CHARACTERISTICS OF HYDROLOGICAL MODELLING OF MAHANADI BASIN USING THE HEC-HMS SOFTWARE

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Submitted by

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I, **SHASHANK VAISHNAVA**, Roll No. **2K18/HFE/020** of **M.Tech** (**HWRE**), hereby declare that the project report titled “**CHARACTERISTICS OF HYDROLOGICAL MODELLING OF MAHANADI BASIN USING THE HEC-HMS SOFTWARE**” which is submitted by me to the Department of Hydraulics and Water Resources Engineering, Delhi Technological University, Delhi in partial fulfillment of the requirements for the award of the degree of Master of Technology, is original and not copied from any source without proper citation. This work has not previously formed the basis for any Degree, Diploma Associateship, Fellowship or other similar title or recognition.

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CERTIFICATE

I hereby certify that the project dissertation titled "**CHARACTERISTICS OF HYDROLOGICAL MODELLING OF MAHANADI BASIN USING THE HEC-HMS SOFTWARE"** which is submitted by **SHASHANK VAISHNAVA,** Roll number **2K18/HFE/020** of M.Tech **(HWRE),** Delhi Technological University, Delhi in partial fulfillment of the requirement for the award of the degree of Master Of Technology, is record of the project work carried out by the students under my supervision. To the best of my knowledge this work has not been submitted in part or fully for any Degree or Diploma to this University or elsewhere.

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ABSTRACT

Hydrological Modeling consists of different mathematical models which represents as well as conclude various hydrological processes and its components to alter the interaction between them. To simulate the rainfall – runoff processes a watershed model HEC-HMS has been used in hydrological processes caused due to precipitation. It helps in predicts different hydrological parameters with respect to the watershed management and its adverse effect along its area. A model for rainfall runoff process is taken across The Mahanadi Basin. Two different catchments were selected Seonath Catchment and Jonk Catchment for the study. Simulations were conducted daily, monthly and yearly time scale resolutions. In this study, two methods were used as a loss models for major components i.e SCS-CN Method and SMA Method. Both the methods have different parameters and to obtain the exact results for both the catchment , they are used on both the catchments to differentiate. Results of both the catchments were different as Simulated runoff and observed runoff of Jonk Catchment somehow follows the exact pattern at various time intervals but for Seonath catchment the simulated runoff and observed runoff were different. The software cannot process the exact rainfall-runoff simulation in Seonath and Jonk catchment present in the Mahanadi Basin obtained by SMA method as it is very complex method for simulation but shows exact results obtained by SCS-CN method along both catchments at various time intervals. The results of present study for the Mahanadi Basin found to be useful for obtaining various objectives as discussed further and also both the methods have been differentiated along with the simulation results for proper rainfall runoff processes.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

CHAPTER – 1

INTRODUCTION

1.1 GENERAL

Water is renowned to be known as the primary demand for the existence of life and it ought to be taken look after ecological balance. Fertile soil within the world is incredibly less, non-renewable however it's degrading thanks to direction of those soils. In the seonath basin most of the half it suffers from upland sediment erosion. Development of the many reservoirs during a single watercourse and braking water at varied positions could be a dangerous sign for variety.

Land use and land cowl in a district doesn't modification solely hydrologic element, however it additionally affects the prevailing atmosphere and bio-diversity. Water pollution in watercourse typically originates typically from non-point supply drawback either within the type of sediment, nitrogen, chemical element or chemical etc., however it can even be a degree source drawback additionally like every trade discharging into the watercourse.

Therefore, water and land management apply ought to be properly planned. Basin or sub-basin is taken into account to be a ideal unit for higher management of those natural resources. Basin scale analysis offers North American country a full system for higher conservation and management of natural resources.

Specially Chhattisgarh region has sensible water and natural resources. The region gets sensible precipitation and storm throughout monsoon season, however additionally suffers from acute shortage in several areas even for water. This space is named rice bowl, however management apply for eroding is incredibly weak thus it additionally affected by upland geological phenomenon drawback. The basic drawback during this space associated with water resources problems: one revenant draughts close to Durg sub-region, eroding from barren lands and so it need higher water and For this purpose it's needed to higher information of hydrological cycle and calculate the hydrological parameters. To the actual measuring of runoff and alluviation in remote sensing of inaccessible areas is sort of troublesome. So it's needed to settle on some acceptable technique that capable to quantify hydrological parameter in the whole a part of the study space or its area.

1.2 IMPORTANCE OF HYDROLOGICAL MODELLING

In currently days use of mathematical models for hydrologic analysis , that works on mass balance system for basin and hard basin parameters victimization remote sensing and geographical data system Hydrological modeling could be a terribly helpful technique for hydrologic investigation.

This is additionally helpful for integrated approach for property development. Concerning however land use ought to be amendment for development in such some way that it ought to produce no disturbance or minimum disturbance to native ecological system. There area unit variety of code obtainable which might simulate the impact of runoff amendment, land-use amendment and sediment and nutrient analysis.

Two kinds of approaches area unit attainable for this purpose. Within the model driven approach, a model or set of models is outlined associated therefore the specified remotely detected knowledge as an input for the preparation output maps. The opposite approach is that the knowledge driven approach. It limits the input spatial knowledge to parameters that will be obtained from usually obtainable maps, such as topographical maps, soil maps, etc. the mixture of those two different approaches helps in hydrological modeling.

In COHS (1991) (National Analysis Council Committee on Opportunities in the Hydrologic Sciences) geophysics is delineated as a distinct Geoscience with a sturdy knowledge domain flavor. The basic that means of geophysics is that the science of water and its movement within the whole surroundings. Geophysics may be used as a scientific analysis and analysis tool among watershed management.

The hydrologic cycle undergo many unique processes for maximizing the output of any particular model. They will be classified as:

- Precipitation
- Interception
- Interflow
- Infiltration and plant uptake
- Water losses within the sort of evapotranspiration, evaporation and ooze.
- Recharge to deep formation
- Upland flow and stream runoff

The subsequent rationalization of geophysical science encompasses social-environmental-economic relating to any watershed. Hence, for understanding different aspects of hydrological modeling, different models can be studied thoroughly which comprises of:

- Hydrological Models
- Physical 'real world' models
- Stochastics Models
- Surface runoff contaminant models

1.2.1 Hydrological Models

A hydrological transport model is known to be as a path for preferably based mathematical model which is pre-dominantly used for the simulation of stream flow, sedimentation and calculation of water quality and its parameters. These models were coming into the picture when people started thinking about the numeric quantity and quality of water. There are a number of models available and they are classified based on how the model works and what are the input and output of the model.

1.2.2 Physical Real World Models

Physical model uses indefinite mathematical calculation of the requirement of any output. The output may be streamed runoff, sedimentation or much more complex.

Process may be derived from a partial differential equation or by empirical formulas. These models can simulate runoff and sedimentation and their interaction with ground water.

1.2.3 Stochastic Models

Stochastic model is used mainly for the combination of mathematics and statistics to relate the different model inputs with their outputs. Such techniques of Neural networks and regressions and other major transferring techniques are used in such kind of model. Flood forecasting is the main tool used in this model where rainfall and runoff are present with moisture conditions in the real world hydrological systems.

1.2.4 Surface Runoff Contaminant Models

These model cannot preferably be counted or has been under the impression of a simple hydrological model in the community of various different other useful models. Sediment and chemical contamination are coming with the surface runoff. Here a main focus is on to determine nutrient or sediment load along with runoff.

1. Models may be classified as linear or nonlinear wherever non one-dimensionality is related to likelihood and unchangeability, creating it tougher to check.

2. The model also can be physical or abstract. Physically primarily based models use equations in an exceedingly standard to replicate processes within the hydrological cycle. Abstract models in distinction do not need empirical measurements.

1.3 OBJECTIVE OF WORK

The overall objectives of the project are mentioned in three parts :

1) To find the simulation results for particular basin.

2) To enumerate all hydrologic process of the watershed.

3) To access differences between model conceptulizations of both Seonath and Jonk Basin and difference between both the basins in relation to modeling.

1.4 ORGANIZATION OF THE WORK

The following work comprises six chapters and every chapter has been dived into sub-chapters in line with the need.

Chapter one of the work is that the basic introduction of the subject and has been divided into four completely different sub-topics that embrace the importance of the model and its parameters and also the use of temporary structure during this activity. It conjointly shows the essential objective of the thesis that has been ended within the later segments and also profoundly comprises the structural layout of the work.

Second chapter shows the work comprises the past information associated with the subject and depicting the low description of the work that had been allotted with completely different objectives of the constant topic.

Third chapter includes the study area of Mahanadi Basin including its subbasins like Seonath and Jonk Basin and the data collection associated with it i.e rainfall and runoff data.

Fourth chapter embraces the description of the basin model and its parameters with the methodologies of the software HEC-HMS and loss models and method associated with it such as SCS-CN method, Soil Moisture Accounting and Muskingum Flood Routing Method.

Fifth chapter shows various results that are concerned and also the numerical and software system simulation and also the results obtained from the simulation and their synchronic calculation.

Sixth chapter shows the conclusion of the results obtained by the results and calculation of the work with its future work for the particular basin.

CHAPTER – 2

LITERATURE REVIEW

M.R. Knebl, Z.-L. Yang, K. and others (2004) - In this study, it develops a framework around of a typical flood modeling along a regional scale which demonstrates NEXRAD Level III rainfall, GIS, and a hydrological model (HEC-HMS/HECRAS). The San Antonio Basin (10,000 km2) in Central Texas, USA, is taken as the medium of study because it's neighborhood states subject to have the tendency for frequent occurrences of severe flash high flooding having occurences at continuous intervals but more spontaneously also another hydraulic model (HEC-RAS) is used which depicts the unsteady state flow through the entire river channel network and as the end results it supports the HEC-HMS-derived hydrographs.

James Oloche OLEYIBLO, Zhi-jia LI (2008) – In this study, it presents an approach of HEC- HMS and Its applicability, capability and suitability for flood forecasting in different catchments along with another software HEC-GeoHMS for the study of dem, an ArcView GIS extension for catchment delineation, terrain pre-processing, and basin processing. The model was calibrated and verified using historical observed data of a particular basin of China. HEC-HMS Version 2.2.1. has been used in this study. The HEC model is meant to be used for the simulation of the surface runoff in response to catchment to precipitation by offering to represent the catchment with interconnected hydrologic and hydraulic components. The model consists of three different processes which is the loss, the transform and the the base flow. From this paper, we can conclude that it is not suitable for complex watershed systems.

Vaishnavi K. Patil, Vidya R. Saraf (2009) – In this study, modified SCS Curve Number is applied to work out loss model as a serious parameter in the rainfall-runoff modeling. The particular model used in Nasik region which falls in Upper Godavari Basin. To describe the various parameters such as peak runoff rates, runoff volume and flow routing methods such as SCS curve number, SCS unit hydrograph, Exponential recession and Muskingum routing methods are taken into account respectively. This particular study has been completed on a little watershed therefore any changes is restricted and an equivalent study can be administered for bigger watersheds.

J. R. Williams and N. Kannan (2012) – In this study, it explained the functioning of CN method and results were found for predicting the basic idea of the direct- link soil-moisture approach. As the different models were applied for the study approach, it became apparent that there is a hinderence in simulating runoff from soils having low capacity. Such problem leads to the revised SMI approach. Thus, the revised SMI method provided a convenient caliberation to study the approach of Hec-Hms software.

D. Halwatura, M.M.M. Najim (2013) – In this Study he has described the Hydrologic simulation predicating a computer model which is a very advanced and rapid computerized model known which is profound to became important tool for understanding the necessity of unnatural human influences like urbanization , deforestration etc on river flows. The software is known to be a very reliable which is developed by the United States Army Corps of Engineers. This model has not calibrated and validated the Sri Lankan watersheds due to some missing spatial data.

Reshma T, Venkata Reddy K, Deva Pratap (2013) - In this study , a runoff for a rainfall event is taken into account in the presence of various influencing factors. Also different and several computer based hydrological model are developed for simulation of runoff in watershed and water resource studies. In this study, HEC-HMS hydrological model has been taken into consideration for the simulation of runoff process for seven rainfall events to find the caliberation and validation results in Walnut Gulch watershed located in Arizona, USA.

Surendra Kumar Mishra (2013) – In this study the direct application in designing the CN or curve number has been shown, which is very helpful in providing the rainfall-generated runoff. Also, the study provides the mechanism for flood forecasting and subsequently for the planning of suitable structures, etc. Especially flooding affected areas, it is also used for river to mitigate the consequences of flooding.This study shows the apparent need of hydrologists and engineers engaged in flooding forecasting, trying to find suitable sites for hydro-electric plant, etc. and also for soil conservationists.

H. L. Zhang and Y. J. Wang (2013) – In this particular study, it is used for the simulation of two flood events for the research of the effect of watershed subdivision along with its performance. The paper indicates about NEXRAD precipitation.The models with different subbasin parameters and sizes are taken for metereological study and the results obtained found to be very sensitive on that particular region.Observed data are very close with the results obtained. The basic idea is to implement the use of the software in Upper Mississippi Region.

M.M.G.T.DeSilva, S. B. Weerakoon, and Srikantha Herath (2014) - In this study, a case study is studied thoroughly for the incident along the Kelani Basin in SriLanka using HEC– HMS software. An incident that has happened within the year 2005 was caliberated for rainfall incidents occured in 2008 and 2010 was taken to evaluate the efficiency of that particular incident which came to be appropriate according to the software.

Praveen Rathod (2015) - In this study, to account for loss Green-Ampt Method is being used along with Hec Hms 3.5 . For better runoff estimation SCS Unit Hydrograph and Snyder Unit hydrograph methods are compared and best suitable method for the study area is chosen for the ultimate simulation. To estimate the reference evapotranspiration, FAO Penman-Monteith method is getting used. The basic idea behind this paper is to suit the height flow discharges and maximizing the Nash-Sutcliffe coefficient supported the study administered. The SCS method gives higher peak discharges for that incident.

Hassan A. K. M. Bhuiyan (2017) - In this study, RADARSAT-2 model is used to derive data from Hec-Hms for flood forecasting at Sturgeon Creek watershed in Manitoba, Canada. It shows that the Soil Moisture Accounting (SMA) and the temperature index algorithms are used the simulation of that particular watershed. Results found to be suitable for flood forecasting in Manitoba. It is proven to be beneficial in capturing peak flows during a rainfall event.

Zeenat Ara (2018) - In this paper, Soil Conservation System (SCS) CN method is used for the runoff estimation which considers parameters like slope, vegetation cover and area of watershed along with the Land cover map developed for the study region was utilized in analyzing the runoff generated over the command area completely. Rainfall data and soil map and other basic neccesseties are being studied for the region was acquired to calculate the antecedent moisture condition (AMC) and hydrological soil group (HSG) map respectively. Hence, SCS curve number has been taken into consideration to employ better results for runoff.

CHAPTER – 3
STUDY AREA AND DATA USED

3.1 THE MAHANADI RIVER

The Mahanadi River is the major river flows in the East Central India. It covers a neighbourhood of equally around 141,600 square kilometres (54,700 sq mi) and features a total course of around 858 kilometres (533 mi), Mahanadi is also majorly known because of Hirakud Dam. It flows majorely through Chhattisgarh and Odisha.

After getting connected by the Seonath Basin, the river flows towards the eastern direction and the remaining part gets joined by the Jonk Basin and Hasdeo Basin rivers before getting joined towards Odisha where it connects with one of the major dam in India, The Hirakud Dam.

After the formation of the Chhattisgarh State, more than half of the portion of Mahanadi lies in Chhattisgarh. At the state of present scenario, nearly about 169 square kilometres basin area of Hasdeo River falls in the districts of Anuppur.

Live storage capacity within the basin has been seen increasingly raging since the independence. From almost 0.8 km^3 within the pre-plan period, the entire live storage capacity of the finished projects around the basin has increased to 8.5 km^3. additionally, a considerable storage quantity of over 5.4 km^3 would be created on completion of projects under construction.

During the monsoon, the Mahanadi River shows a discharge rate of 2,000,000 cubic feet per second, almost the maximum amount because the much larger Ganges.

3.1.1 Basic Parameters Of Mahanadi Basin :

COMPONENTS	DETAILS
Country	India
State	Chhattisgarh
Cities	Rajim, Sambhalpur, Cuttack
Administrative Areas	Raipur, Janjgir, Bilaspur (Chhattisgarh), Sambalpur, Subarnapur,Boudh,Anugul, Cuttack, Khanki, Jagatsinghpur, Jharsuguda (Odisha)
Coordinates	20.11°N 81.91°E
Length	858 KM
Elevation	890 m
Basin Size	141,600 sq. km
Average	2119 meter cube per second
Maximum	56,700 meter cube per second

Table 3.1 Basin Parameters Of Mahanadi Basin

Table 3.1 shows the basic parameters of Mahanadi basin which identifies the area, its size, maximum and average runoffs, elevation, its length and the direction of its flow from various districts.

Figure 3.1 indicates outer layout of The Mahanadi which is obtained from www.mapsofindia.com. It shows the total area of the basin connecting different parts of Chhattisgarh,India along with its boundaries laying Jharkhand, Madhya Pradesh and Orissa.

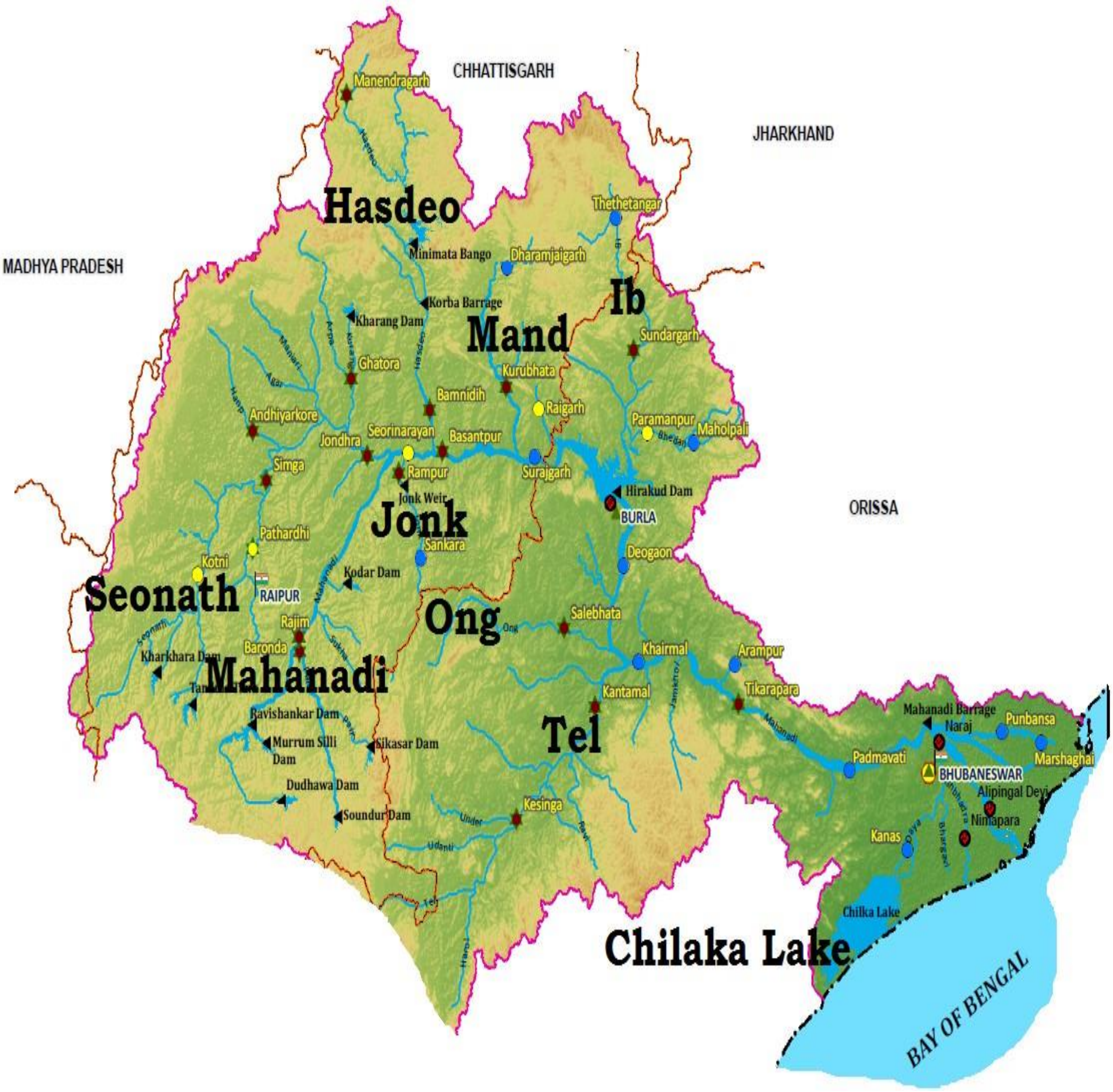


Figure 3.1 The Mahanadi Basin (source- www.mapsofindia.com)

3.2 SEONATH BASIN

Seonath geographical area is largest tributary of Mahanadi basin. it's placed in central-east a part of Chhattisgarh state. It contains terribly fertile land here major crop is rice and that‘s why it's conjointly referred to as rice-ball region of chhattisgarh. it's settled in between two hundred to 230 North and 800 to 830 East. Its total length is 290 kilometre. the entire catchment basin of Seonath is thirty,761 sq.km of geographical area and Chhattisgarh. It covers a total area of 30,560 sq.km in Chhattisgarh and a very little space is in geographical area.

It originates close to Panbaras hills of Ambagarh Chowki, Mohela block Rajnandgaon district Chhattisgarh state Asian nation,it is placed at 624 m higher than the ocean level. General slope of the basin comes below Mahanadi watercourse slope and is towards the north and north east and regionally in some places towards east. The topography of the watershed is sort of flat. whereas flowing northward receives the water of the Tandula, Arpa, Kharun, Agar, Hamp Aamner, Leelagar, Kharkhara, Jamuniya and Maniyari and its major tributaries.

Seonath basin generally shows tropical wet and dry climate, temperatures stay moderate throughout the year, except from March to June, which might be very hot. The temperature in April–May typically rises higher than forty eight °C (118 °F). These summer months even have dry and hot winds. In summers, the temperature may go up to fifty °C.

Figure 3.2 represents the index map of Seonath Basin which shows the entire catchment area and the flow direction of Mahanadi river started from Kanker and ending in Simga District. The mean annual rain within the basin varies from 1005 metric linear unit to 1255 metric linear unit. throughout the study amount on a median this space receives regarding 1150 metric linear unit of rain. It receives rain primarily from ending of June to Sep then somewhat in Gregorian calendar month to December. The Winters last from Gregorian calendar month to Gregorian calendar month and area unit gentle, though lows will fall to five °C (41 °F).

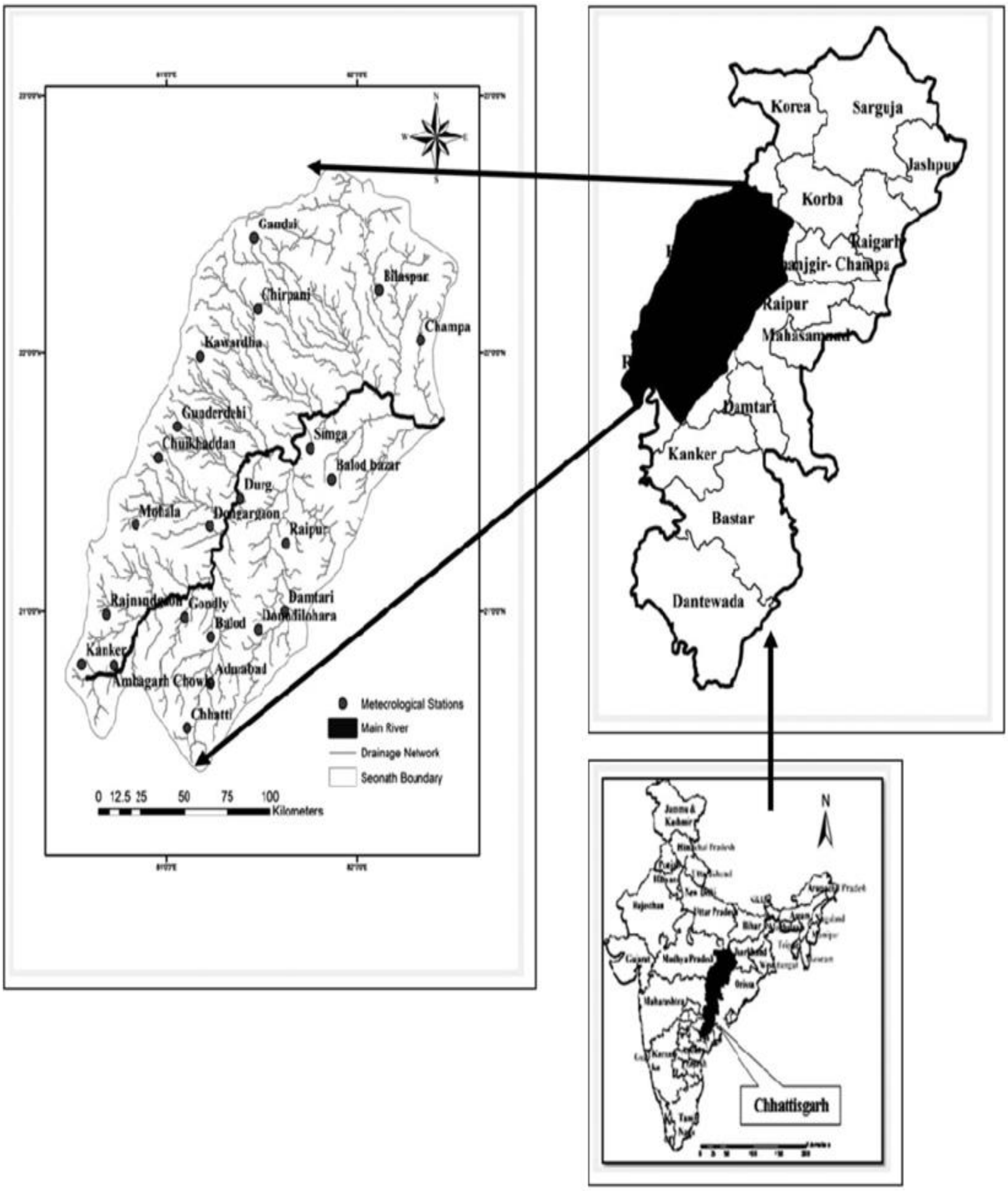


Figure 3.2 Index Map of The Seonath Basin (source- www.google.com)

3.3 JONK SUB BASIN

The stream Jonk originates within the sonabeda upland in Nuapada district of Orissa at associate degree elevation of 700 m. The Jonk merges with the Mahanadi close to Sourinarayan upstream of the Hirakud dam once traversing a distance of concerning 182 kilometer. Machkanalla, Sukha nalla, Kantra nalla, Kermel nadi and Ranidhara nalla area unit the necessary tributaries. The sub-basin lies between north latitudes of 20°28' and 21°44' and therefore the east longitudes of 82°20' and 83°00'. It drains a section of 3,484 km2, that is sort of a pair of.46% of the whole space of the Mahanadi basin. Figure 3.3 shows the layout of Jonk Basin obtained from www.mapsofindia.com.

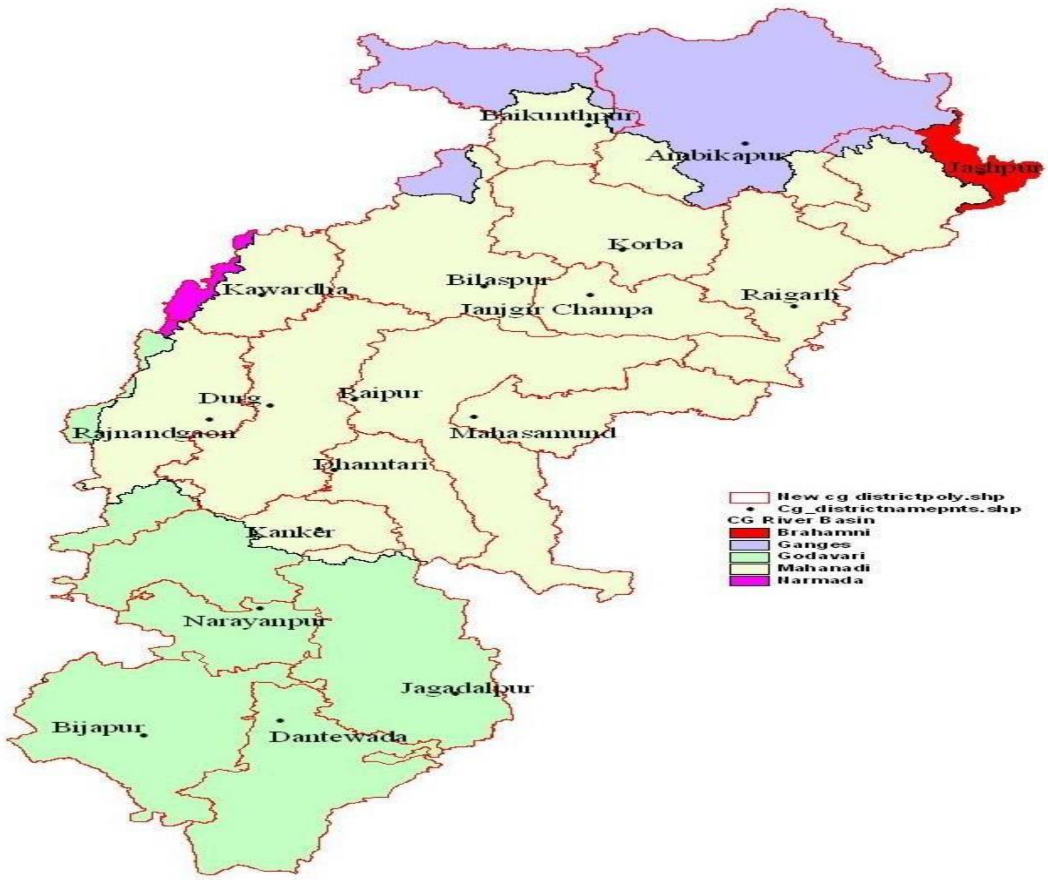


Figure 3.3 The Jonk Basin (source- www.mapsofindia.com)

3.4 DATA COLLECTION

- The Daily rainfall is collected from https://indiawris.gov.in/wris and Chhattisgarh Water Resources Department (https://cgwrd.in/) for the past six years (2014 to 2019) for every twenty four hours.

- The Daily Discharge data has been collected from https://indiawris.gov.in/wris for the past six years (2014 to 2019) for every twenty four hours.

CHAPTER – 4
METHODOLOGY

4.1 HEC – HMS SOFTWARE

The Hydrologic Modeling System is used for the simulation of processes regarding precipitation and runoff for any watershed system. The software uses big selection of geographic areas for determining numerous issues together with giant geographic area facility and flood geophysics, and also little urban or natural watershed runoff. The software is further discussed with respect to the description of the software, its benefits, applications and key features of the software.

4.1.1 Description

A basin model is generally made by dividing hydrologic cycle into simple minor items with certain boundaries. Different models are selected which represents water path and energy inputs. Every model used in the software has different methods to solve numerous problems regarding our environment. Creating the proper selection needs watershed data, goal and judgement for engineering purposes regarding any particular area.

4.1.2 Benefits

The software has various tools for the development of different urban watersheds and for designing structures like pump stations, reservoir and diversions. The software allows to design a model for one purpose but also can be redesigned for another purpose work at a very lowest cost effecting techniques. Like a system modeling operation can be change into reservoir operation. Basically the main goal for the usage of this program is to attain flexibility of any project at a given period of time without any obstructions.

4.1.3 Applications

HEC-HMS is used by USACE to style and find outcomes and for alternative functions. The FEMA ordered the application to be used in hazardous situation. The Federal Energy restrictive Commission (FERC) accepts the benefits of application for generation of hydropower. HEC-HMS is used by state bodies, local governments and engineering corporations and used by university professors for teaching purposes. It is used widely for study of water, urban management, flow prediction, flood injury reduction and time period system operations.

4.1.4 Key Features

The Software has variety of basic geophysical features such as :

- Precipitation
- Plant Evapo-transpiration
- Snowmelt
- Ground Surface Storage
- Soil Infiltration
- Surface Runoff
- Subsurface Baseflow
- Channel Routing with Losses
- Diversion Structures
- Reservoirs with Dam Failure
- Interior Flood Geophysical Science
- Storm Events

HEC-HMS is the product of the Hydrologic Engineering Center inside the U.S. Army Corps of Engineers. The program got made in 1992 as a replacement for HEC-1 which was typical for hydrologic simulations.

The new software provides identical simulation capabilities. However it has progressed them with advances in numerical analysis that found to be considerably quicker. It also gives computer program to generate values easier to use the computer code.

The program is currently widely used and accepted for several official functions, like floodway, rainfall runoff modeling etc.

4.1 OUTLINE OF SOFTWARE

The software includes many procedures like unit hydrographs, event infiltration and hydrologic routing. As shown in Figure 4.1, The software log interface mainly consists of a menu bar, tool bar and four blocks.

These blocks are referred to as The Watershed Explorer, The Component Editor, The Message Log and The Desktop.

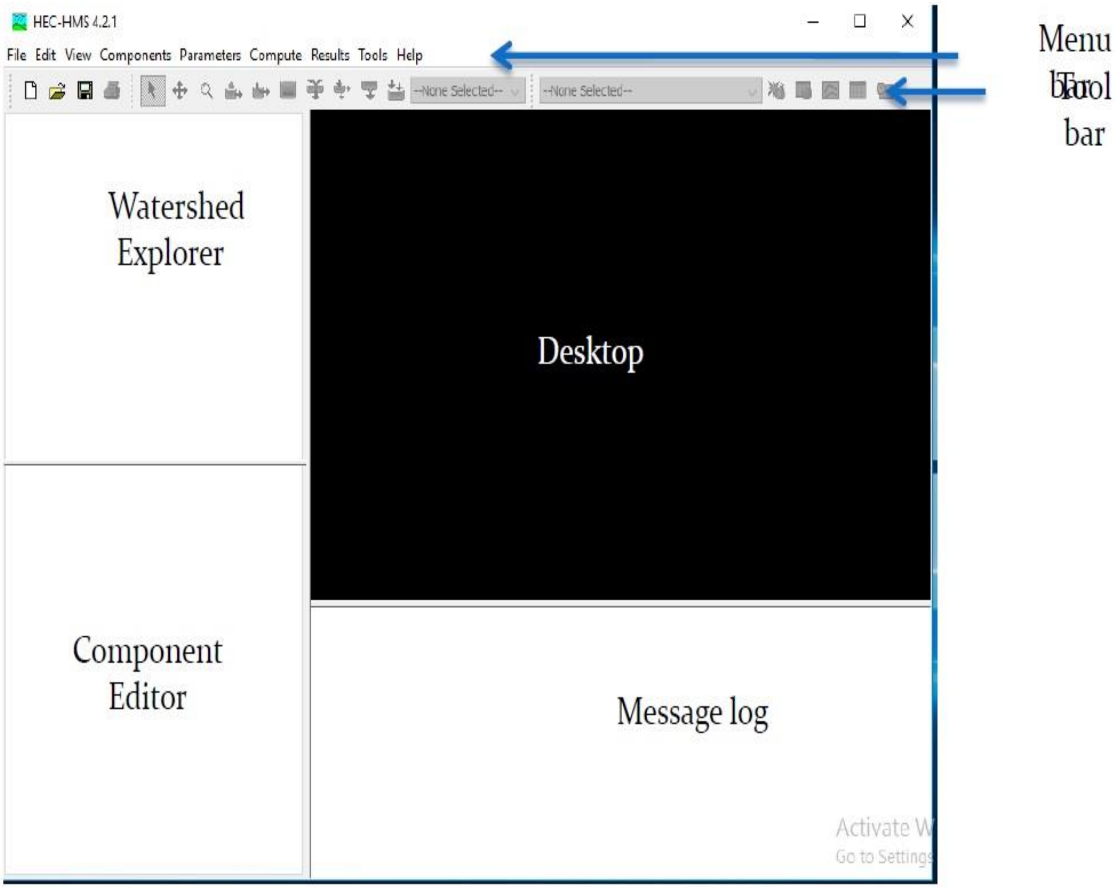


Figure 4.1 Outline Of The Software

Also, Figure 4.2 represents the creation of a model which consists of different tools such as sub basin, reach, sink, junction, reservoirs creation tools for further modeling into the software.

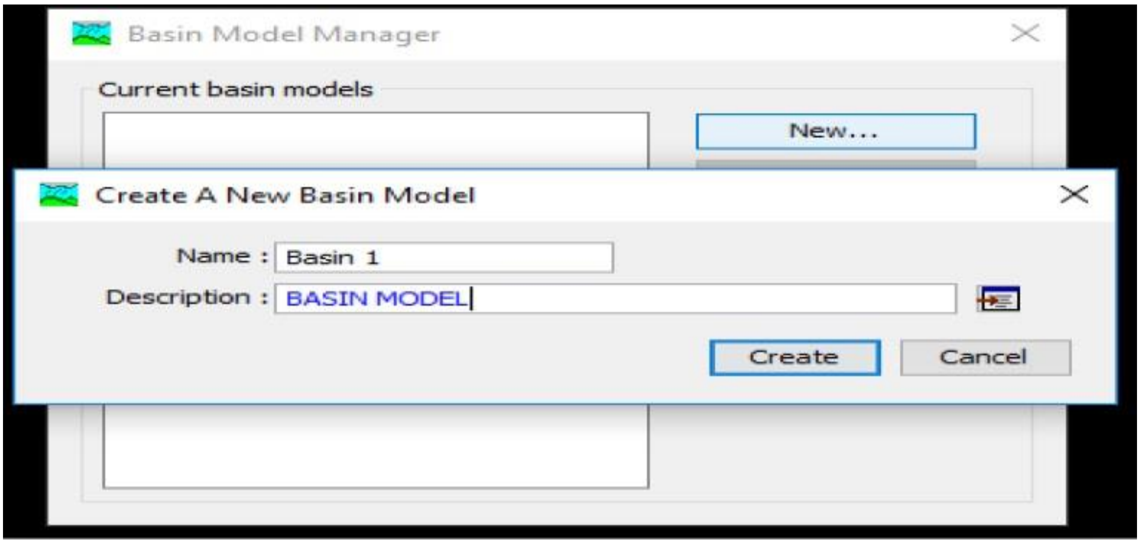


Figure 4.2 Creating Basin Model

Figure 4.3 represents the program settings by virtue of which we can compute routing and modeling methods for the software to obtain various results. Here, we have to choose methods for further processing into the software.

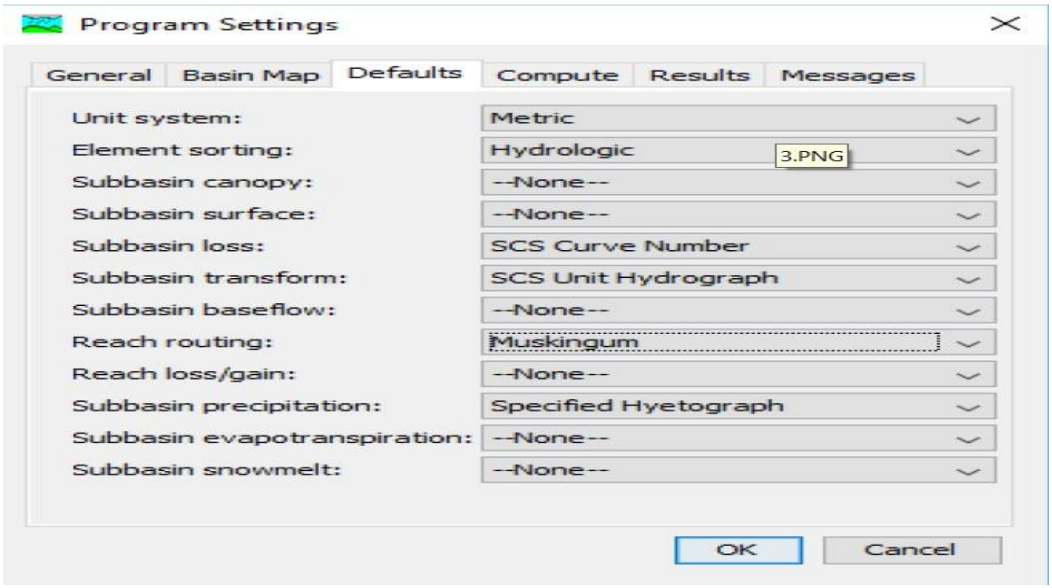


Figure 4.3 The Program Settings for SCS-CN Method

4.3 SCS CN Method

The soil conservation service curve number (SCS-CN) method had been created and developed in 1954. It was then published by the Conservation Service (now being called as the Natural Resources Conservation Service) of the us Department of Agriculture (USDA) in 1956.

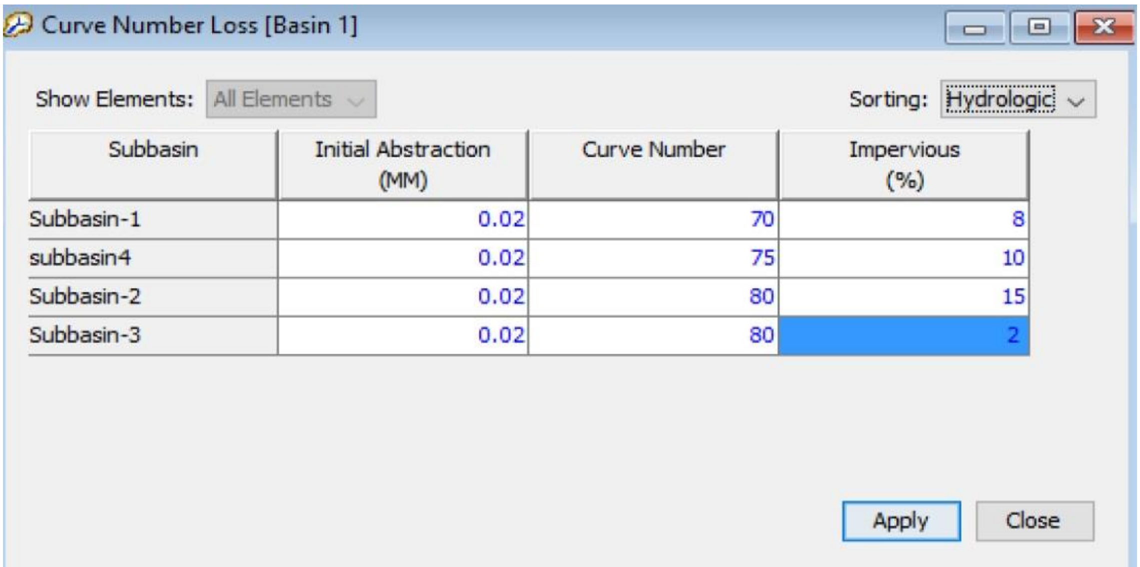
It is one among the foremost popular methods for computing the quantity of surface runoff for a given rainfall event from small agricultural, forest and concrete watersheds.

Basically, the most prolonged idea behind SCS-CN was to create an understanding to account the many reasons behind soil susceptability and accepatability also included the characteristics of watersheds just like the type of soil, treatment of landuse, and the conditions of the soil surfaces along with its moisture conditions.

The SCS-CN method is determined to be based upon the the actions of water balance equation and other two fundamental hypotheses. Figure 4.4 shows the computation of SCS-CN into the software with respect to its curve number for both the basins.

The first and foremost equation equates the ratio of the actual amount of direct surface runoff (Q) to the entire rainfall (P) (or maximum potential surface runoff) to the ratio of the quantity of actual infiltration (F) to the quantity of the potential maximum retention (S).

The second equation is basically related to the the initial abstraction (Ia) to the potential maximum retention, thus the SCS-CN method comprises of:



Subbasin	Initial Abstraction (MM)	Curve Number	Impervious (%)
Subbasin-1	0.02	70	8
subbasin4	0.02	75	10
Subbasin-2	0.02	80	15
Subbasin-3	0.02	80	2

Figure 4.4 The SCS Curve Number for Seonath and Jonk Basin

a) Water Balance Equation

$$\boldsymbol{P = Ia + F + Q} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots..(1)$$

b) Proportionality Equality Hypothesis

$$\boldsymbol{Q/P - Ia = F/S} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(2)$$

c) Ia - S hypothesis

$$\boldsymbol{Ia = \lambda S} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots..(3)$$

Where P= total rainfall; Ia =initial abstraction; F= cumulative infiltration excluding Ia; Q= direct runoff; and S= potential maximum retention or infiltration.

By combining both the equations (1) & (2), we get

$$\boldsymbol{Q = (P - Ia)2/(P - Ia + S)}$$

Equations may only be valid for $P \geq Ia. For\ \lambda = 0.2$, the equation may be written as:

$$\boldsymbol{Q = (P - 0.2\,S)2/(P + 0.8\,S)}$$

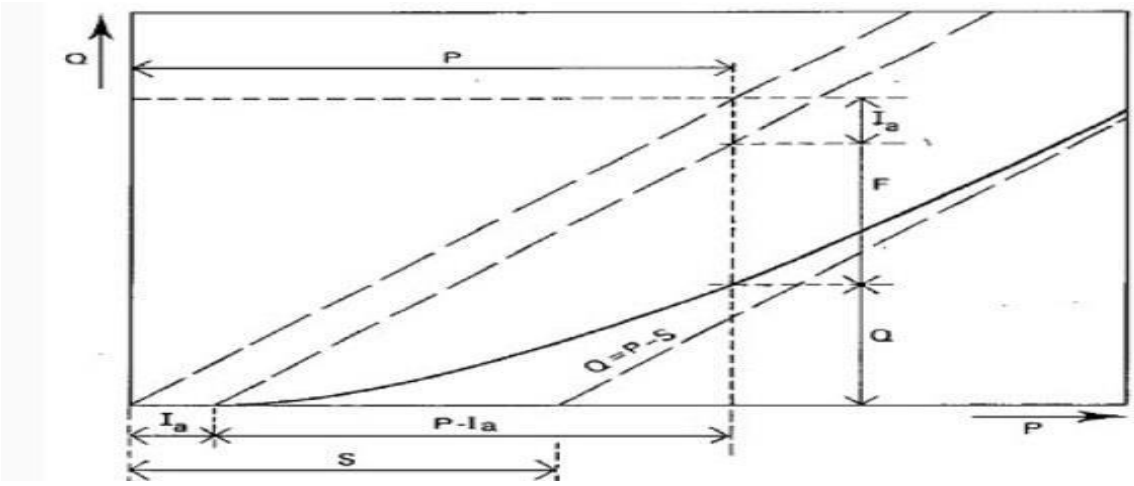


Figure 4.5 : Runoff vs Accumulated Rainfall Graph
(source- www.google.com)

Accumulated runoff Q versus accumulated rainfall P according to the Curve number Method.

From figure 4.5 and figure 4.6, it can be depicted that the prevailing SCS-CN method may be just a one parameter model for the computation of surface runoff from daily storm rainfall, for the simplest yet tactic method was originally developed using the daily rainfall-runoff data of annual extreme flows.

S can be said to be a constant and is typically obliged to be the maximum difference of (P-Q) which will occur for that very particular given storm and watershed conditions.

The most common difference between the S and CN is that S contains or said to be a dimensional quality (L) but CN can be depicted as a non-dimensionless quantity. The CN assumabely varies from 0 to 100.

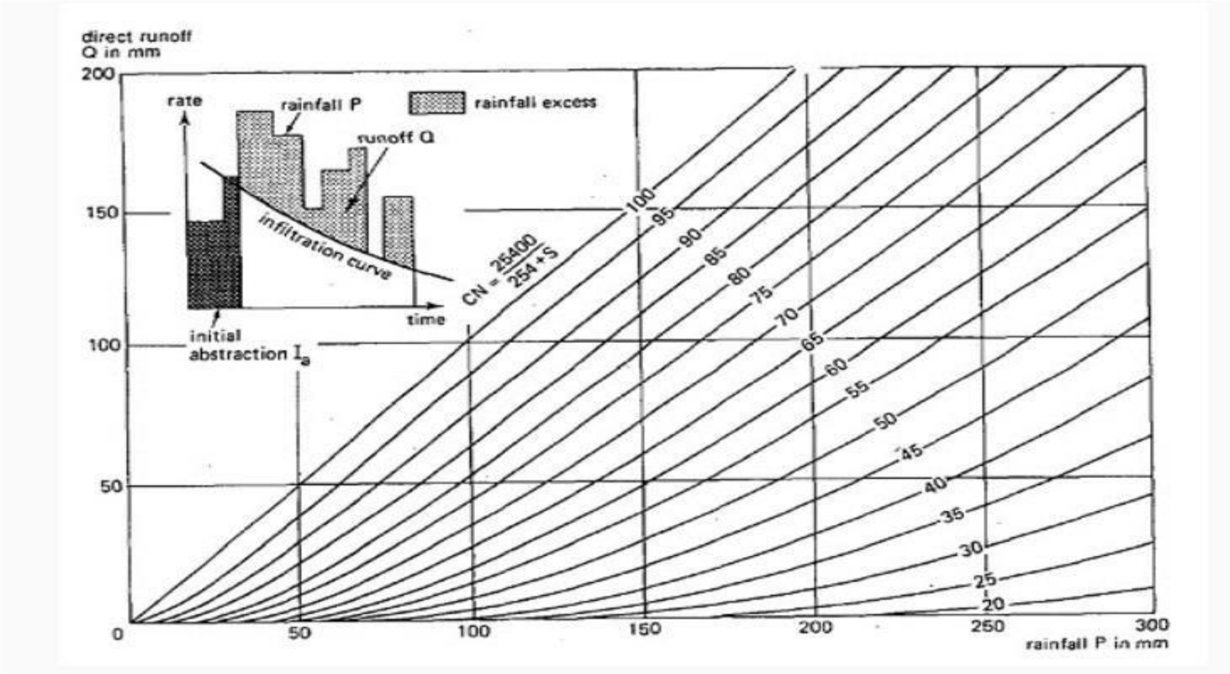


Figure 4.6 : Graphical Solution Of Q

(source -www.google.com)

Graphical solution of runoff depth Q as a function of rainfall depth P and curve number.

Figure 4.7 represents the flow chart of HecHms software which mainly shows the working of the software by impleting different methods, creation of different data manager, implementation of various datas (precipitation, runoff etc) and lastly, how to run and analyze the results obtained by the software.

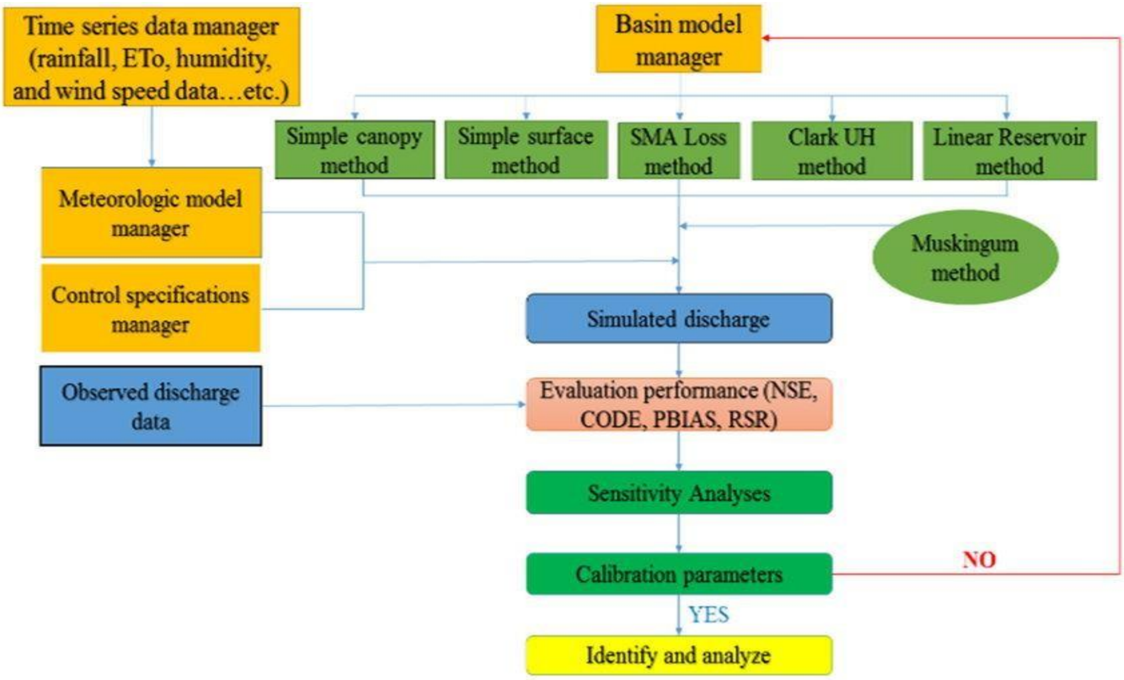


Figure 4.7 : The HEC-HMS Flow Chart
(source- www.google.com)

4.4 SOIL MOISTURE ACCOUNTING:

The model is known as to be the continuous model which is used for wet as well as for dry periods. The simulation of water from the ground is the main goal of this model. The catchment of the model can be illustrated in figure 4.8 which shows different layers of storages. To obtain runoff excess amount of water gets stored in which the storage has its own capacity to regulate inflow and outflow. During modeling the interception component exhibits sources of precipitation which either gets captured by trees or either by vegetation. It is the primary storage which has to fill before the precipitation reaches to other source of storage. The water thus gets evaporated until trapped in that particular storage.

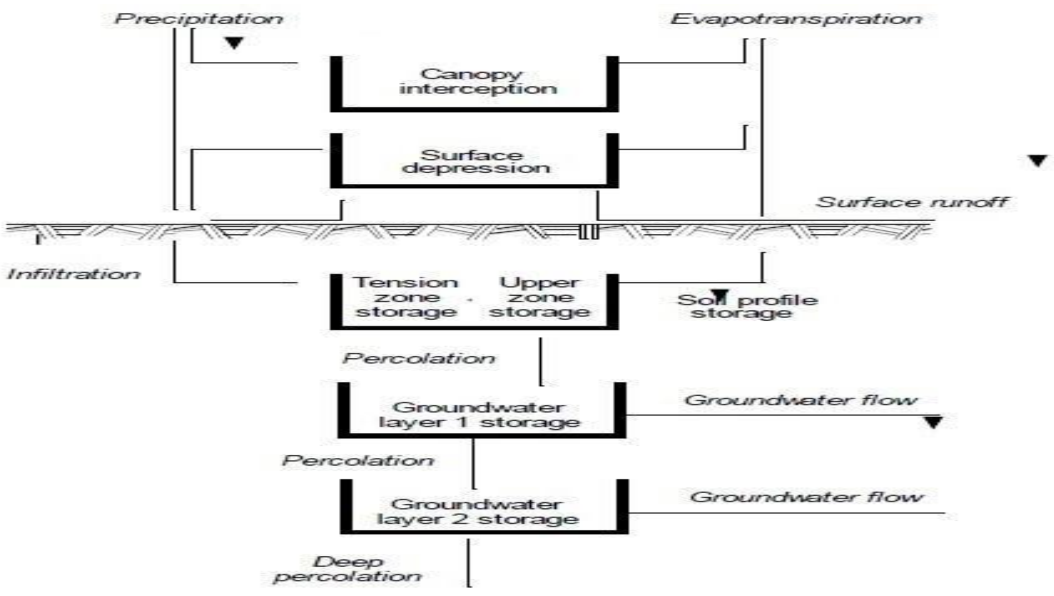


Figure 4.8 Basic Layout Of Soil Moisture Accounting (www.google.com)

Flow Component

The Soil Moisture Accounting Model includes flow into, out of and between the storage volumes. This flow thus can take the shape of:

1) Precipitation- Precipitation is known to be an input to the system of storages. Precipitation contributes to the cover of interception storage. If the cover storage fills, then the surplus amount is further available for infiltration.

2) Infiltration- Infiltration is the water that enters into the profile from the bottom surface. Water available for infiltration during this time step comes from precipitation which passes through canopy interception where water already present in surface storage.

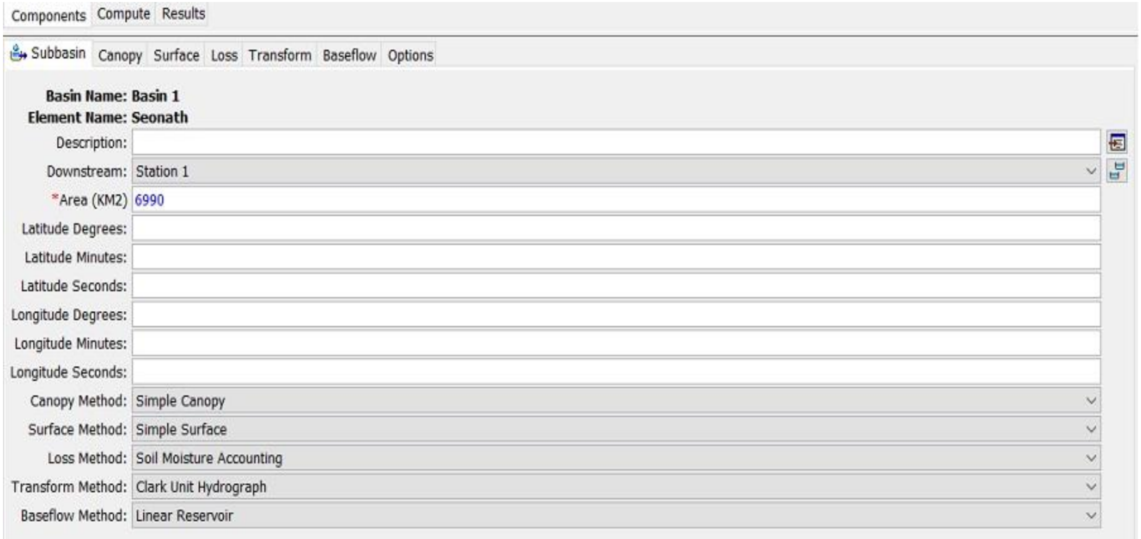


Figure 4.9 Soil Moisture Accounting Interface for Seonath Basin

SMA model interface created for Seonath Basin and Jonk Basin can be shown into the Figure 4.9 and 4.10. It mainly depicts how to compute the SMA method for both the basins into the software. The results often gets compared with the observed data to attain proper caliberated values.

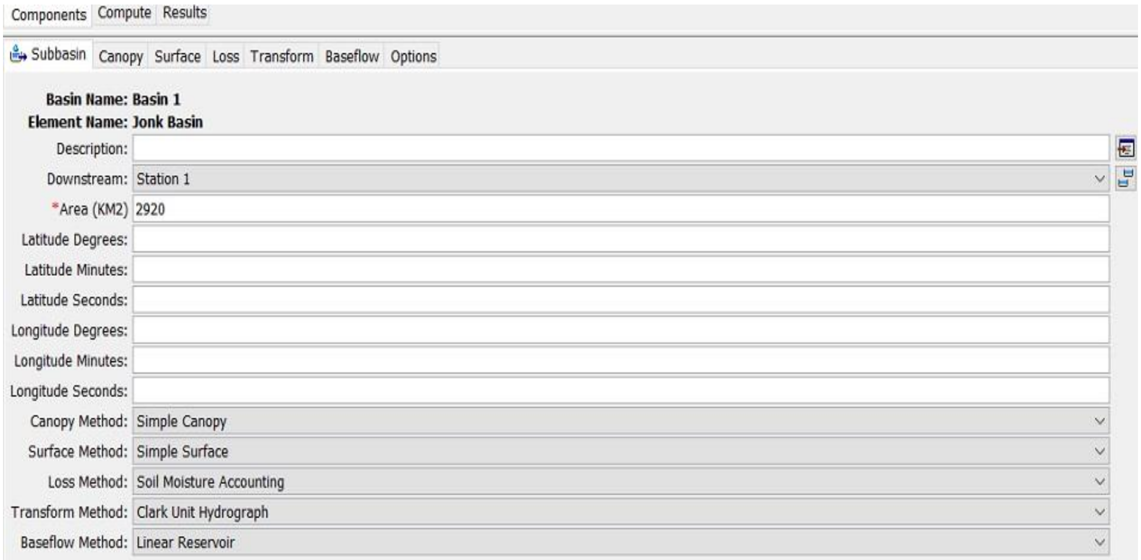


Figure 4.10 Soil Moisture Accounting Interface for Jonk Basin

4.5 MUSKINGUM METHOD

The Muskingum Routing unit models uses Muskingum method in natural and artificial channels to analysis the basic route of the flow. The Muskingum Routing is basically use to calculate the discharge due to the hydrograph at inflow and upstream end. It depends on the continuity equation and therefore is also known to be the Muskingum storage relationship. Only the Muskingum parameters k and x are required for the calculation. We can calculate that both parameters are fixed. Continuity equations are generally used for the Muskingum Method.

The Equations used in Muskinghum Routing are Continuity Equations:

$$I - O = \frac{ds}{dt} \qquad \text{.....(1)}$$

And the Storage Relationship:

$$S = k \times [\, x \times I - (1-x) \times O \,] \qquad \text{......(2)}$$

Where :

I = Inflow to the reach (cubic meters per second)
S = Outflow from the reach (cubic meters per second)
O = Storage in the reach (cubic meters)
t = Time
w = Weighting Coefficient (seconds)
k = Storage Constant (seconds)

Combining both the equations, an equation is obtained to calculate outflow:

$$O_2 = C_0 I_2 + C_1 I_1 + C_2 O_1 \qquad \text{.......(3)}$$

Where the coefficients C_0 , C_1 and C_2 are defined as ;

$$C_0 = - \frac{k \times x - 0.5 \times \Delta t}{k \times (1-x) + 0.5 \times \Delta t} \qquad \text{.........(4)}$$

$$C_1 = \frac{k \times x + 0.5 \times \Delta t}{k \times (1-x) + 0.5 \times \Delta t} \quad \ldots\ldots\ldots(5)$$

$$C_2 = \frac{k \times (1-x) - 0.5 \times \Delta t}{k \times (1-x) + 0.5 \times \Delta t} \quad \ldots\ldots\ldots(6)$$

For the Muskingum method to be derived completely without complextion, the value of x is recommended between 0.0 to 0.3 .Hence, In muskingum routing interface the values are taken as 0.2 for both basins as shown in the Figure 4.11 .

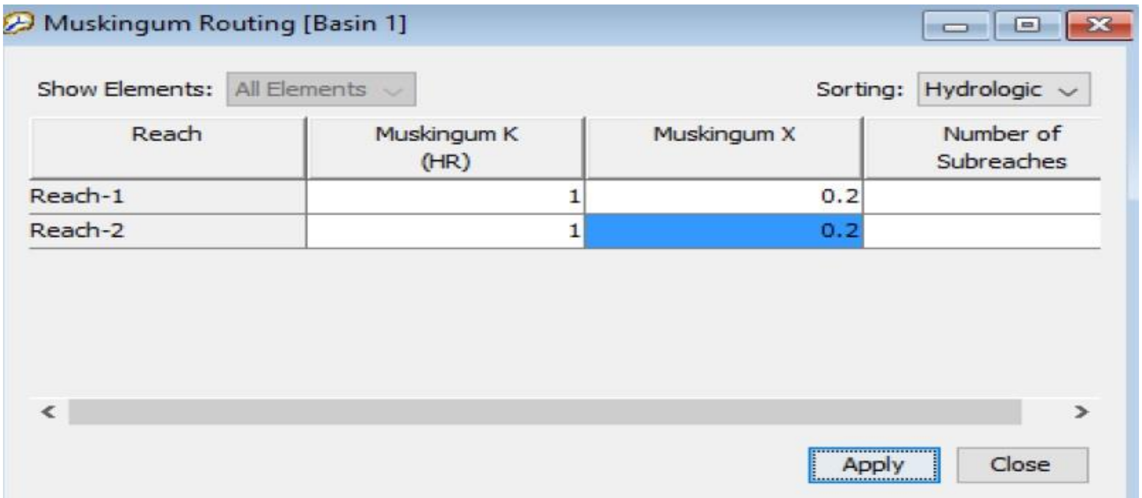


Figure 4.11 Muskingum Routing Method Interface For Seonath and Jonk Basin

CHAPTER – 5

RESULTS

Results Obtained By SCS-CN Method (Seonath Basin) :

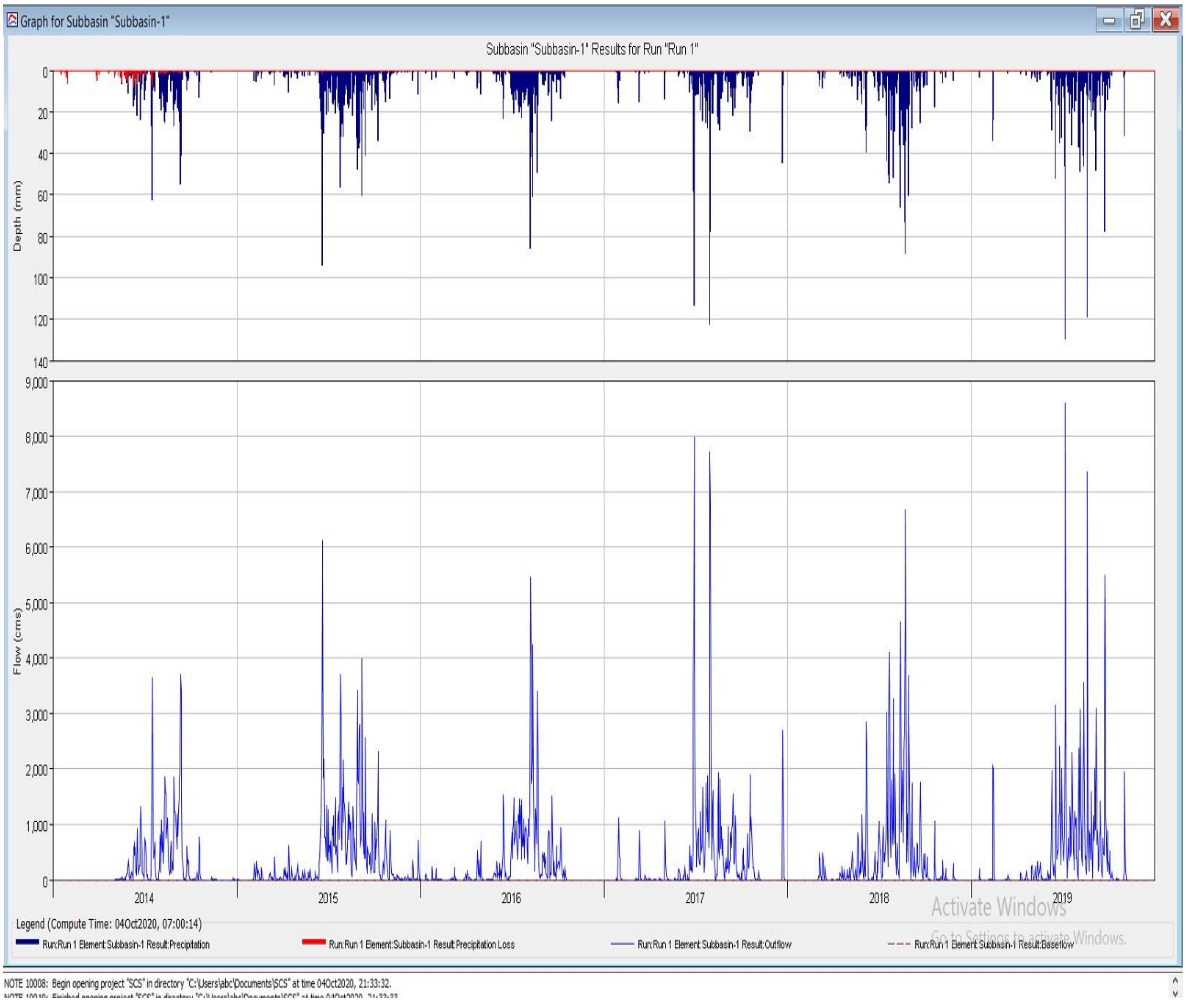


Figure 5.1 Final Graph For Seonath Basin indicating precipitation, precipitation loss, outflow and Baseflow

Figure 5.1 shows the result occupied for Seonath Basin on the accountancy of its daily precipitation, precipitation loss, outflow and baseflow. As per result:

1) The outflow found to be maximum in year 2019 and lowest in the year 2014.
2) The baseflow found to be very least along the entire processing in every year.
3) The precipitation found to be very maximum in the year 2019 and lowest in the year 2014 respectively.
4) The precipitation loss has occurred maximum in the year 2014 but found to be least on every year at various time interval.

FINAL SUMMARY RESULTS:

Figure 5.2 shows the summary of the results obtained by HEC-HMS software 4.2 containing peak discharge which came to be 8590.2 cubic meters per second for Seonath Basin. Method involved is SCS-CN curve method.

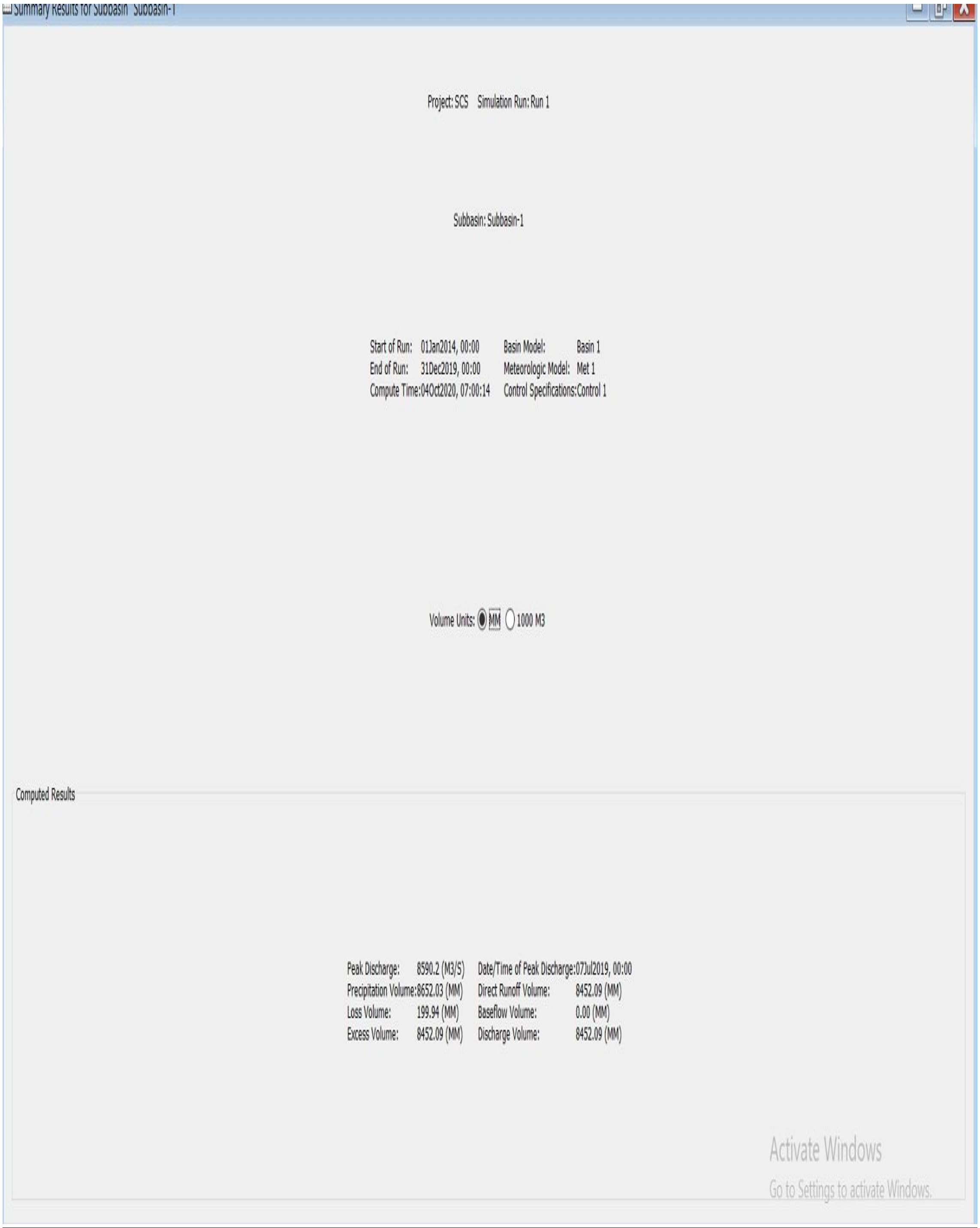


Figure 5.2 The figure represent Peak Discharge and Time of Peak Discharge.

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Precipitation Graph:

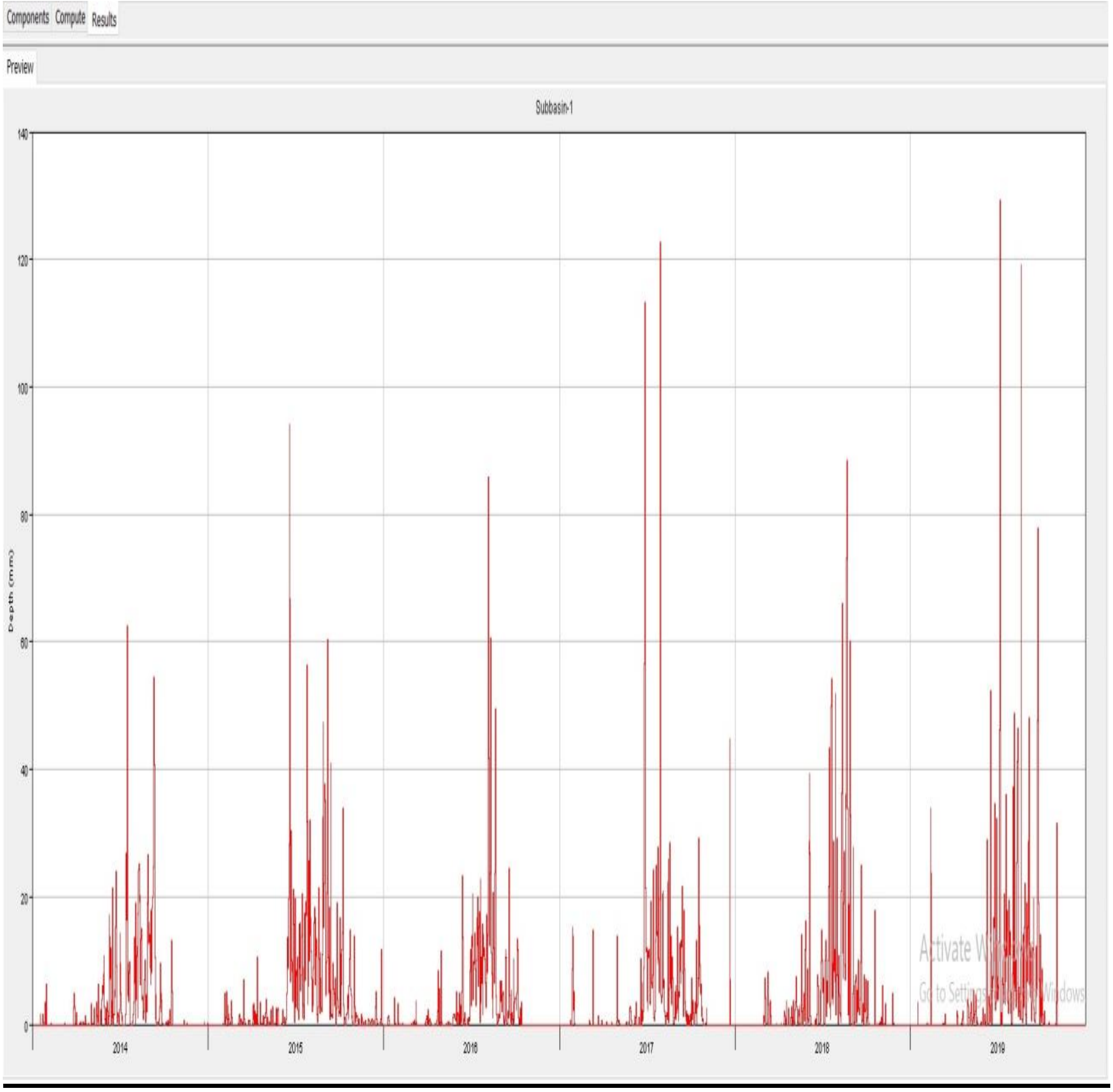

Figure 5.3 The above graph represents Daily Precipitation Data (Year-Wise) For Seonath Basin.

Figure 5.3 shows The Precipitation graph is generated by the Hec-Hms Software 4.2 for Seonath Basin. Hence, it shows that the peak precipitation graph has been plotted for the year between 2014 to 2019 thus peak precitipation has been obtained in 7th July 2019 which is 129 mm and average minimum precipitation to be 1.1 mm

Direct Runoff Graph :

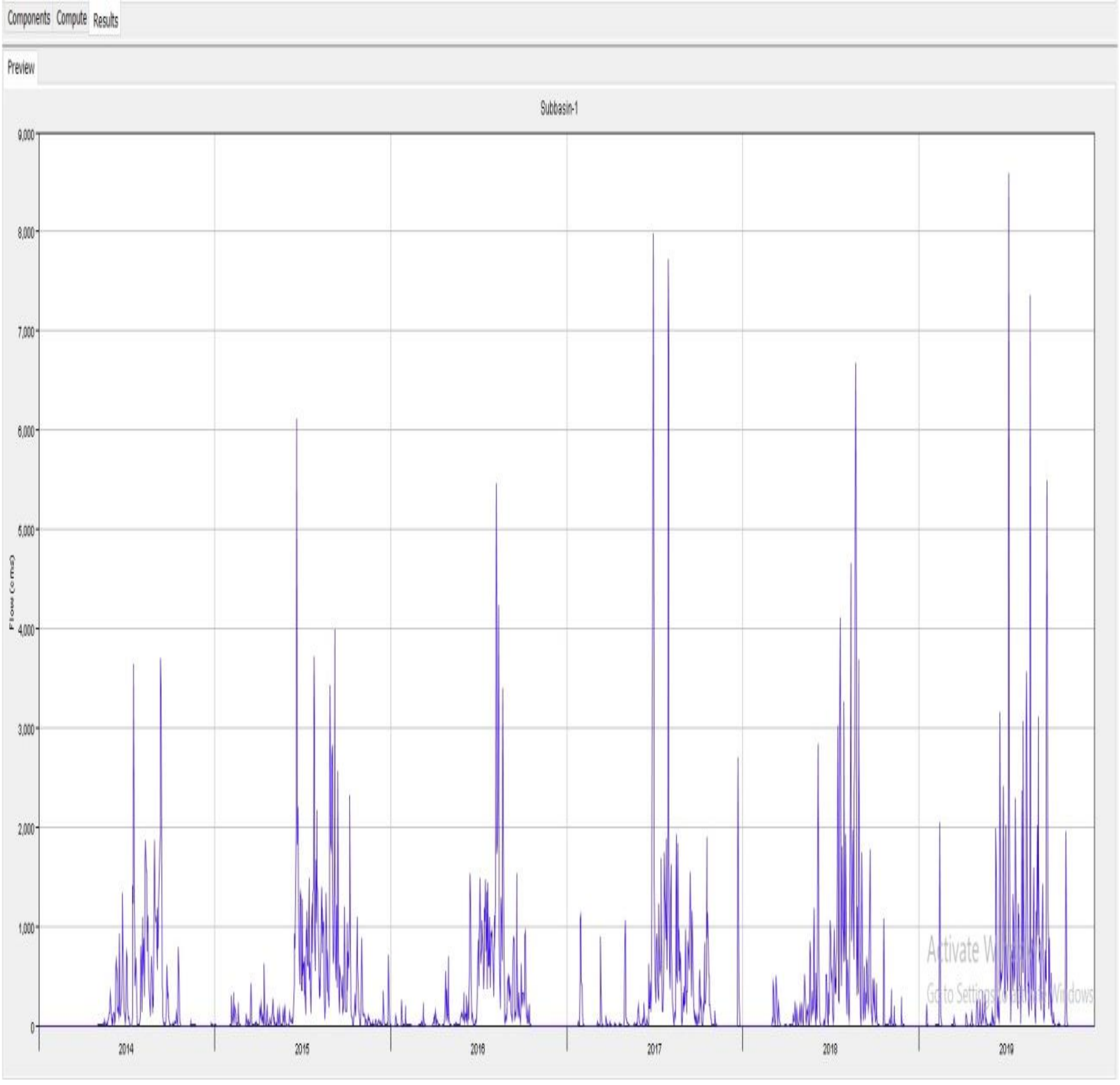

Figure 5.4 The above graph represents the daily runoff year wise for Seonath Basin

Figure 5.4 represents The Direct Runoff graph which is generated by the Hec-Hms Software 4.2 for Seonath Basin. Hence, it shows that the Runoff graph has been plotted for the year between 2014 to 2019 thus peak runoff has been generated in 7th July 2019 which is 8590.2 meter cube per second

Observed Runoff vs Simulated Runoff Results :

From HecHms 4.2 software, figure 5.5 shows the results of observed vs simulated runoffs for seonath basin, which depicts the variations between observed runoff and simulated runoff obtained by software**.**

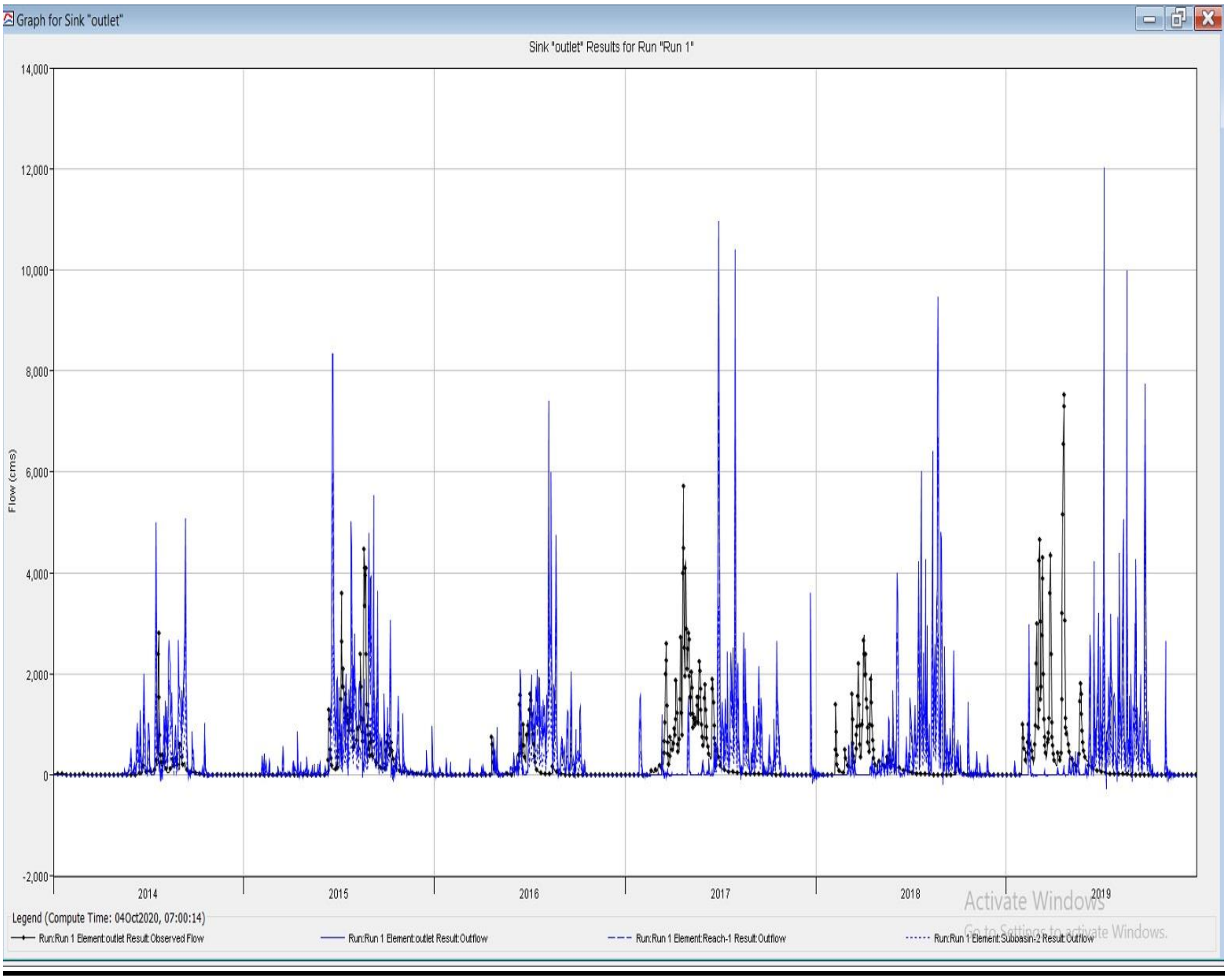

Figure 5.5 Simulation Results For Seonath Basin

In the Seonath catchment the SCS-CN Method simulated the daily runoff which follows the observed data at various time intervals but also does not suit for some years like 2018 and 2019. The height of observed runoff is larger than the simulated runoff. However, it will be appropriate to say that they are matching in some months rather than whole year but it gives a basic idea for simulation to be proper for seonath basin. Hence, HEC-HMS software can be used for such particular region with SCS-CN method.

Results Obtained By SCS-CN Method (Jonk Basin) :

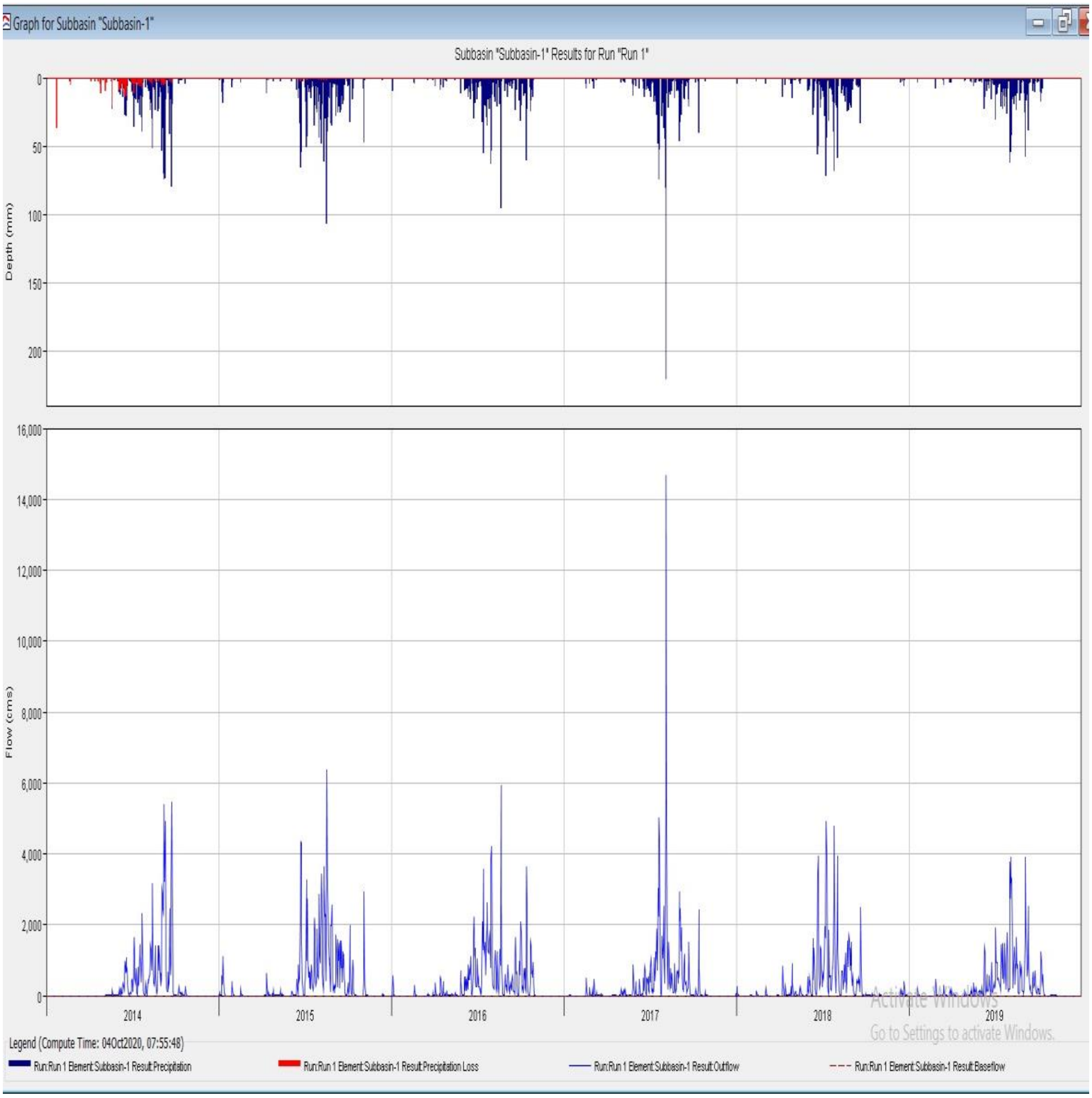

Figure 5.6 Final Graph For Jonk Basin indicating precipitation, precipitation loss, outflow and Baseflow

Figure 5.6 shows the result occupied for Jonk Basin on the accountancy of its daily precipitation, precipitation loss, outflow and baseflow. As per result:

1) The outflow found to be maximum in year 2017 and lowest in the year 2014.
2) The baseflow found to be very least along the entire processing in every year.
3) The precipitation found to be very maximum in the year 2017 and lowest in the year 2014 respectively.
4) The precipitation loss has occurred maximum in the year 2014 but found to be least on every year at various time interval along its processing.

FINAL SUMMARY RESULTS :

Figure 5.7 shows the summary of the results obtained by HEC-HMS software 4.2 containing peak discharge which came to be 14660.3 cubic meters per second for Jonk Basin. Method involved is SCS-CN curve method.

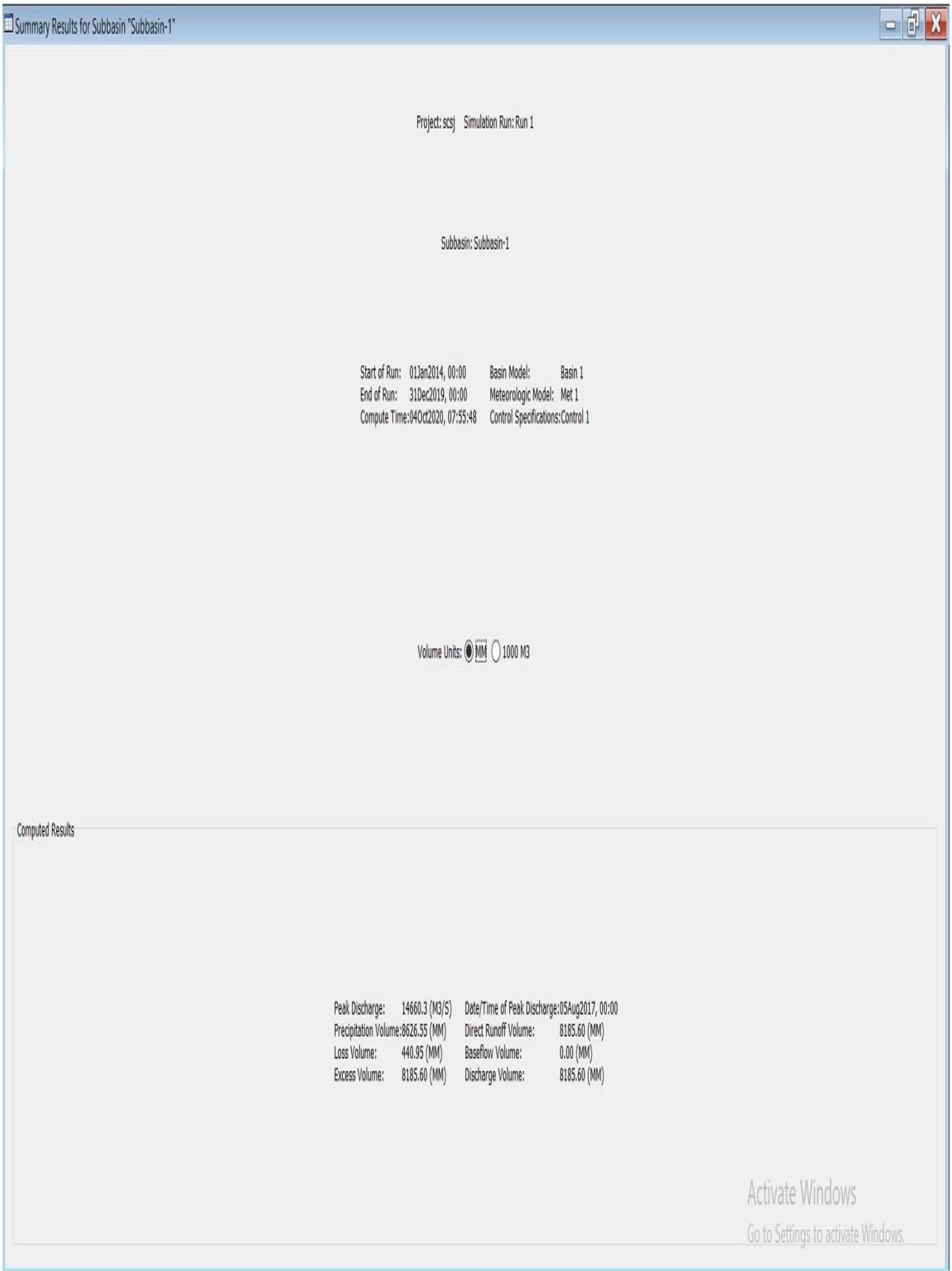

Figure 5.7 The figure represent Peak Discharge and Time of Peak Discharge.

Precipitation Graph:

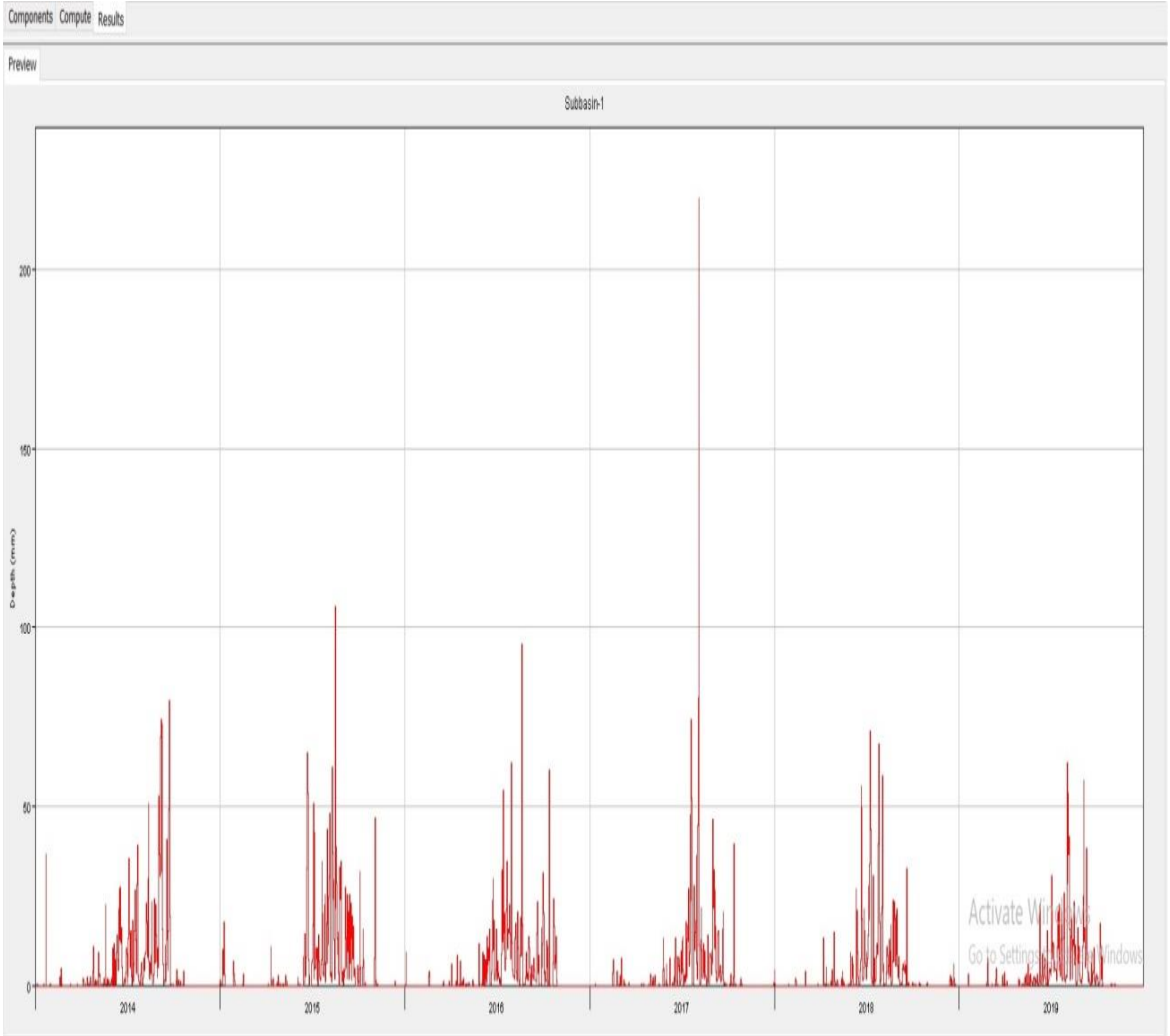

Figure 5.8 The above graph represents Daily Precipitation Data (Year-Wise) For Jonk Basin.

Figure 5.8 represents the Precipitation graph is generated by the Hec-Hms Software 4.2 for Jonk Basin. Hence, it shows that the peak outflow graph has been plotted for the year between 2014 to 2019 thus peak precitipation has been obtained in 5th August 2017 which is 288 mm and average minimum precipitation to be 1.2 mm.

Direct Runoff Graph:

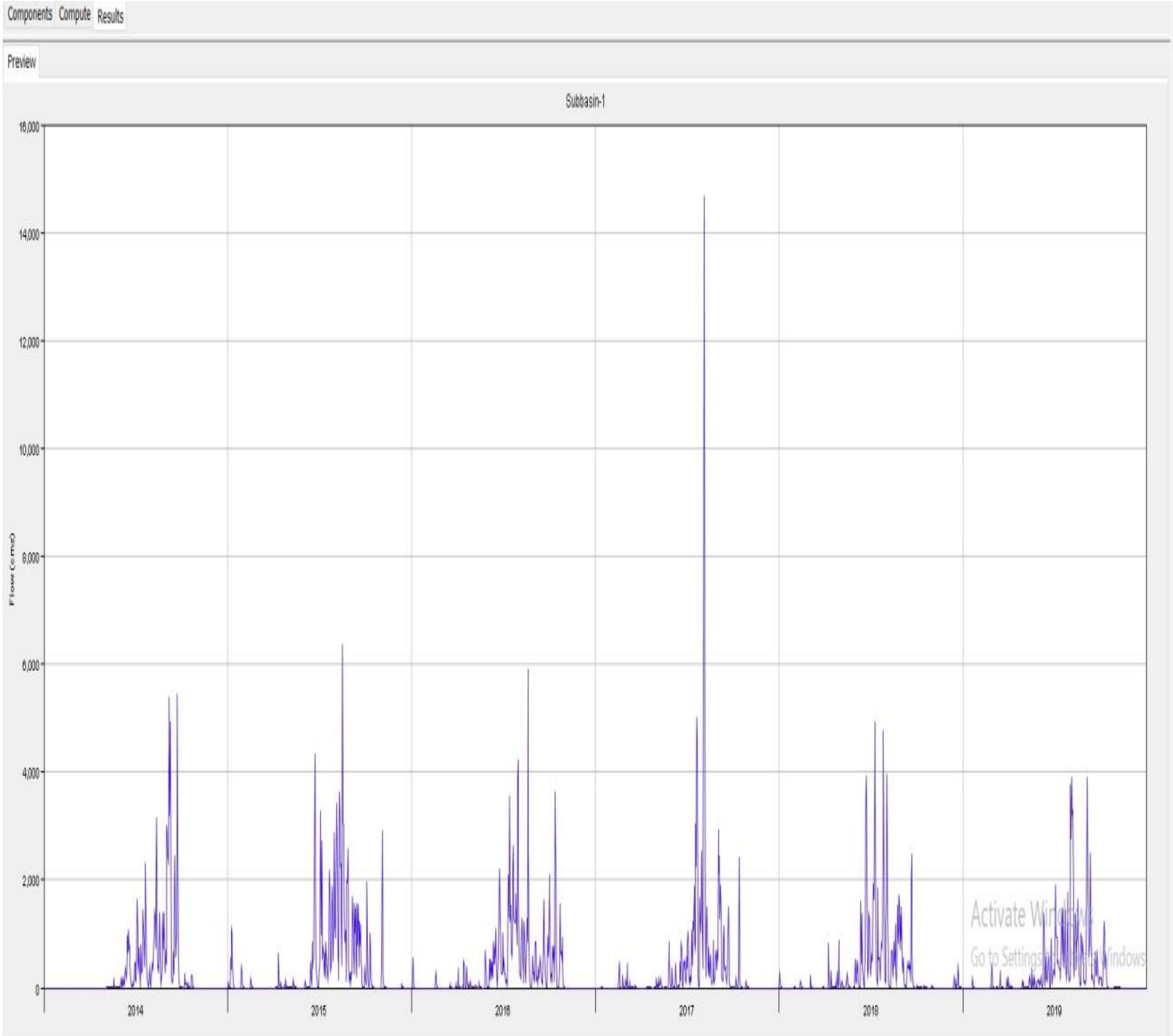

Figure 5.9 The above graph represents the Daily Runoff Data (Year-Wise) for Jonk Basin

Figure 5.9 shows The Direct Runoff graph is generated by the Hec-Hms Software 4.2 for Jonk Basin. Hence, it shows that the Runoff graph has been plotted for the year between 2014 to 2019 thus peak runoff has been generated in 5th August 2017 which is 14660.3 meter cube per second.

Observed Runoff vs Simulated Runoff Results :

From HecHms 4.2 software, figure 5.10 shows the results of observed vs simulated runoffs for Jonk Basin, which depicts the variations between observed runoff and simulated runoff obtained by software**.**

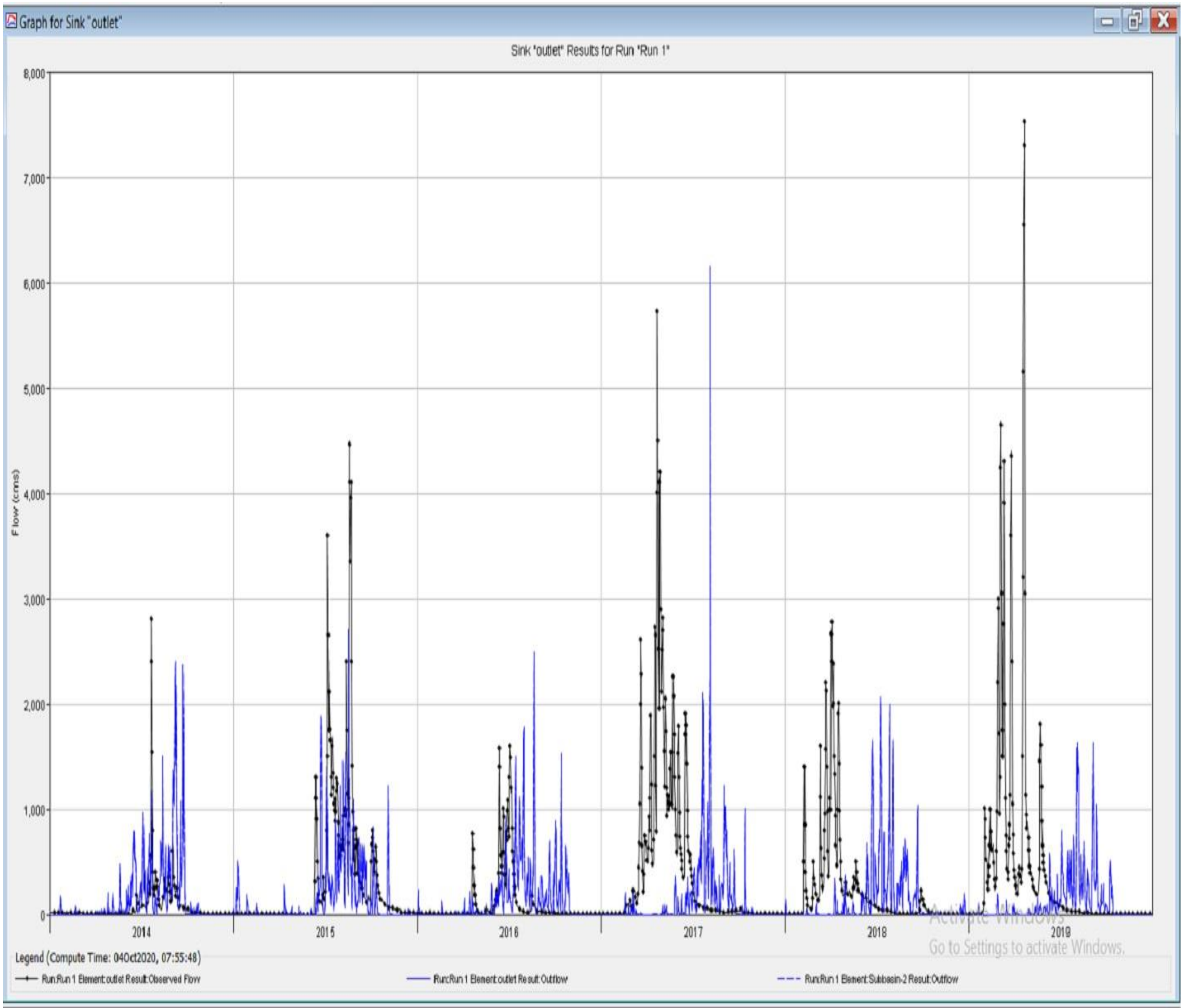

Figure 5.10 Simulation Results For Jonk Basin

In Jonk Sub Basin, the SCS-CN simulated daily data follows the observed data at various time intervals but also does not suit for some years like 2017, 2018 and 2019. The height observed runoff is larger than the simulated runoff. But in some months the daily simulated and observed data are matching with each other. Thus, gives a basic idea for simulation to be occur properely for Jonk Basin. Hence, HEC-HMS software can be used for such particular region with SCS-CN method.

Results Obtained By Soil Moisture Accounting Method (Seonath Basin) :

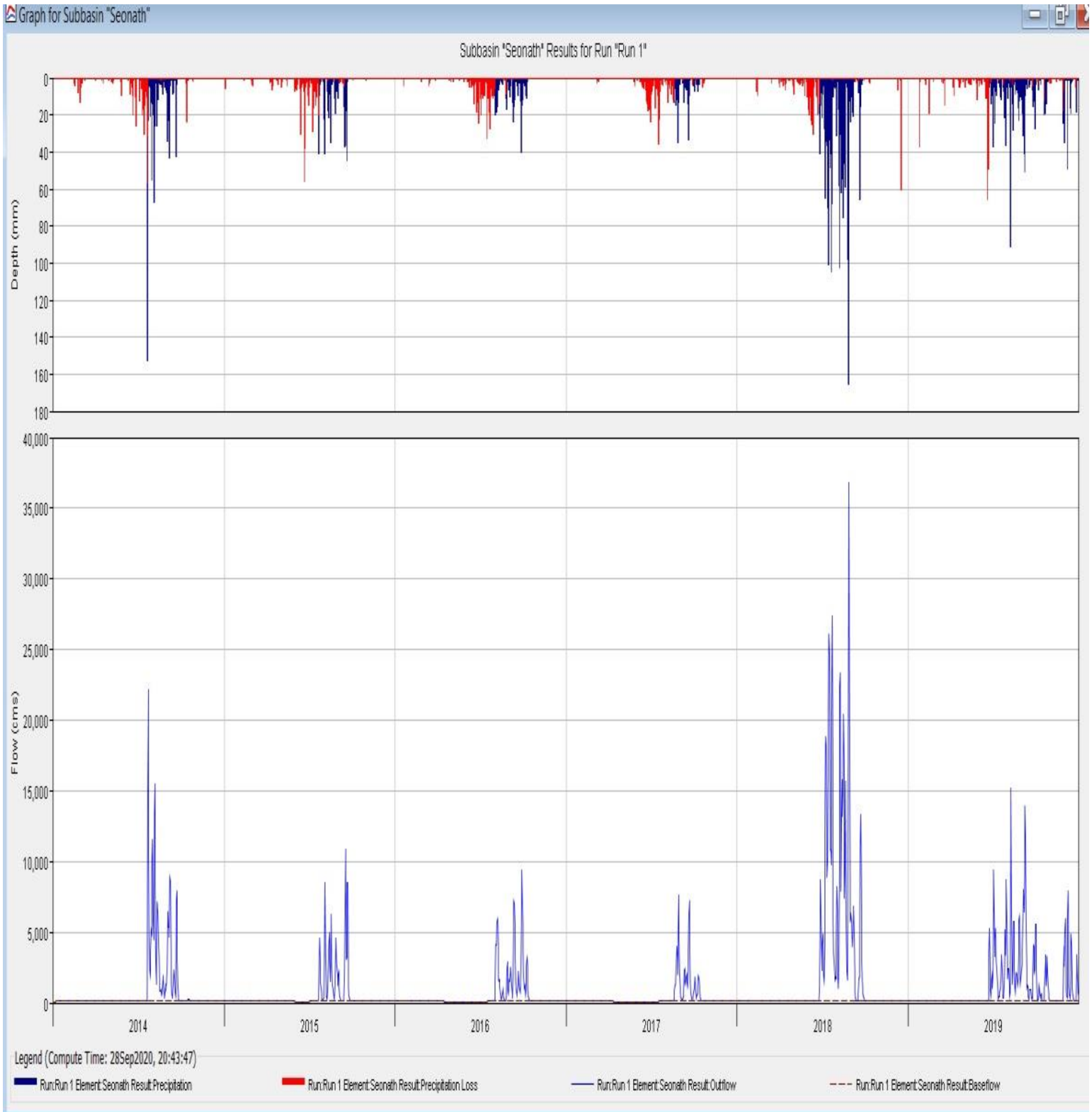

Figure 5.11 Final Graph For Seonath Basin indicating precipitation, precipitation loss, outflow and Baseflow

Figure 5.11 shows the result occupied for Seonath Basin on the accountancy of its daily precipitation, precipitation loss, outflow and baseflow. As per result:

1) The outflow found to be maximum in year 2018 and lowest in the year 2014.
2) The baseflow found to be very least along the entire processing in every year.
3) The precipitation found to be very maximum in the year 2018 and lowest in the year 2014 respectively.
4) The precipitation loss has occurred maximum in the year 2018,2019 but found to be least on every year at various time interval.

FINAL SUMMARY RESULTS :

Figure 5.12 shows the summary of the results obtained by HEC-HMS software 4.2 containing peak discharge which came to be 36763.3 cubic meters per second for Seonath Basin. Method involved is Soil Moisture Accounting method.

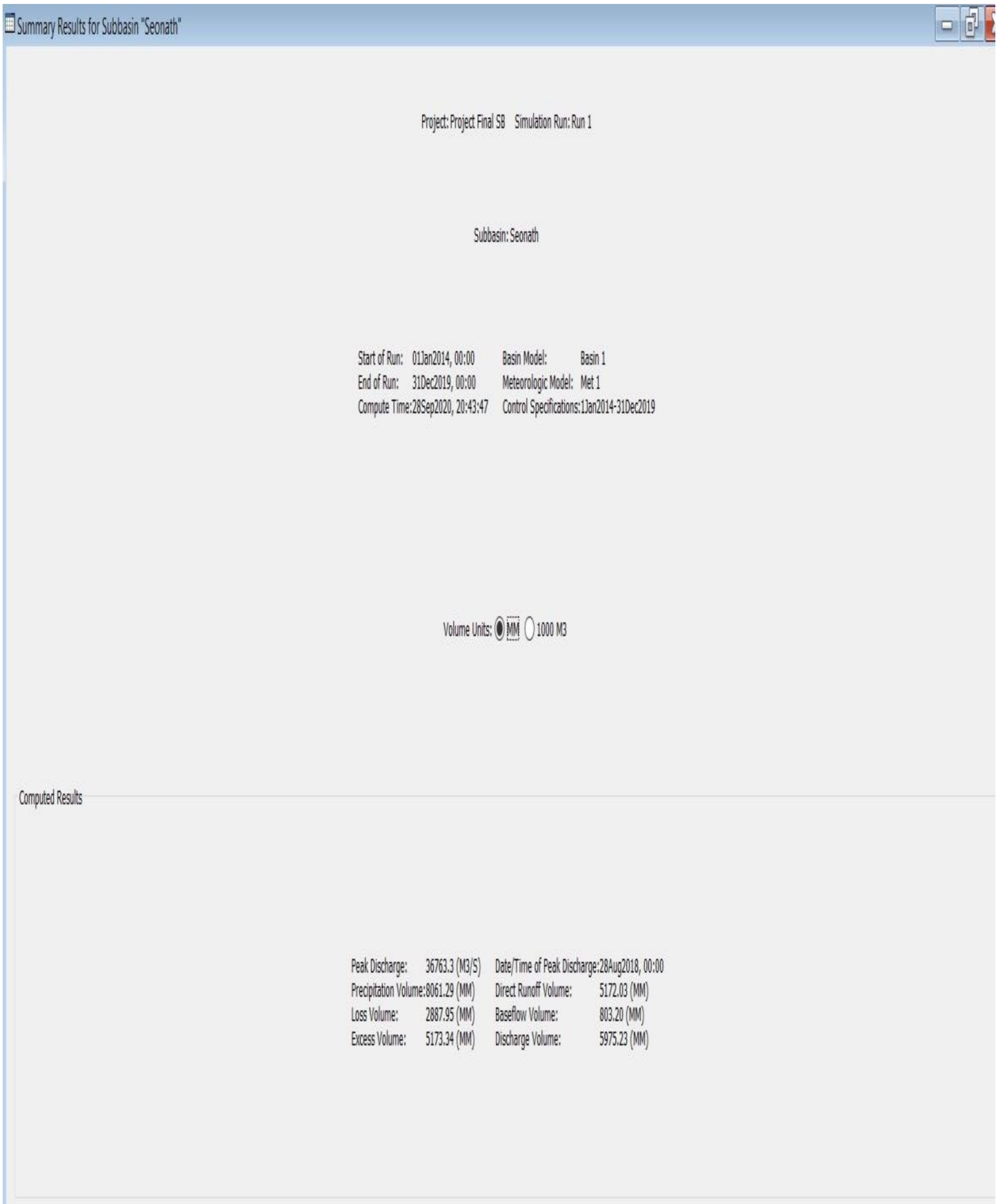

Figure 5.12 The figure represent Peak Discharge and Time of Peak Discharge.

MONTHLY SIMULATED VS OBSERVED RUNOFF OF SEONATH BASIN (SMA MODEL USED)

MONTH	OBSERVED (m^3/s)	SIMULATED(m^3/s)
January	6.52	14.78
February	12.43	7.92
March	5.27	4.13
April	1.72	21.03
May	3.10	17.31
June	83.51	196.52
July	566.74	419.96
August	283.38	138.87
September	97.38	81.21
October	31.33	21.28
November	8.89	13.21
December	5.72	4.48

Table 5.1 – Monthly Average Simulated Vs Monthly Average Observed Runoffs for Seonath Basin

From Table 5.1, we can conclude that In the Seonath Basin the monthly simulated runoffs are lower than observed runoffs for seven months and are higher for the rest of the year. According to the Table 5.1 , both the runoffs are not close with each other. The model results are closer to the observed runoff two months which has very low runoff rather than highest runoff periods. For example, In December and March both the runoff values found to be close towards each other during that year.

Hence, monthly simulation results found to be mismatched numerically for Seonath Basin and model cannot show the exact results as it should be.

Precipitation Graph:

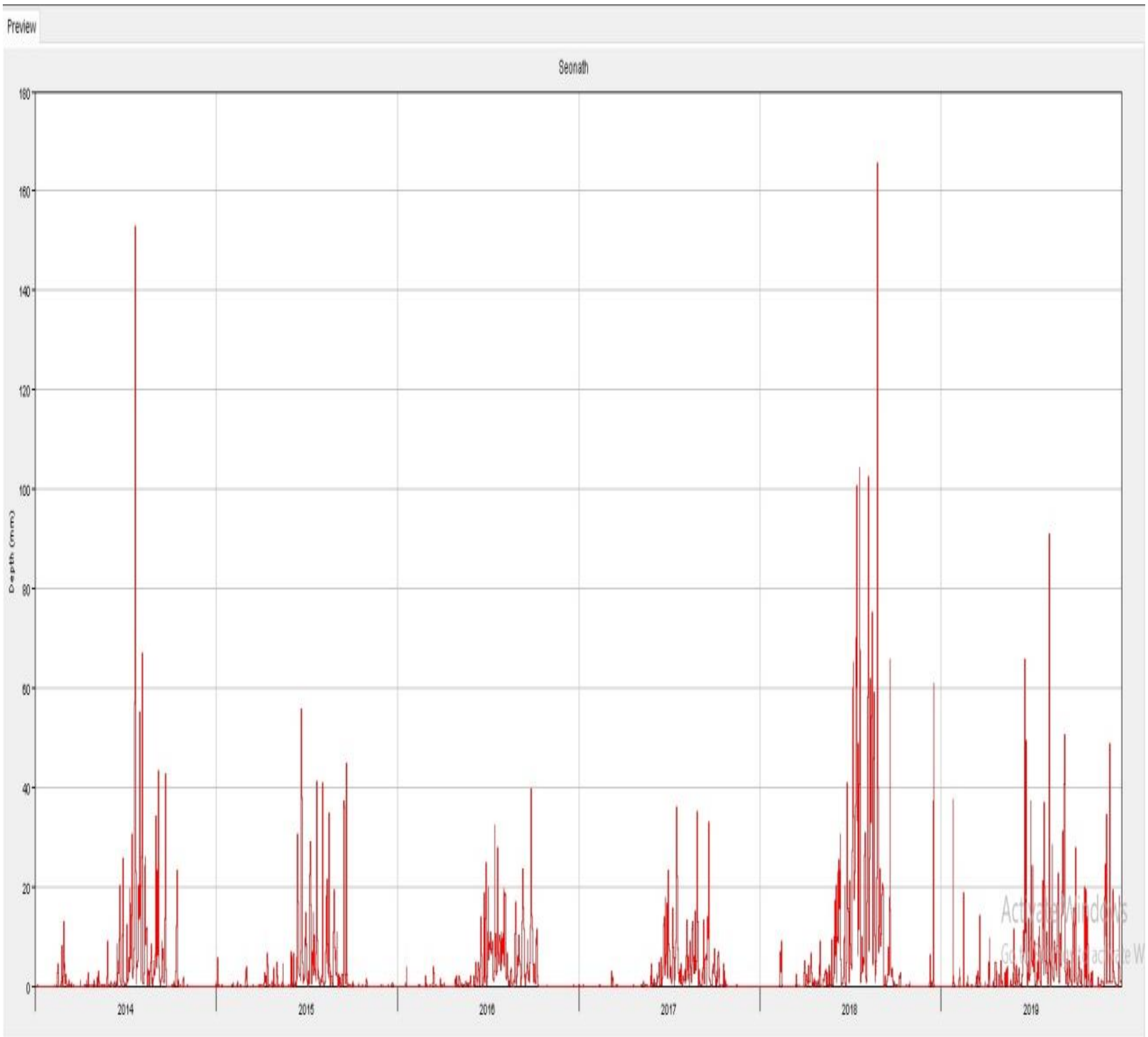

Figure 5.13 The above graph represents Daily Precipitation Data (Year-Wise) For Seonath Basin

Figure 5.13 represents The Precipitation graph is generated by the Hec-Hms Software 4.2 for Seonath Basin. Hence, it shows that the peak precipitation graph has been plotted for the year between 2014 to 2019 thus peak precitipation has been obtained in 28th August 2018 which is 145 mm and average minimum precipitation to be 3.1 mm

Direct Runoff Graph :

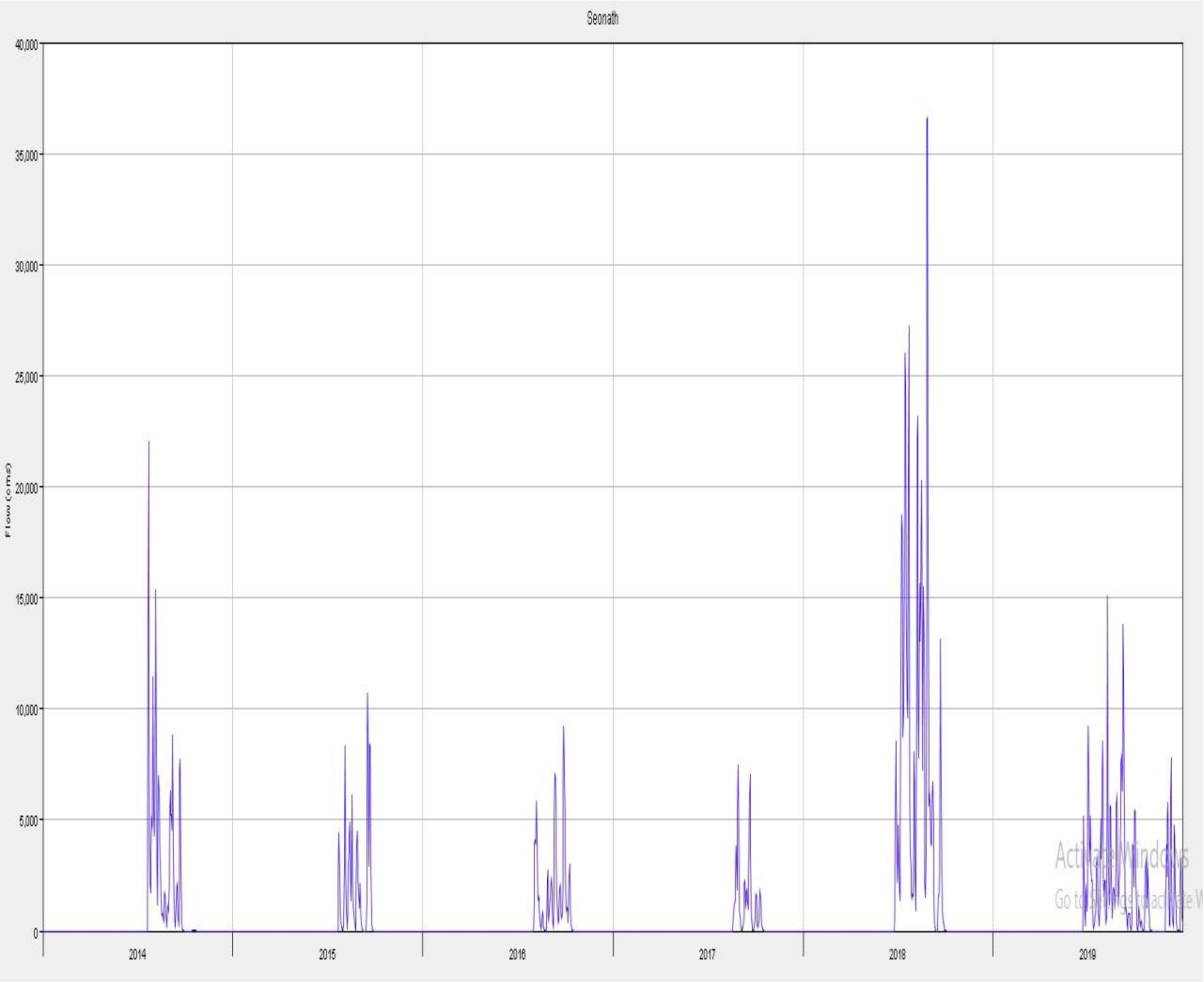

Figure 5.14 The above graph represents the Daily Runoff Data (Year-Wise) for Seonath Basin

Figure 5.14 represents The Direct Runoff graph is generated by the Hec-Hms Software 4.2 for Seonath Basin. Hence, it shows that the Runoff graph has been plotted for the year between 2014 to 2019 thus peak runoff has been generated in 28th August 2018 which is 36763.20 meter cube per second.

Observed Runoff vs Simulated Runoff Results :

From HecHms 4.2 software, figure 5.15 shows the results of observed vs simulated runoffs for seonath basin, which depicts the variations between observed runoff and simulated runoff obtained by software**.**

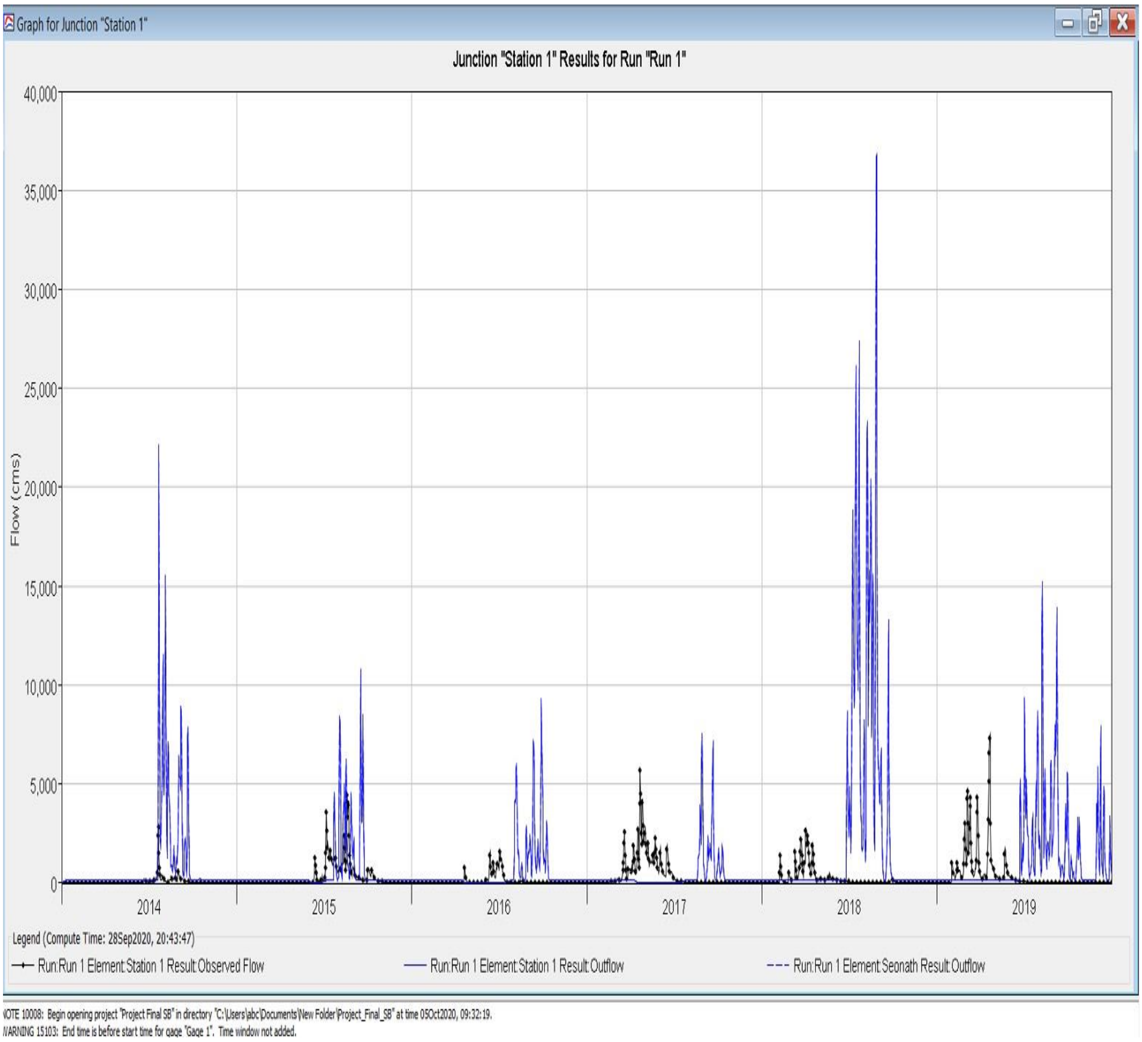

Figure 5.15 Simulation Results For Seonath Basin

In the Seonath catchment the Soil Moisture Accounting runoffs does not follow the exact patterns. The height of observed runoffs are larger than that of simulated runoffs. However, as per the observation it will be appropriate to conclude that they will follow the data patterns for some periods during that particular year and if not then this moments often came under rare possibility.

Results Obtained By Soil Moisture Accounting Method (Jonk Basin) :

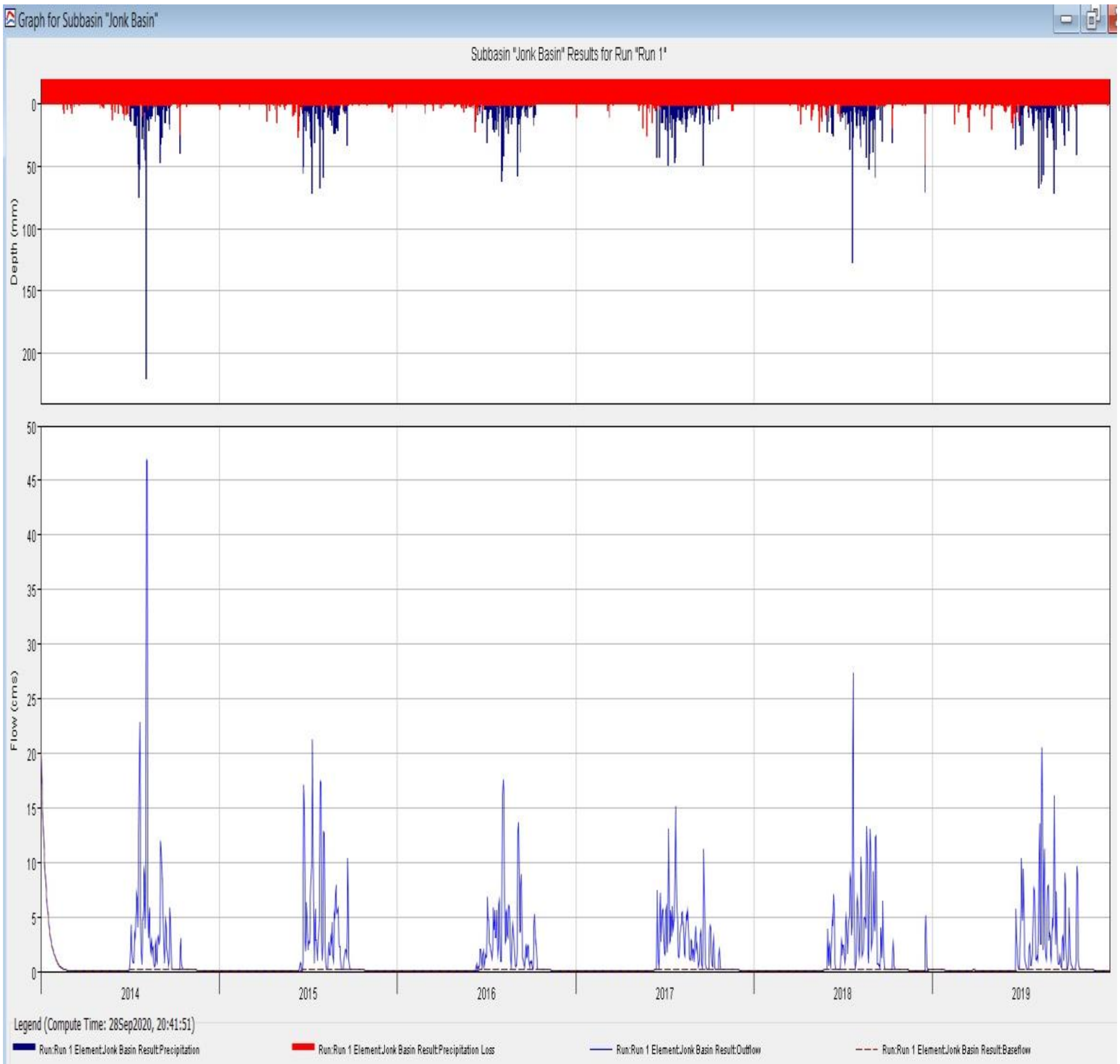

Figure 5.16 Final Graph For Jonk Basin indicating precipitation, precipitation loss, outflow and Baseflow

Figure 5.16 shows the result occupied for Jonk Basin on the accountancy of its daily precipitation, precipitation loss, outflow and baseflow. As per result:

1) The outflow found to be maximum in year 2014 and lowest in the year 2016.
2) The baseflow found to be very least along the entire processing in every year.
3) The precipitation found to be very maximum in the year 2014 and lowest in the year 2016 respectively.
4) The precipitation loss has occurred maximum in the year 2014,2015,2016,2017,2018 and 2019 but found to be least on every year at various time interval along its processing.

FINAL SUMMARY RESULTS :

Figure 5.17 shows the summary of the results obtained by HEC-HMS software 4.2 containing peak discharge which came to be 3932.9 cubic meters per second for Jonk Basin. Method involved is Soil Moisture Accounting method.

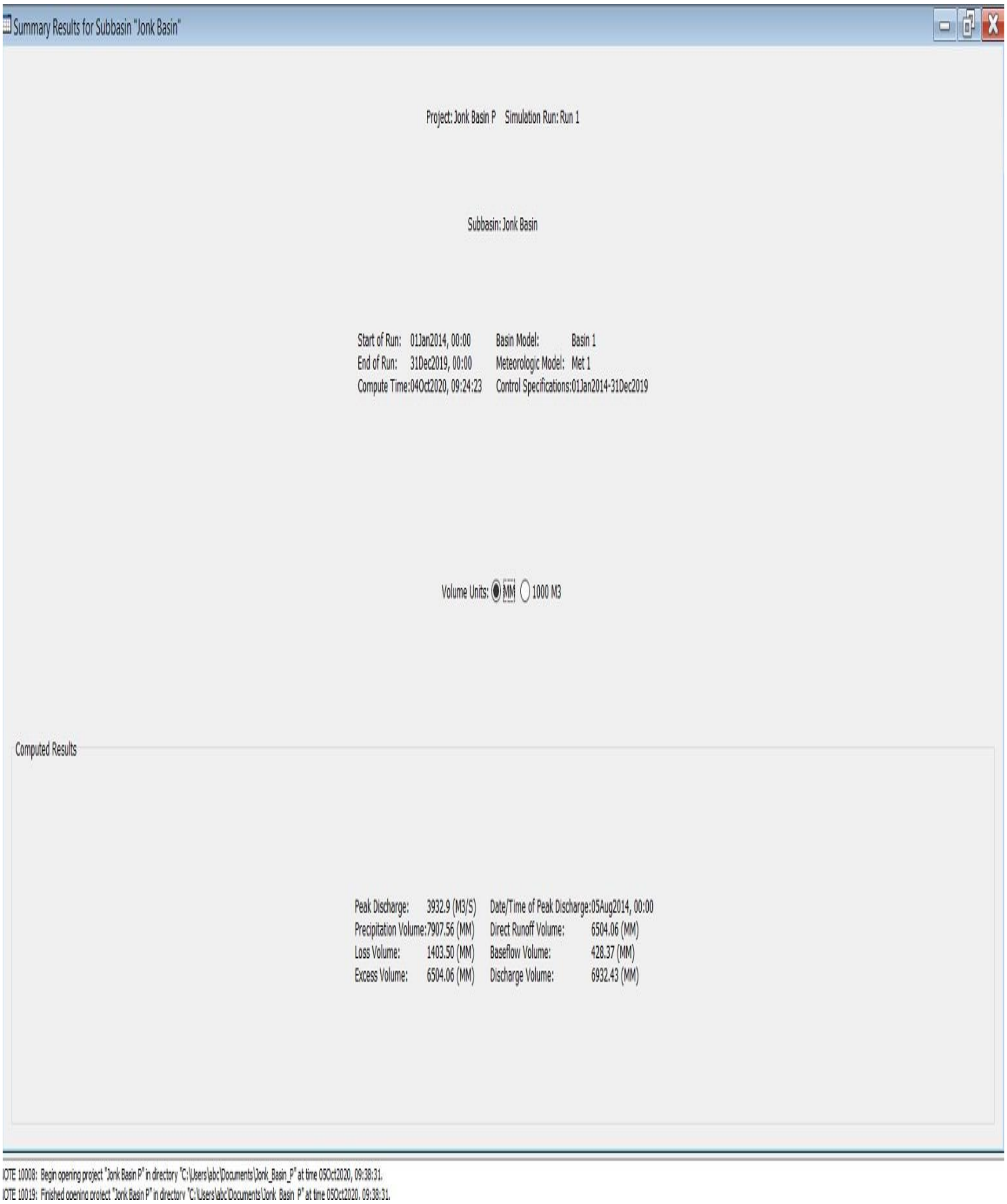

Figure 5.17 The figure represent Peak Discharge and Time of Peak Discharge.

MONTHLY SIMULATED VS OBSERVED RUNOFF OF JONK BASIN (SMA MODEL USED)

MONTH	OBSERVED (m^3/s)	SIMULATED (m^3/s)
January	3.89	5.82
February	5.08	6.09
March	6.27	7.88
April	9.11	9.71
May	9.82	8.89
June	11.28	11.59
July	19.68	21.63
August	23.39	24.97
September	18.89	17.11
October	10.82	9.02
November	4.38	3.41
December	2.79	1.08

Table 5.2 – Monthly Average Simulated Vs Monthly Average Observed Runoffs for Jonk Basin

From Table 5.2, we can conclude that In the Jonk Basin the monthly average runoff results are higher than the monthly average observed runoffs for seven months but is low for rest period. According to Table 3.2, both the average simulated and observed runoffs are very close in various months. The results are closer to the observed values during the period of high monthly average observed runoff. For example, from June to September the monthly average simulated and observed runoffs are very close to each other during the year.

Hence, monthly simulation results found to be correct numerically for Jonk Basin.

Precipitation Graph:

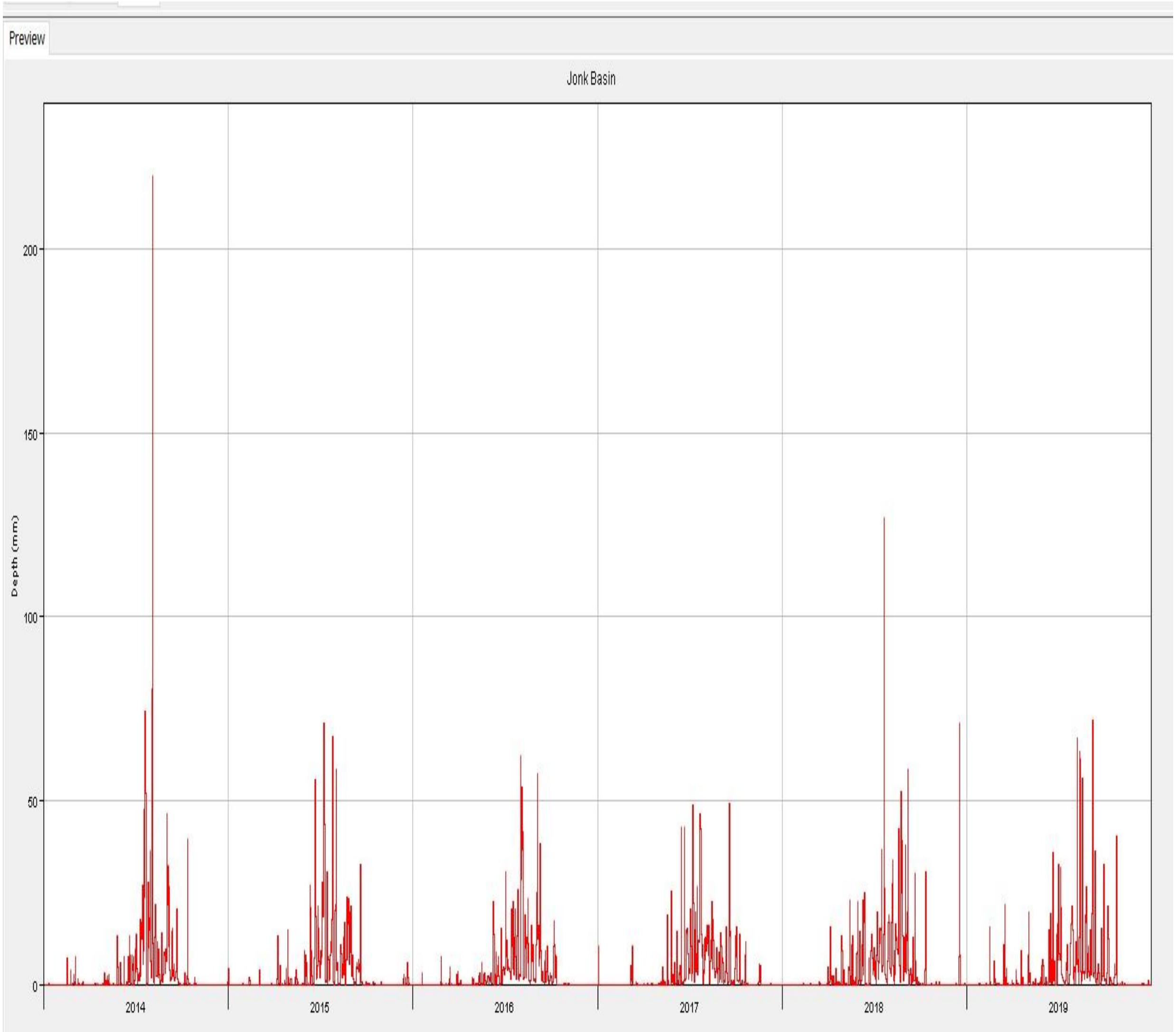

Figure 5.18 The above graph represents Daily Precipitation Data (Year-Wise) For Jonk Basin

Figure 5.18 represents The Precipitation graph is generated by the Hec-Hms Software 4.2 for Jonk Basin. Hence, it shows that the peak outflow graph has been plotted for the year between 2014 to 2019 thus peak precitipation has been obtained in 5th August 2014 which is 288 mm and average minimum precipitation to be 3.1 mm.

Direct Runoff Graph:

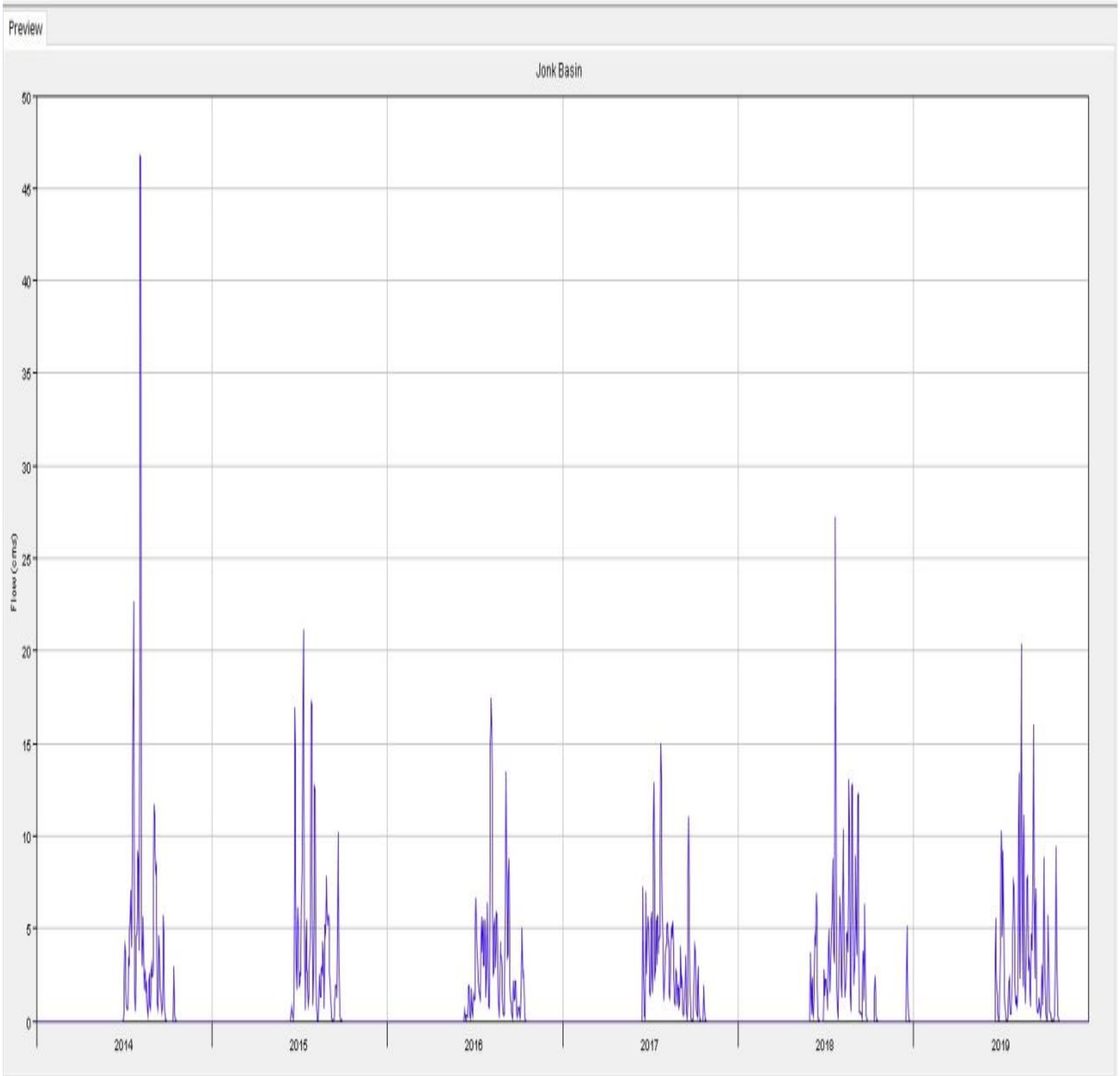

Figure 5.19 The above graph represents Daily Runoff Data (Year-Wise) For Jonk Basin

Figure 5.19 represents The Direct Runoff graph is generated by the Hec-Hms Software 4.2 for Jonk Basin. Hence, it shows that the Runoff graph has been plotted for the year between 2014 to 2019 thus peak runoff has been generated in 5th August 2014 which is 46.9 meter cube per second.

Observed Runoff vs Simulated Runoff Results :

From HecHms 4.2 software, figure 5.20 shows the results of observed vs simulated runoffs for Jonk basin, which depicts the variations between observed runoff and simulated runoff obtained by software**.**

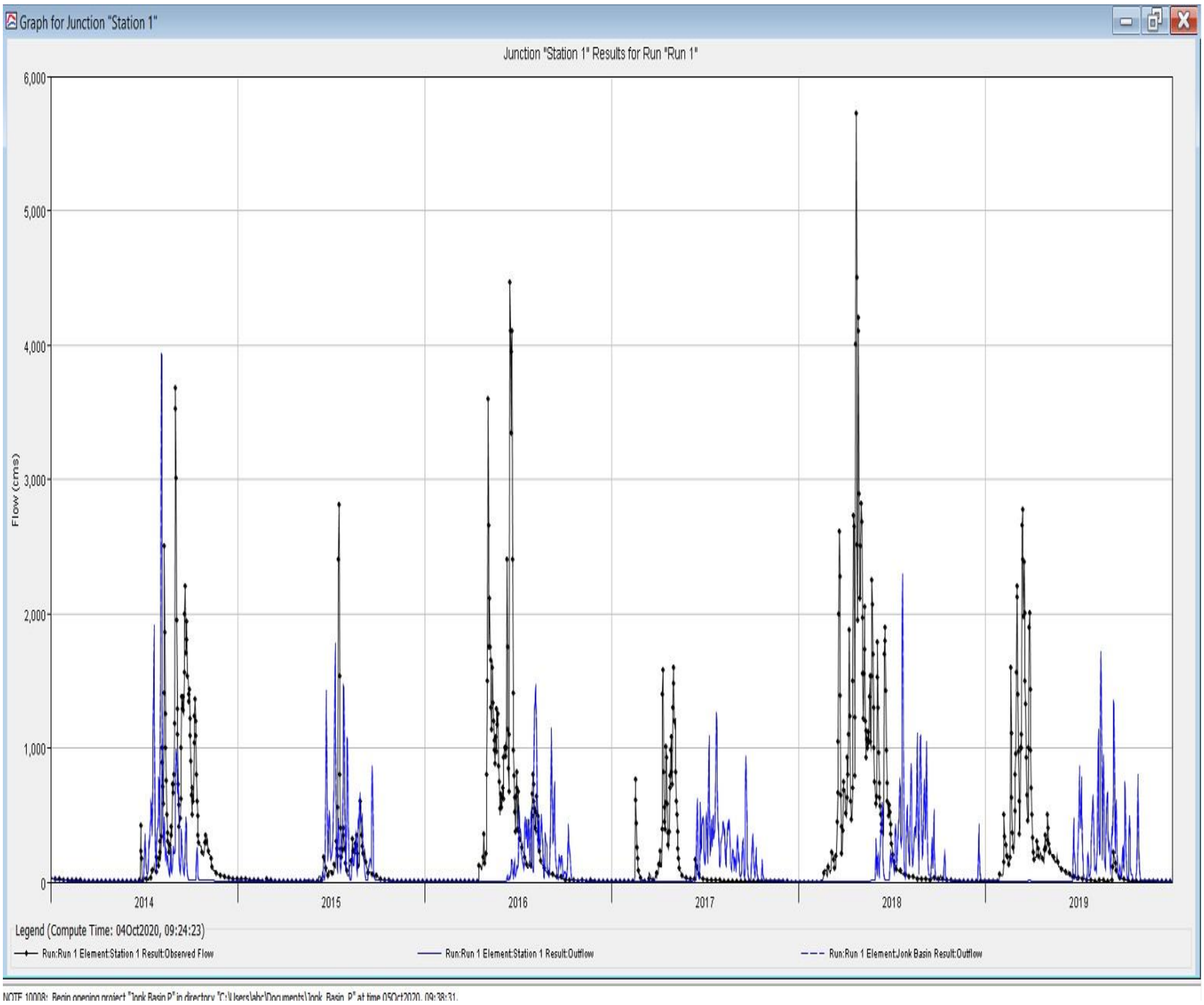

Figure 5.20 Simulation Result For Jonk Basin

In the Jonk Basin, the Soil Moisture Acconting model the values of both results and taken data are nearer to each other. Peak runoffs of both the simulated and observed data are determined to match together in scale and time. Here, the patterns of both the simulated and observed runoff are very similar. By such results, The software has found to be efficient for Jonk Basin rather than Seonath Basin in terms of both scale and time.

CHAPTER – 6
CONCLUSIONS

The HEC-HMS software is very useful in understanding the various whereabouts for the management of different types of watersheds depending upon their characteristics and its depending on the ecosystem such as during the actions of flood mitigation, disaster management etc. The main function of HEC-HMS is to understand the simulation between the magnitude and the peak of any flood occurrence on a small or at a very large scale. It is also known to be a flood prediction tool because it nearly helps in the early warnings of any level of occurrence of flood at any levels. It also predicts the simulation between daily flow around the basins to calculate any hinderence caused by the actions of water, rain or flood etc.

The HEC-HMS is also taken into consideration to be a better tool for understanding the movements of water during the low tides to high tides to basically form a modeling technique to get warn about in a very distinctive manner. It produces data for a low forecast to derived the conditions of drought occurrence in advance without any difficulties.

To understand the hydrological modeling approach of the area of Mahanadi Basin located in Chhattisgarh regions covering the two most indulged Sub basins around it i.e Seonath basin and Jonk Basin different values are to be given to different modeling techniques to find the characteristics of the hydrological modeling of these basins. Also the data has been taken only for six years from 2014 to 2019 but for every day interval to form a more frequent but simple data modeling relations between the rainfall and its runoff. The basic goal of HEC-HMS is can be understand by as follows:

1. The first and basic approach of HEC-HMS is to understand the simulation between the rainfall and runoff modeling between the basins to understand the direction of flow.

2. Due to urbanization the peak runoff has been hindered and distinctive solutions for the actions according to flood plains and its capacities, due to the control taken for the land use for basic necessities.

3. If according to the proper urbanization has been guaranteed along a place, so there has to be a mode of approach to find a better solutions for every difficulties facing around for the development of that particular area.

The study is taken place for two different basins:

- Seonath Basin- Peak discharge has been shown on 28th Aug 2018 i.e 36763.30 m3/s and also the precipitation values to be find as 145 mm.

- Jonk Basin- Peak discharge has been shown on 5th Aug 2017 i.e 14660.3 m3/s and also the precipitation values to be find as 288 mm.

Difference between the catchments in relations to modeling :

We can conclude that properties related to topography for any catchment plays an important role in the hydrological processes. Proper Simulation has been done for both the sub basins accurately and According to the results Jonk Sub Basin has the maximum difference with relation to its elevation and slope whether Seonath has some average properties though the basin has a huge discharge diffrences. The results of simulation relates to the observed data in Jonk Basin rather than in Seonath basin. It shows the software nature which allows it to accumulate discharge and other properties from such topographic conditions.

Difference between model conceptualizations :

Between the two sub basins, the simulation results for Jonk Basin are better than the Seonath Basin because of difference in elevations as the latter has lower elevation compared to the first one.

SCS-CN model runoff results were much closer to exact numbers in both sub basins unless Soil Moisture Accounting (SMA). Both SMA and SCS-CN models gave good results in both the catchments regarding its runoffs. With variations to the results obtained by the software Jonk basin shows better results.

Therefore, after running the models repeatedly the simulated streamflow results have been analyzed. At each set of parameters. In this model, the SCN and Soil Moisture Accounting and Muskingum models have been monitored from the above results the basin idea we get that Seonath Basin and Jonk Basin give different results but can be occupied morally on the same date for latter two basins thus they profound to attain peak discharges on 28th August 2018 and 5th August 2017. For different stations, it gives the proper idea for the rainfall simulation taken for daily rainfall for over the period of six years from 2014 to 2019.

Future Scope Of The Study :

It can be done by taken into the consideration of the basic two things for the proper simulations of the results i.e rainfall and runoff and should be taken for long period of years not only for six years but for over a larger period of time. It has showed better results for the region where runoff is lower than the region of higher runoffs but for that long period of years should be taken for precise results. Also time interval should be derived not only on daily basis but also for six hours and fifteen minutes interval to give more authentic results. Thus, this hydrological model is recommended for the future works regarding flood modeling and flood risk managements and its purposes of a study area.

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