damage of property. It causes the damage to roads (Both pucca and katcha) in the rainy season every year (M. Mujibor Rahman et al., 2009).

1.4 IMPORTANCE OF EFFICIENT DRAINAGE SYSTEM

The impacts of flooding can be devastating. Huge financial burden often follows major storm events to recover from structural damage. Well-designed drainage systems allow for effective discharge of stormwater, reducing property losses and expenditures on recovery (Sohn et al., 2020). The drainage channel plays a crucial role in mitigating flood risks and requires comprehensive understanding and management strategies. Even though an effective flood control strategy frequently involves modifying drainage systems in previous studies' recommendations, which include increasing the capacity of channels (Ali, 2019; Ayari & Asyiawati, 2023), minimizing flow blockages caused by debris accumulation (Ayari & Asyiawati, 2023), upgrading structure design (Wijaya & Agustina, 2022), and enhancing the efficiency of water flow (Setiawan et al., 2020) (Achmad Ghozali et al., 2024).

1.5 STUDY AREA AND PROBLEM STATEMENT

Maligaon, Guwahati, Assam is taken as the study area. Situated in the western part of Guwahati and well known for the headquarters of Northeast Frontier Railway and Northeast Frontier Railway Stadium.

Stormwater from Nilachal hill and surrounding hills goes to the pond in front of the KV School, Maligaon. The stormwater coming to the Maligaon Railway Colony area results in increased surface runoff and creates water logging in the area. There exists drainage system to carry the stormwater coming to the area. This study is made to check the efficiency of the existing drainage system in the area.

1.6 OBJECTIVE

The objectives of the study are stated below:

1. To determine the runoff generated in the area.
2. To check the efficiency/capacity of the existing drainage system of the area.
3. To resection of the inadequate drains.

1.7 METHODOLOGY

The following methodology is followed:

1. Preparation of the Base Map of the study area.
2. The Digital Elevation Model (DEM) of the study area is generated in the GIS environment.
3. Delineation of the catchment area is undertaken in the DEM.
4. The runoff is estimated at the outlet point of the catchment using the Rational Method Formula.
5. The discharge carrying capacity of the existing drains are calculated using Manning's equation.
6. Comparison between actual runoff generated and existing drains runoff is made to check the drains efficiency.
7. Redesigning of the drain section having inadequate discharge carrying capacity.

CHAPTER 2

LITERATURE REVIEW

3.1 Brief Review of Few References-

- Qiangqiang Li et al., (2016) carried the research to provide more solutions for urban waterlogging prevention and control in China, takes Shijiazhuang as its research object; concludes the causes of water logging by analysing different factors like geography, climate characteristics, and urban construction in Shijiazhuang; and then brings forward the differentiated solutions—like perfecting rain-caused flood safety system, perfecting the drainage system, establishing underground pipeline tunnel system, and building the “sponge city”—in different situations. The author hopes to build Shijiazhuang a city which can pass the test of heaviest possible rains and to provide other cities in China some feasible methods to deal with their waterlogging problems.
- Mi Pale Kyi et al., (2017) studied the performance of the existing drainage capacity by using Modified Rational Method and then to propose the appropriate drain size with effective drainage capacity for the Yangon City, Myanmar. Due to inadequate size, lack of proper maintenance and tidal effect, the existing drains in most of the places are not serving the purpose during rainy season. Therefore, new dimension of drain sections were proposed by using Manning’s equation. In this study, HEC-HMS, hydrological model is used to evaluate the design discharge for external catchments. To simulate rainfall-runoff process, SWMM is used for checking the proposed drain size capacity. According to simulation result from SWMM, almost all the major drain and minor drain can carry the peak discharge for 10 year Average Recurrence Interval. Thereafter, EPA SWMM can also simulate the response of catchment events in which runoff, water depth profile, pressured pipeline flow and outflow hydrograph are obtained.
- M. Mujibor Rahman et al., (2009) studied the rainfall induced flooding that it is caused by

high intensity storm, rainfall and runoff in the city area that is inundated due to lack of proper drainage system and inefficient management. It ascertains the water logging problem, its cause and its effects on the environment of the city from the perception of authorities of different organizations and people living in different wards of Khulna City Corporation. A field survey has been conducted during 2008 in Khulna City Corporation. This water logging becomes a burden for the inhabitants of Khulna city and creating adverse social, physical, economic and environmental impacts. Disruption of traffic movement and normal life, damage of structures and infrastructure, destruction of vegetation and aquatic habitats and loss of income potentials are the encountered effects of water logging on city life. The storm water becomes polluted as it mixes with solid waste, clinical waste, silt, contaminants, domestic wastes and other human activities that increase the water born diseases.

- Md. Shiblur Rahaman et al., (2020) carried out his work to investigate the major causes of waterlogging and its negative effects on life, from the viewpoint of people residing in different areas of Noakhali Pourashava, Bangladesh, various government, non-government, development organizations as well as various stakeholders including experts. It has been found that Noakhali Pourashava experienced waterlogging during peak monsoon season. Most of the inhabitants/respondents of the Noakhali Pourashava claimed that lack of drainage facility; excessive rainfall; inadequate, low capacity and conventional drainage system; natural siltation; improper waste management; absence of proper inlets and outlets; and blockage and encroachment of existing drainage are responsible for waterlogging. It has ascertained that the water logging becomes a burden for the inhabitants of the Pourashava and creating adverse effects on livelihood, society, infrastructure, economy and environment. Other notable adverse effects of waterlogging are disruption of traffic movement and normal life, structures and infrastructure damage and loss of income potentials with a lot of sufferings. The stagnant water acts as a breeding site for the vectors of various diseases and becomes a health hazard to people residing in the waterlogged area.

- Ar. Chandresh Sahu, Ar. Harshita Mishra (2024) studied water logging problem in Delhi: Causes, impact and solutions. Delhi has faced water logging as an issue for our urban sector with the rapid unorganized growth of Delhi, unsatisfactory drainage infrastructure and unplanned urban development. Not only does this recurring problem disrupt daily life but it also implies significant health risks and economic damage. The present study explores the reasons, consequences and possible remedies of waterlogging in Delhi. A detailed literature review, demographic analysis and case study of Delhi are done for evaluation the current strategies followed with recommendations to reduce water logging. The study undertook a SWOT analysis to better understand what are the strengths, weaknesses opportunities and threats of Delhi's approach towards managing water.
- Mr. Chougale J.B et al., (2019) studied water logging problem in Vasai, Maharashtra. It was found that 'Vasai' faces such problems very severely during monsoon. City gets water logged most of the time as intensity of rain is heavy. This is a major issue for Municipal Corporation and also the residents of Vasai. The haphazard growth of the population has imparted huge load on the existing sewers which failed to work efficiently during rainy season. Hence water logging is more frequent. Therefore, to avoid such difficulties water need to be obstructed where it won't impart any damage to the public life and water can be utilized while detaining, for different purposes and the water which is let into sea can be reduced. Runoff estimation was done by Rational Method and also with the help of modern softwares like Storm Water Management Model (SWMM).

CHAPTER 3

STUDY AREA

3.1 INTRODUCTION

The study area is Maligaon, a locality of Guwahati, Assam. Situated in the western part of Guwahati at latitude 26°9’15” N and longitude 91°41’50” E, well-known for the headquarters of Northeast Frontier Railway and Northeast Frontier Railway Stadium.

Stormwater coming from the surrounding hills goes to the pond in front of KV school, Maligaon. Catchment delineation map of the study area is prepared with the help of ArcGIS.

The catchment having the outlet point as 26° 9'13.95"N and 91°41'31.85"E.

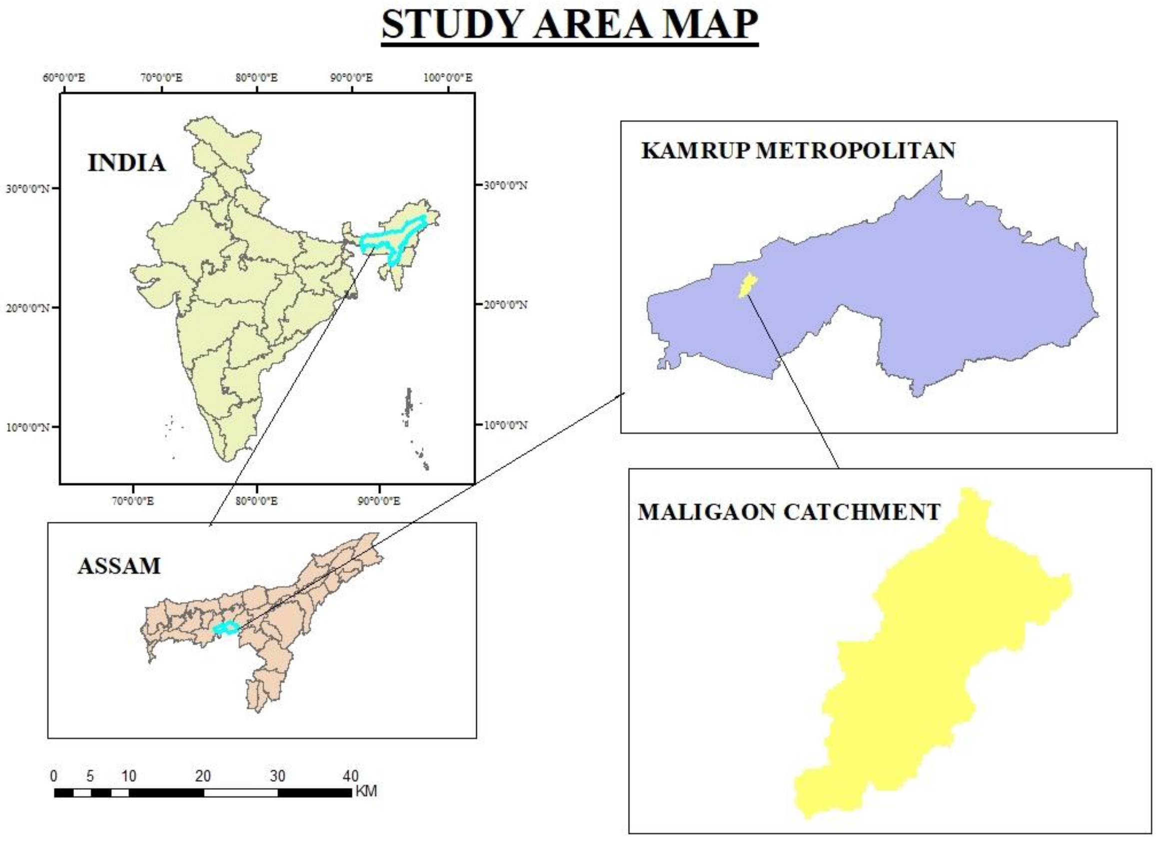


Fig. 3.1- Study Area Map prepared in ArcGIS

3.2 DIGITAL ELEVATION MODEL

Digital Elevation Model (DEM) is the digital representation of the land surface elevation with respect to any reference datum. DEM is frequently used to refer to any digital representation of a topographic surface. DEM is the simplest form of digital representation of topography (Balasubramanian,2017). Digital elevation model (DEM) is generally produced by photogrammetric techniques from stereo-photo pairs, stereo satellite images or interpolation of elevation data. Procedures for delineating streams and watersheds from DEMs were followed in the study. A DEM of 30 m resolution was used to drive the needed hydrological parameters (Mohamed et al.,2011).

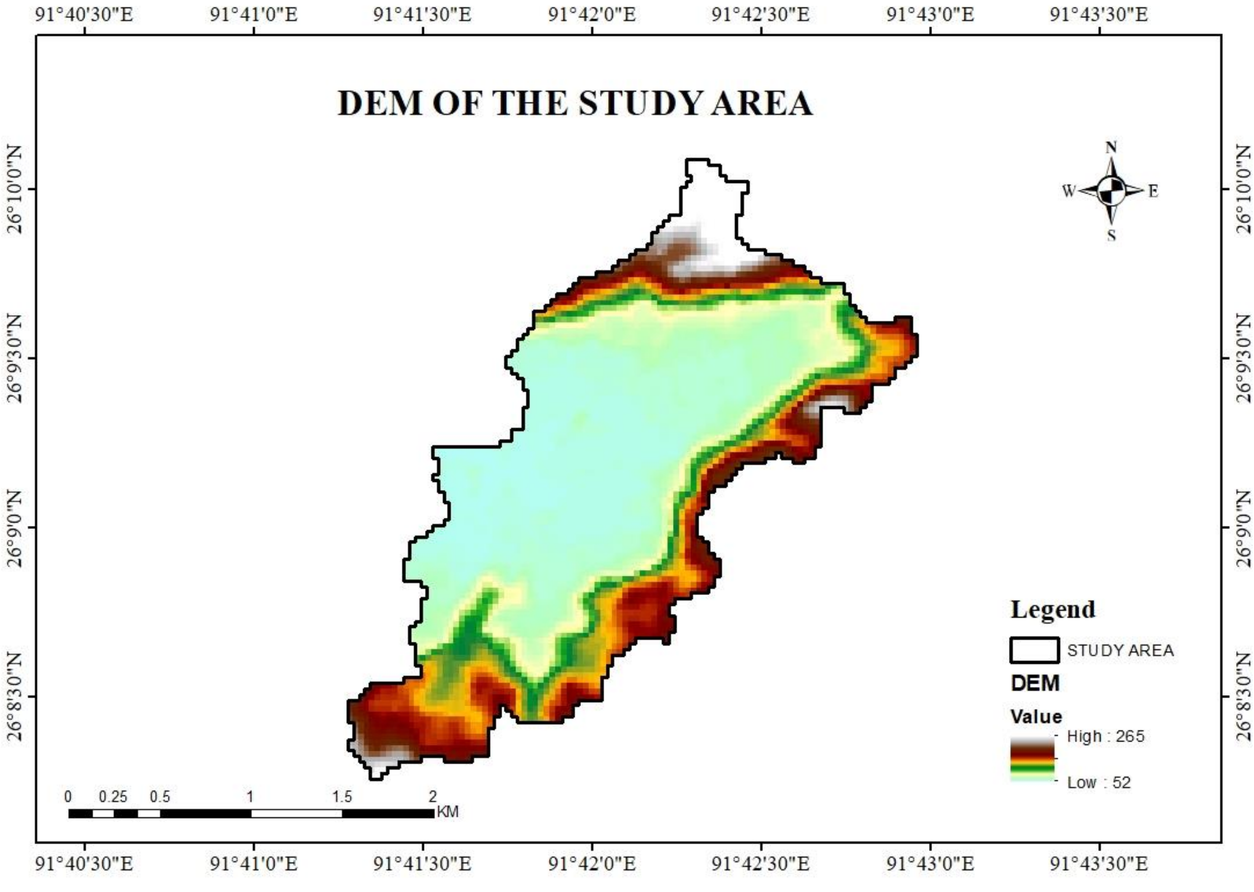


Fig.3.2- DEM of the study area

3.3 DELINEATION OF CATCHMENT OF THE STUDY AREA

For the purpose of delineation of catchment area, DEM obtained must be filled to be create a depression less DEM. Flow directions are needed in hydrology to determine the paths of water movement. A grid representing flow direction is produced from the DEM. The values of grid cells in the flow direction grid represent a code for defining one of eight possible directions for water to move out of that cell. The directions of this grid define a unique path from each cell to the DEM outlet. From the flow direction grid, the flow accumulation grid was formed. By tracing the unique downstream path of each cell, the total number of upstream cells draining through each cell is calculated (Mohamed et al.,2011). Once the flow accumulation map is formed the catchment can be delineated by pouring the outlet point. This methodology of extracting the catchment is shown in the Flow diagram in Fig.3.3.

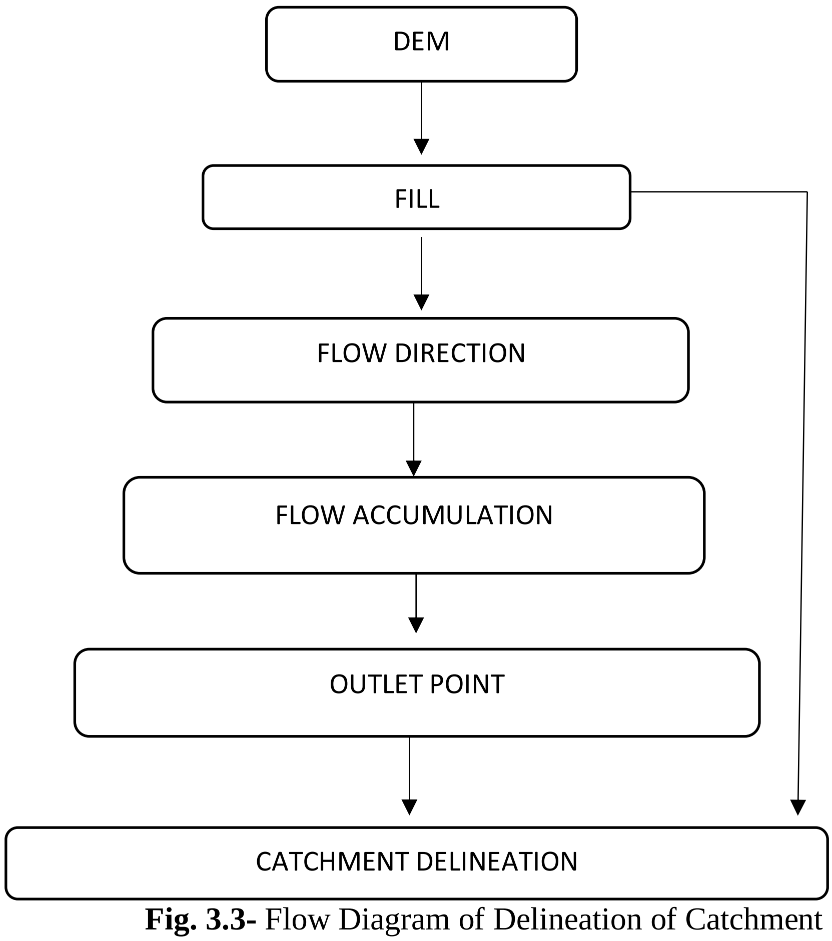


Fig. 3.3- Flow Diagram of Delineation of Catchment

The main objective of this methodology is to extract the watershed or the contributing area. A watershed is the upslope area contributing flow to a given location. Such an area is also referred to as a basin, catchment or contributing area. Watersheds can be delineated from the DEM by computing the flow direction and using it in the watershed function (Mohamed et al.,2011). A catchment area is usually defined as the area of land around a lake, river or some form of water body (Neal et al., 2002; Sassolas-Serrayet et al., 2018).

The delineation of the catchment of the study area has been done under GIS environment. For this purpose, a Digital Elevation Model (DEM) is obtained from https://earthexplorer.usgs.gov by creating polygon along the boundary of the study area and setting data in SRTM 1 Arc-Second Global. The DEM tile is downloaded in GeoTiFF format.

The DEM is then processed using a GIS software ArcGIS 10.4. The DEM is given as input raster in the ArcGIS Hydrology tool under Spatial Analysts Tool extension tool in the ArcGIS software. By the geo-processed techniques, the delineation of the catchment has been done. The DEM is filled and then flow direction and flow accumulation map is created using the same Hydrology tool under Spatial Analysts Tool.

The outlet point is then defined, which is the pond in front of KV school, Maligaon having latitude 26° 9'13.95"N and longitude 91°41'31.85"E. This outlet point is used as a source for delineating the catchment boundary with the help of watershed tool of Hydrology tool. The contributing catchment area for this study is obtained and is shown in fig 3.4.

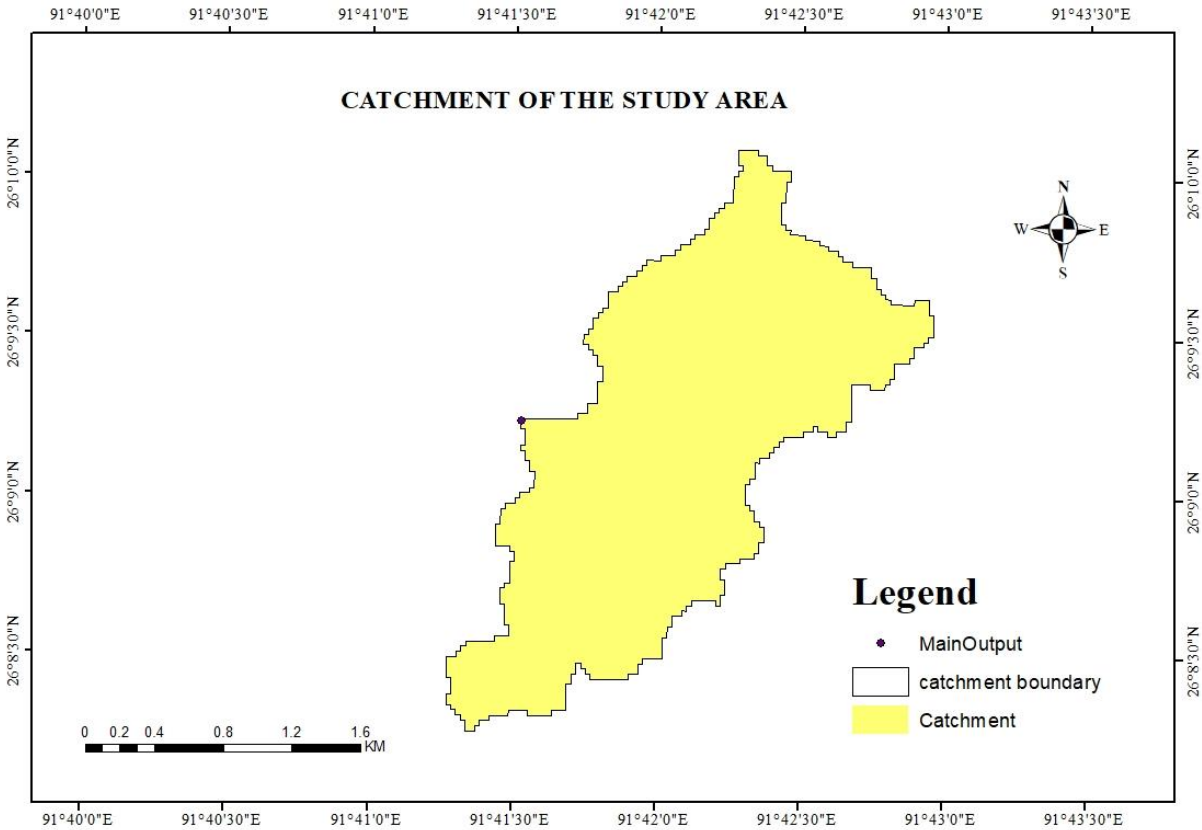


Fig.3.4- Catchment of the study area

3.4 CATCHMENT AREA CALCULATION

The catchment boundary obtained is clipped and converted from raster to polygon and projected the coordinate system is set to WGS 1984 UTM Zone 46N.The area of the catchment is obtained.

Table 3.1 Area of the whole catchment

CATCHMENT	LATITUDE	LONGITUDE	AREA (Km^2)
Whole catchment	26° 9'13.95"N	91°41'31.85"E	3.93124

3.5 DELINEATION OF THE SUB-CATCHMENTS

The whole catchment is further divided into 10 sub-catchments by defining 10 outlet points.

Fig 3.5- Google Earth Pro image showing whole catchment and 10 outlet points of sub-catchments

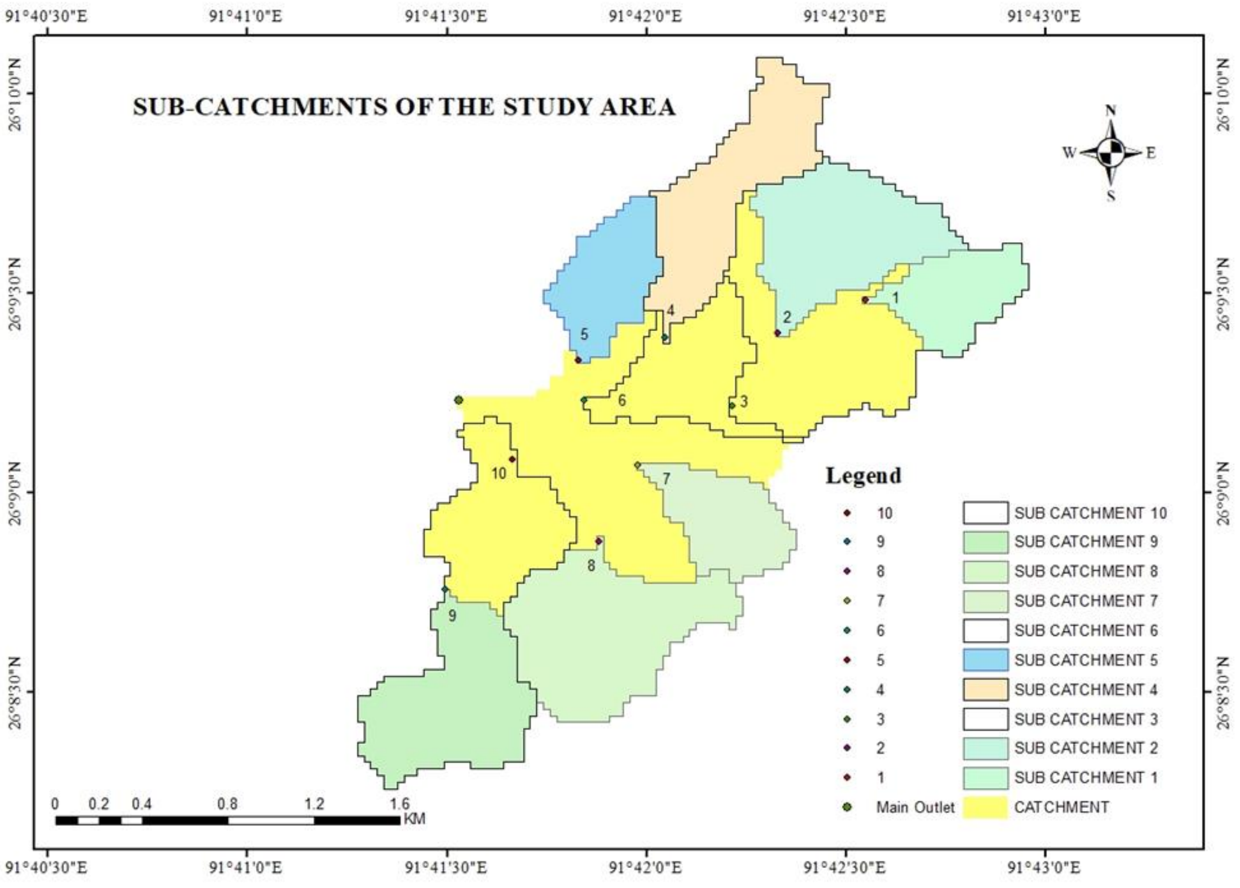


Fig 3.6- Sub-catchments of the study area prepared in ArcGIS

The sub-catchments are delineated using the same hydrology tool in the ArcGIS. The sub-catchments are obtained as shown in fig 3.6. Area of each sub-catchments are then obtained

Table 3.2- Area of Sub-catchments

SUB-CATCHMENT	LATITUDE	LONGITUDE	AREA (Km2)
1	26° 9'28.93"N	91°42'32.94"E	0.200781
2	26° 9'24.00"N	91°42'19.83"E	0.398137
3	26° 9'13.05"N	91°42'12.96"E	1.038940
4	26° 9'23.28"N	91°42'2.81"E	0.386170
5	26° 9'19.93"N	91°41'49.86"E	0.219578
6	26° 9'13.96"N	91°41'50.60"E	1.696810
7	26° 9'4.07"N	91°41'58.76"E	0.214469
8	26° 8'52.62"N	91°41'52.82"E	0.482790
9	26° 8'45.42"N	91°41'29.79"E	0.405897
10	26° 9'5.02"N	91°41'39.85"E	0.725467

CHAPTER 4

RUNOFF ESTIMATION

4.1 INTRODUCTION

This chapter aims to discuss the estimation of the direct surface runoff. For the estimation of surface runoff, the Rational Method Formula is used.

4.2 RUNOFF

Surface runoff is the overland flow of excess rainfall which initially joins a stream network in a basin system. The runoff water enters the master stream through a series of channel networks. The volume of water measured at the basin outlet is known as stream flow or total runoff, which comprises base flow, interflow, and overland flow (Betson, 1964; Sribas Kanji & Subhasish Das, 2024). Runoff generated from a watershed depends on rainfall, infiltration, and watershed characteristics and it can be measured daily, monthly, or annually. Watershed runoff is a major concern due to its impact on environmental, agricultural, and flood potential (M. I. Adham et al., 2014). It's important to know the runoff volume for a watershed for drainage system planning and design.

4.3 RATIONAL METHOD

Rational method was first used in 1889 developed by Emil Kuichling. The Rational equation is the easiest method to obtain peak runoff from watershed. Most common and quickest method of runoff estimation. The rational method is the oldest method still probably the most widely used method for design of storm drains. This method is for small areas, especially the size of the drainage basin fixed to a few acres (Burra et al.,2021).

It is mainly an intensity-based rainfall prediction method to calculate peak flows, based on watershed characteristics and the particular rainfall event.

Indeed, the original Rational Method is based on four assumptions: (1) the rate of rainfall is constant throughout the storm and uniform over the whole catchment; (2) the contributing area is uniform over the whole catchment; (3) sewers flow at constant pipe-full velocity throughout time of concentration; (4) catchment imperviousness is constant throughout the storm (Butler and Davies, 2011; Sheng Wang and Heng Wang,2018).

The rational method is used for the computation of surface runoff. This rational method is essentially a simple formula based on the catchment's runoff-producing potential, average intensity of rainfall, and catchment drainage area. The formula is

Q =C x i x A

Where, Q = discharge in cumec

C = co-efficient of run-off(dimensionless)

i = rainfall intensity

A = drainage area

4.4 RUNOFF CALCULATION

The runoff at the outlet is calculated using the rational method formula. The intensity of rainfall, i is considered as 20 mm/hr and Runoff coefficient C is taken as 0.8 for semi-urban area. 0.28 is a conversion factor, constant to convert peak discharge to unit m^3/s.

Therefore, the runoff, Q = 0.28 x C x i x A

Where, Q = Peak runoff (m^3/s)

C = Co-efficient of run-off(dimensionless)

i = Rainfall intensity (mm/hour)

A = Area (Km^2)

For the whole catchment,

Area, A= 3.93124 Km^2

Runoff discharge = 0.28 x C x i x A = 0.28 x 0.8 x 20 x 3.93124

=17.612 m^3/s

The runoff discharge for the sub-catchments are calculated using the same formula. The discharge values are plotted in the table below:

Table 4.1 -Runoff of sub-catchments

SUB-CATCHMENT	**LATITUDE**	**LONGITUDE**	**AREA (Km^2)**	**RUNOFF (m^3/sec)**
1	26° 9'28.93"N	91°42'32.94"E	0.200781	0.8995
2	26° 9'24.00"N	91°42'19.83"E	0.398137	1.7837
3	26° 9'13.05"N	91°42'12.96"E	1.03894	4.6545
4	26° 9'23.28"N	91°42'2.81"E	0.38617	1.7300
5	26° 9'19.93"N	91°41'49.86"E	0.219578	0.9837
6	26° 9'13.96"N	91°41'50.60"E	1.69681	7.6017
7	26° 9'4.07"N	91°41'58.76"E	0.214469	0.9608
8	26° 8'52.62"N	91°41'52.82"E	0.48279	2.1629
9	26° 8'45.42"N	91°41'29.79"E	0.405897	1.8184
10	26° 9'5.02"N	91°41'39.85"E	0.725467	3.2501

CHAPTER 5

EVALUATION OF EXISTING DRAINAGE SYSTEM

5.1 INTRODUCTION

One of the crucial things in urban life is the problem of flooding that occurs and the actions that will be taken to mitigate flooding. The development of urban drainage systems is very important. The existence and condition of the drainage system must be able to drain the flow of rainwater that is stagnant on the road pavement (Adams Nur Oktalinov Fikri et al.,2023).

Drainage network is an important element for any community. The artificial and natural drainage helps to remove sullage and storm water from surface and prevents many problems such as water logging, environmental pollution etc. So it has importance in the natural consequence as well as in our daily life. Drainage in human settlements has assumed considerable significance due to the enormous population growth and the rapid but haphazard urbanization evident in most countries (Mulik. N. M. et al.,2021).

5.2 IMPORTANCE OF EFFICIENT DRAINAGE SYSTEM

1. Prevents flooding

Flooding poses serious property damage and can even cause loss of life. Draining stormwater from the urban area reduces risk caused due to flooding.

2. Infrastructure Protection

Flooding can cause structural damage to infrastructures which may result to structural failures. Effective drainage lowers maintenance costs and extends the life of infrastructure.

3. Health and Hygiene

Stagnant water in the drains provides a breeding ground for mosquitoes and other pests, leading to spreading of diseases like dengue and malaria. Efficient drainage system carries the stormwater effectively to the outlet point.

4. Economic Effect

Water logging disrupt traffic and day-to day activities that have direct impact on the economy. Effective drainage prevents water logging thus minimizing economic loss of the city.

5. Environmental Protection

Efficient drainage systems drain excess runoff and release it into main streams thus reducing pollution.

5.3 DRAINAGE DISCHARGE

For calculating the mean velocity and discharge in open channels, Manning's equation is the most common. The equation is based on some measured hydraulic parameters such as hydraulic radius, water surface slope and roughness coefficient (Mohamed Salah Abd Elmoaty and El-Samman T. A.,2020). Considering uniform flow condition, the water surface slope is same as the channel bed slope (Ferguson, 2007). The hydraulic radius is the ratio of cross-sectional area and wetted perimeter. Roughness coefficient (n) is defined as a parameter that represents the channel roughness and resistance to flow. According to previous studies made, there are many significant factors that affects the velocity of flow in a channel such as area, wetted perimeter, maximum surface velocity, slope of water surface, maximum depth, roughness coefficient, and water temperature (Huthoff and Augustijin, 2005). Mainly, Manning's roughness coefficient, n depends on surface roughness and factors like vegetation cover, cross-sectional irregularity, channel silting, scouring, obstruction and stage or depth of flow (Dr. Mimi Das Saikia and Meenu Das,2015).

The Manning equation is an empirical equation for analysing water flows in channels and culverts where the water is open to the atmosphere which means the flow is not under pressure. Irish engineer Robert Manning in 1891 introduced the equation.

The Manning's equation to estimate velocity of flow in the channel is

$$V= \frac{1}{n} R^{2/3}S^{1/2}$$

Here, V = Average velocity of flow (m/s)

n= Manning's coefficient

R= Hydraulic radius (m) =A/P

S= Channel bed slope

The velocity equation is used to calculate discharge.

The discharge equation can be written as

Q = A x V

Here, Q = Discharge (m^3/s)

A= Area of the channel (m^2)

V= Velocity of flow in the channel (m/s)

5.4 PARAMETERS REQUIRED FOR DISCHARGE CALCULATION

5.4.1 Manning's Roughness Coefficient

The Manning's roughness coefficient, n for various surfaces is given below:

Table 5.1 Manning's roughness coefficient values

Type of Surface	Value of n
i) Brick pitched drain	0.017
ii) Plastered brick surface	0.015
iii) Plastered brick surface with neat cement finish	0.013
iv) Concrete pipes upto 600 mm dia	0.015
v) Concrete pipes above 600 mm dia	0.013
vi) Dry rubble masonry	0.033
vii) Dressed ashler surface	0.015
viii) Dry stone pitching	0.020
ix) Kutcha drain	0.025

Source: GUIDELINES ON URBAN DRAINAGE (First Revision) IRC: SP:50-2013

5.4.2 Free board

Free board is an important consideration in analyzing open channel flow. Freeboard is defined as the vertical distance between maximum water level to the top edge of the channel.

For minimum free board Guidelines on Urban Drainage (First Revision) IRC: SP:50-2013 may be referred to

Table 5.2 Freeboard Values

Drain size	Free Board
i) Beyond 300 mm bed width	10 cm
ii) Beyond 300 mm & upto 900 mm bed width	15 cm
iii) Beyond 900 mm & upto 1500 mm bed width	30 cm

Source: GUIDELINES ON URBAN DRAINAGE (First Revision) IRC: SP:50-2013

For larger drains the free board shall be higher up to 90 cm depending upon the discharge.

5.4.3 Channel Bed Slope

The bed slope of the drain channel is estimated in Google Earth Pro using Elevation profile tool.

5.4.4 Type of Drain Section

Types of Drain section present in the study area are rectangular section and trapezoidal section.

5.4.4.1 Rectangular Section

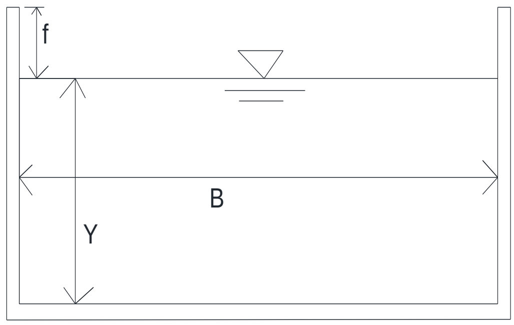


Fig 5.1 Rectangular section diagram

Rectangular channel having bottom width B, depth of flow Y and free board f.

Cross-sectional area, A and wetted perimeter can be written as

A = B x Y

P = B + 2Y

5.4.4.2 Trapezoidal Section

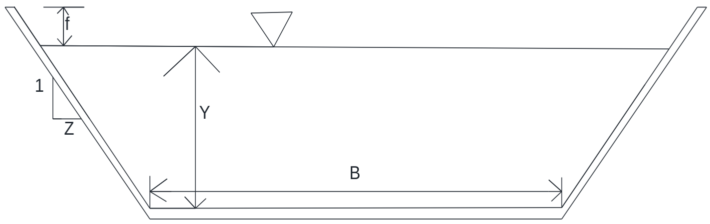


Fig 5.2- Trapezoidal section diagram

Trapezoidal Channel having bottom width B, depth of flow Y, free board f and side slope in the ratio 1: Z(V:H).

Cross-sectional area, A and wetted perimeter can be written as

A = (B +ZY) x Y

P = B + 2Y$\sqrt{1+Z^2}$

5.5 DRAINS DISCHARGE CALCULATION

Considering the above factors and formulae of Manning's equation, the discharge carrying capacity of the drains existing in the study area has been calculated.

Table 5.3 Discharge calculation of the existing drains

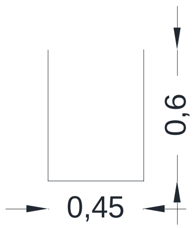
REFERENCE TO OUTLET POINT	LATITUDE	LONGITUDE	AREA	NATURE/TYPE OF DRAIN	SECTION	TOP WIDTH (m)	BOTTOM WIDTH (m)	DEPTH (m)	FREEBOARD (m)	EFFECTIVE DEPTH (m)	CROSS SECTIONAL AREA, A (m^2)	WETTED PERIMETER, P (m)	HYDRAULIC RADIUS, R=A/P	$R^{2/3}$	SLOPE	VELOCITY (m/s)	CARRYING CAPACITY (Q)(m^3/s)
1.	26°9'28.93"	91°42'32.94"	EAST GOTANAGAR	NS/MASONRY,MEDICAL DRAIN, n=0.015		0.45	0.45	0.6	0.15	0.45	0.2025	1.35	0.15	0.282	0.0259	3.029	0.613
2.	26°9'24"	91°42'19.83"	EAST GOTANAGAR	NS/RCC, ENGINEERING DRAIN, n= 0.013		2.75	2.75	1.4	0.5	0.9	2.4750	4.55	0.544	0.666	0.0177	6.818	16.873

Table 5.3 Discharge calculation of the existing drains (Continued)

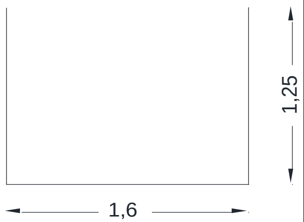
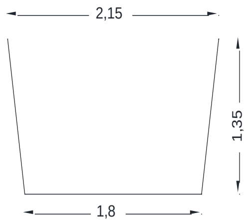
REFERENCE TO OUTLET POINT	LATITUDE	LONGITUDE	AREA	NATURE/TYPE OF DRAIN	SECTION	TOP WIDTH (m)	BOTTOM WIDTH (m)	DEPTH (m)	FREEBOARD (m)	EFFECTIVE DEPTH (m)	CROSS SECTIONAL AREA, A (m^2)	WETTED PERIMETER, P (m)	HYDRAULIC RADIUS, R=A/P	$R^{2/3}$	SLOPE	VELOCITY (m/s)	CARRYING CAPACITY (Q) (m^3/s)
3.	26°9'13.05"	91°42'12.96"	EAST GOTANAGAR	NS/RCC, ENGINEERING DRAIN, n= 0.013		1.6	1.6	1.25	0.5	0.75	1.2000	3.10	0.387	0.531	0.0481	8.958	10.749
4.	26°9'23.28"	91°42'2.81"	WEST MALIGAON	NS/RCC, ENGINEERING DRAIN, n= 0.013	 Z =0.1296	2.15	1.8	1.35	0.5	0.85	1.6237	3.51	0.462	0.598	0.0155	5.714	9.278

Table 5.3 Discharge calculation of the existing drains (Continued)

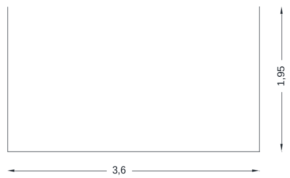
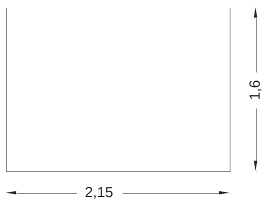
REFERENCE TO OUTLET POINT	LATITUDE	LONGITUDE	AREA	NATURE/TYPE OF DRAIN	SECTION	TOP WIDTH (m)	BOTTOM WIDTH (m)	DEPTH (m)	FREEBOARD (m)	EFFECTIVE DEPTH (m)	CROSS SECTIONAL AREA, A (m^2)	WETTED PERIMETER, P (m)	HYDRAULIC RADIUS, R=A/P	$R^{2/3}$	SLOPE	VELOCITY (m/s)	CARRYING CAPACITY (Q) (m^3/s)
5.	26°9'19.93"	91°41'49.86"	CENTRAL GOTANAGAR	KUTCHA,ENGINEERING DRAIN, n= 0.025		3.6	3.6	1.95	0.5	1.45	5.2200	6.50	0.803	0.864	0.0208	4.984	26.018
6.	26°9'13.96"	91°41'50.60"	CENTRAL GOTANAGAR	NS/RCC, ENGINEERING DRAIN, n= 0.013		2.15	2.15	1.1	0.5	0.6	1.2900	3.35	0.385	0.529	0.0154	5.053	6.518
						2.15	2.15	1.6	0.5	1.1	2.3650	4.35	0.544	0.666	0.0154	6.359	15.039

Table 5.3 Discharge calculation of the existing drains (Continued)

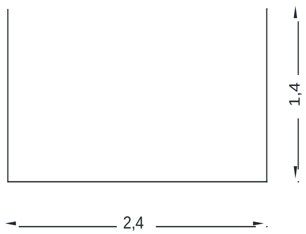
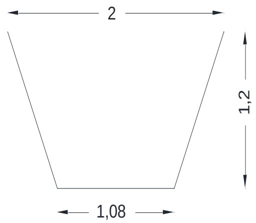
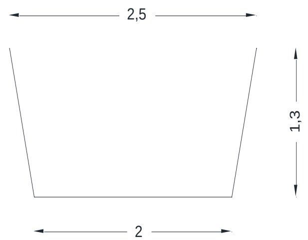
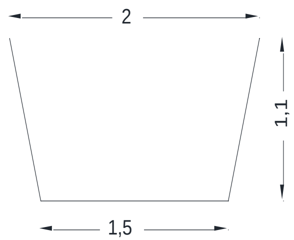
REFERENCE TO OUTLET POINT		**LATITUDE**	**LONGITUDE**	**AREA**	**NATURE/TYPE OF DRAIN**	**SECTION**	**TOP WIDTH (m)**	**BOTTOM WIDTH (m)**	**DEPTH (m)**	**FREEBOARD (m)**	**EFFECTIVE DEPTH (m)**	**CROSS SECTIONAL AREA, A (m^2)**	**WETTED PERIMETER, P (m)**	**HYDRAULIC RADIUS, R=A/P**	**$R^{2/3}$**	**SLOPE**	**VELOCITY (m/s)**	**CARRYING CAPACITY (Q) (m^3/s)**
7.		26°9'4.07"	91°41'58.76"	CENTRAL GOTANAGAR	NS/RCC, ENGINEERING DRAIN, n= 0.013		2.4	2.4	1.4	0.5	0.9	2.1600	4.2	0.514	0.642	0.0476	10.774	23.272
8.		26°8'52.62"	91°41'52.82"	GOSHALA COLONY	NS/MASONRY, MEDICAL DRAIN, n= 0.015	 Z = 0.3833	2	1.08	1.2	0.3	0.9	1.2825	3.008	0.426	0.567	0.0064	3.021	3.875

Table 5.3 Discharge calculation of the existing drains (Continued)

REFERENCE TO OUTLET POINT	LATITUDE	LONGITUDE	AREA	NATURE/TYPE OF DRAIN	SECTION	TOP WIDTH (m)	BOTTOM WIDTH (m)	DEPTH (m)	FREEBOARD (m)	EFFECTIVE DEPTH (m)	CROSS SECTIONAL AREA, A (m^2)	WETTED PERIMETER, P (m)	HYDRAULIC RADIUS, R=A/P	$R^{2/3}$	SLOPE	VELOCITY (m/s)	CARRYING CAPACITY (Q) (m^3/s)
9.	26°8'45.42"	91°41'29.79"	NAMBARI COLONY	MASONRY,ENGINEERING DRAIN , n =0.015	 Z = 0.1923	2.5	2	1.3	0.5	0.8	1.7231	3.629	0.475	0.609	0.0267	6.630	11.423
10.	26°9'5.02"	91°41'39.85"	NAMBARI COLONY	MASONRY,ENGINEERING DRAIN, n =0.015	 Z = 0.2273	2	1.5	1.1	0.3	0.8	1.3455	3.141	0.428	0.568	0.0449	8.028	10.801

CHAPTER 6

EXISTING DRAINAGE SYSTEM, RESULTS AND DISCUSSION

6.1 INTRODUCTION

A comparison of the carrying capacity of the existing drains in the study area is made with the actual runoff generated in the area/ sub-catchment areas. This comparison identifies the adequacy of the drains.

Table 6.1 Comparison of adequacy of existing drains discharge with the sub-catchments surface runoff

OUTLET	SUB-CATCHMENT DISCHARGE (m^3/s)	EXISTING DRAINS DISCHARGE (m^3/s)	REMARKS
1	0.8995	0.613	INADEQUATE
2	1.7837	16.873	ADEQUATE
3	4.6545	10.749	ADEQUATE
4	1.7300	9.278	ADEQUATE
5	0.9837	26.018	ADEQUATE
6	7.6017	6.518 15.039	ADEQUATE
7	0.9608	23.272	ADEQUATE
8	2.1629	3.875	ADEQUATE
9	1.8184	11.423	ADEQUATE
10	3.2501	10.801	ADEQUATE

6.2 RESULTS AND DISCUSSION

From the above analysis, it has been observed that 9 out of 10 drain sections are adequate to carry the runoff generated in the study area. The result indicates that at outlet 1 there is an overflow runoff of 0.2865 m^3/s.

Thus, to discharge the runoff at outlet 1, the design section of the capacity for the peak discharge (0.8995 m^3/s) has been done. Considering a rectangular section,

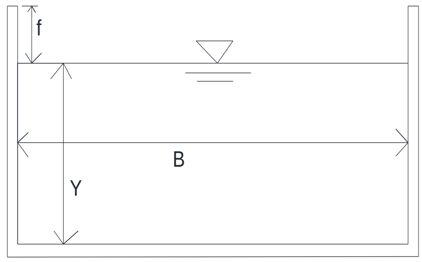


Fig 6.1 Rectangular section diagram considered for resection

Assuming, Width of the Channel = B in m

Effective Depth of the Channel = Y=B/2 in m

Area = A = B x B/2 in m^2

Wetted perimeter = P in m

Hydraulic Radius = R = A/ P = B/4

Using Manning's equation, considering the Manning's coefficient, n = 0.015

V = 1/n x R $^{2/3}$ x S ^{½} = (1/0.015) x $(B/4)^{2/3}$ x S ^{½}

Area required, A = Q / V

$$B \times B/2 = \frac{0.8995}{\frac{1}{0.015} * \left(\frac{B}{4}\right)^{\frac{2}{3}} * 0.0087^{\frac{1}{2}}}$$

B = 0.724 m

Since Effective Depth, Y = B/2 = 0.362 m

Therefore, Depth of the channel after considering freeboard of 0.15 m is 0.512 m.

Thus, the design section of the drain must have bottom width of 0.724 m and depth of 0.512 m to safely convey the discharge generated.

CHAPTER 7

CONCLUSION

7.1 INTRODUCTION

An integrated remote sensing and GIS based study on urban storm water flooding in the Maligaon area of Guwahati city has been carried out. The Maligaon area surrounded by Nilachal hills and other hills serves as the study area. The stormwater from the hills gets disposed of in the pond in front of KV school, Maligaon.

The study of the existing drainage system has been carried out to check the efficiency of the drains.

7.2 CONCLUSION

The study carried out by delineating the catchment and then determine the surface runoff. The pond in front of the KV school is the disposal site for the catchment runoff. Considering the pond as the outlet the delineation of the catchment is carried out. The catchment has an area of 3.93124 Km^2. The runoff generated using Rational method in the catchment is found to be 17.612 m^3/s. The whole catchment was further divided into 10 sub-catchments by defining 10 outlet points. The sub-catchments labelled s 1 to 10 and their corresponding areas were 0.200781 Km^2, 0.398137 Km^2, 1.03894 Km^2, 0.38617 Km^2, 0.219578 Km^2, 1.69681 Km^2, 0.214469 Km^2, 0.48279 Km^2, 0.405897 Km^2, 0.725467 Km^2. Rational method was applied for estimation of runoff for all sub-catchments. The computed peak discharge for sub-catchments 1 to 10 are 0.8995 m^3/sec, 1.7837 m^3/sec, 4.6545 m^3/sec, 1.7300 m^3/sec, 0.9837 m^3/sec, 7.6017 m^3/sec, 0.9608 m^3/sec, 2.1629 m^3/sec, 1.8184 m^3/sec, 3.2501 m^3/sec respectively. The discharges for the existing drain cross-sections at the 10 outlets have been calculated using Manning's equation of velocity and discharge. The discharge referenced to outlet of sub-catchments 2 to 10 are found to be adequate, i.e., out of 10 drain sections 9 were found to be adequate. The discharge referenced to outlet of sub-catchment 1 was found to be 0.613 m^3/sec.

This result in an overflow runoff of 0.2865 m^3/s. In order to safely convey the runoff of 0.8995 m^3/sec the drain resection has been calculated. The resection drain must have bottom width of 0.724 m and depth of 0.512 m to safely convey the discharge generated.

7.3 SCOPE FOR FUTURE WORK

The work can further be done considering more number of sub-catchments. Urbanization or population growth factor can be considered for checking the existing drains efficiency. Considering population projection will predict the drains performance in the future. Climate change impact on the stormwater drainage system can be studied to analyse its efficiency.

CHAPTER 8

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