CHAPTER 1

INTRODUCTION

1.1 Background of Study

Flooding is a general and temporary condition of partial or complete inundation of normally dry land areas overflow of inland or tidal waters from the unusual and rapid accumulation of runoff of surface waters from any source [1]. Meanwhile, [2] describe that the flooding is an overflowing of water onto land that is normally dry and floods can happen during heavy rains, when ocean waves come on shore, when snow melts too fast or when dams or levees break. Flooding may happen with only a few inches of water, or it may cover a house to the rooftop.

Flooding occurs in everywhere and it is a threat experienced anywhere in the world that receives rain. According to [3] UK has experienced heavy floods over the past decade, which have affected thousands of people and caused millions of pounds worth of damage. In developing countries, most of houses in many countries can be destroyed instantly causes of heavy rain and flooding event. Meanwhile, Malaysia is not exclusive from the environmental problems of flooding.

Malaysia lies in a geologically stable region which is free from earthquakes, volcanic activities and strong winds such as tropical cyclones which periodically affect some of its neighbors. It lies geographically just outside the 'Pacific Ring of Fire'. However it is does not mean that Malaysia is totally free from natural disasters and calamities, as it is often hit by floods, droughts, landslides, haze, tsunamis and human made disasters. Monsoonal floods are an annual occurrence which varies in terms of severity, place and time of occurrences with a recent 2010 flood in Kedah and Perlis being among the worst flood ever experienced by the country [4].

Besides that, Perak also one of the state that involved in flood occurrence. According to [5] Perak government has asked to allocate of RM400 million for used to prevent floods in the Kerian district and the severity of floods were harms assets of villagers that staying in the Kerian district such as homes, padi fields and oil palm plantations said Menteri Besar Datuk Seri Zambry Abdul Kadir. Managing flood risk in Kerian District is a critical issue because land use change is expected to increase flood hazard in the study area. The numbers of flood victims in Kerian, Perak were increasing and were affected the nearest area such as Kampung Alor Setangguk, Kampung Batu, Kampung Parit Abu Hasan, Kampung Batu 40 Bukit Merah, Kampung Parit Mat Keling, Kampung Tebuk and Kampung Perlis. Meanwhile, the main tributaries of Sungai Kurau are Sungai Ara and Sungai Merah.

Sungai Kurau represents the main drainage and draining an area of approximately 682 km^2 that is generally low lying. Mid valleys of the river are characterized by low to undulating terrain, which give way to broad and flat floodplains. Ground elevations at the river headwaters are moderately high, being 1,200 m and 900 m respectively in Batu Besar and Batu Ulu Trap. The slopes in the upper 6.5 km of the river averaged 12.5% whilst those lower down the valleys are much lower, of the order of 0.25% to 5%. In addition, upstream of the confluence of Sungai Kurau there is a Bukit Merah Dam that used to store the rainfall water. The embankment of reservoir is RL11.28m, has a crest length of about 579 m and height at the deepest point of about 9.1m. It is drained by an area of about 480sq.km and has a storage capacity of 92.8Mcm. **Figure 1.1** shows the satellite image for Sungai Kurau and Bukit Merah Dam location. Meanwhile, **Figure 1.2** shows the Bukit Merah Dam, Kerian.

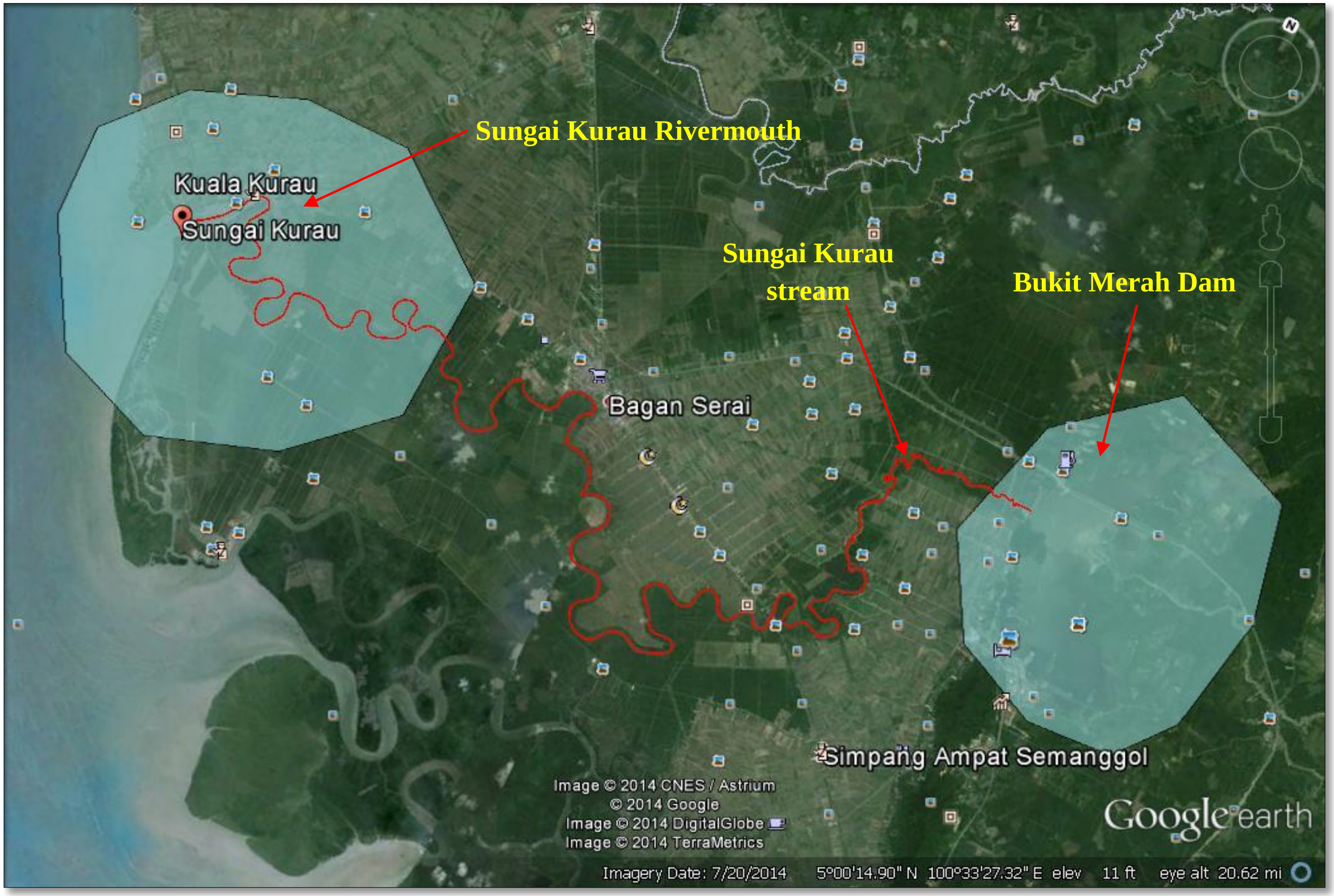


Figure 1.1: Sungai Kurau and Bukit Merah Dam.

Figure 1.2: Bukit Merah Dam, Kerian.

1.2 Problem Statement

Flooding problems that often disturb the tranquility of the villagers is due to heavy rainfall caused by the Northeast monsoon which brings in more rainfall compared to the Southwest monsoon. During heavy rainfall, the Bukit Merah Lake dam released excess water after reaching dangerous levels and the nearest villages affected by the overflowing of water from Bukit Merah Lake dam. When the excess water flowed to Sungai Kurau and into the sea, the high tide would push it back to low-lying villages, thus the land was covered by water. **Figure 1.3** shows water from Bukit Merah dam filling up a waterway.

Figure 1.3: Water from Bukit Merah dam filling up a waterway.

1.3 Objectives

The primary goals for the project title of 'Major Cause of Flood Peak Risk for Sungai Kurau'' are as following:

i. To develop Hydrologic Model for Sungai Kurau from 2005 to 2010.
ii. To analyze the precipitation-runoff processes from year 2005 to 2010 by using HEC-HMS Software.

1.4 Scope of Study

In achieving objectives of project, a comprehensive study was conducted and it covers the following scopes of study:

i. Gather information on hydrologic data of Sungai Kurau in order to compute manually and can be processed by the HEC-HMS software.
ii. Analyze the rainfall-runoff graph that generated by HEC-HMS Software.

CHAPTER 2
LITERATURE REVIEW

2.1 Hydrologic Cycle

All the water of the Earth including the atmosphere, ocean, surface water and groundwater participates in the natural system known as hydrologic cycle. As water moves through all these elements repeatedly [6]. Evaporation of water from water bodies such as oceans and lakes, formation and movement of clouds, rain and snowfall, stream flow and groundwater movements are some examples of the dynamic aspects of water. **Figure 2.1** is a schematic representation of the hydrologic cycle. Water in the oceans evaporates due to the heat energy provided by solar radiation. The water vapor moves upwards and forms clouds. While much of the clouds condense and fall back to the oceans as rain, a part of the clouds is driven to the land areas by winds. There they condense and precipitate onto the land mass as rain, snow, hail, sleet and many more. A part of the precipitation may evaporate back to the atmosphere even while falling [7]

Once the water reaches the ground, one of two processes may which is some of the water may evaporate back into the atmosphere or the water may penetrate the surface and become groundwater. Groundwater either seeps its way to into the oceans, rivers and streams or is released back into the atmosphere through transpiration. The balance of water that remains on the earth's surface is runoff, which empties into lakes, rivers and streams and is carried back to the ocean, where the cycle begins again [8].

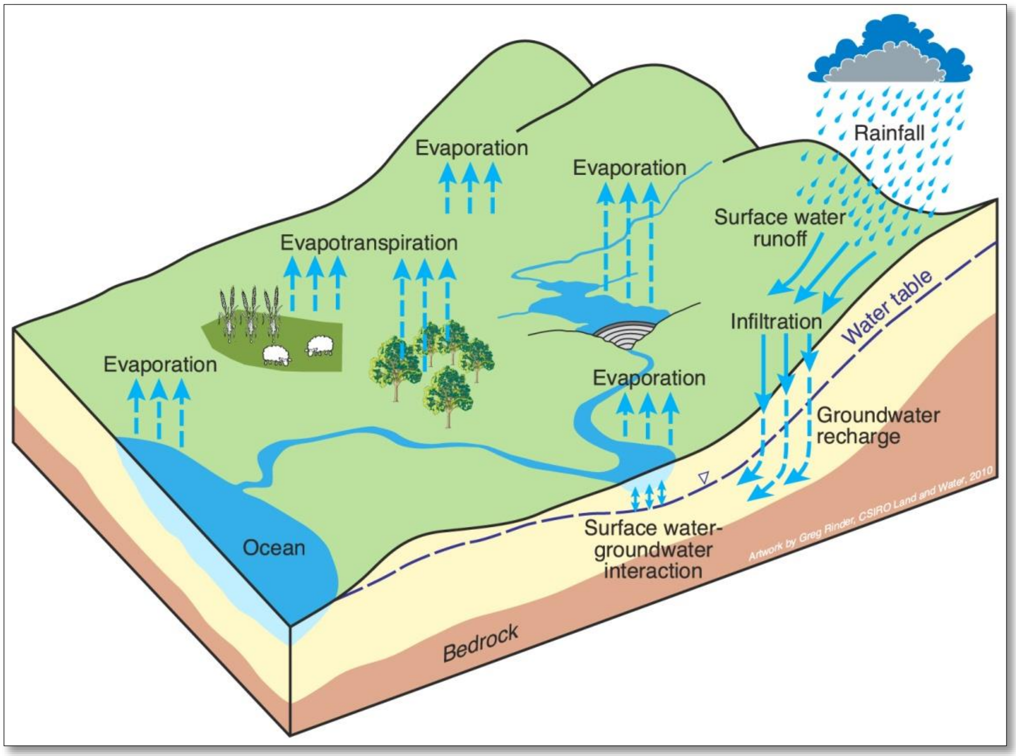


Figure 2.1: The Hydrologic Cycle

The oceans are the dominant reservoir in the global water cycle, holding over 97% of the world water. In contrast, the atmosphere holds only 0.001% and the rest are locked up in ice caps, snow and underground storage. The hydrological cycle is indeed global, because continents and oceans exchange water. Over the oceans, evaporation exceeds precipitation and the difference contributes to precipitation over land. Over land, 35% of the rainfall comes from marine evaporation driven by winds and 65% comes from evaporation from the land. As precipitation exceeds evaporation over land, the excess must return to the oceans as runoff [9]

2.2 Monsoon pattern in Malaysia

According to [10] the weather in Malaysia is characterized by two monsoon regimes, namely the Southwest Monsoon from late May to September and the Northeast Monsoon from November to March. The Northeast Monsoon brings heavy rainfall, particularly to the east coast states of Peninsular Malaysia and western Sarawak, whereas the Southwest Monsoon normally signifies relatively drier weather.

The transition period in between the monsoons is known as the intermonsoon period. The northeast monsoon is the major rainy season in the country. Monsoon weather systems which develop in conjunction with cold air outbreaks from Siberia produce heavy rains which often cause severe floods along the east coast states of Kelantan, Terengganu, Pahang and East Johor in Peninsular Malaysia, and in the state of Sarawak in East Malaysia. The southwest monsoon is comparatively drier throughout the country except for the state of Sabah in East Malaysia. During this season, most states experience monthly rainfall minimum (typically 100 - 150 mm). In particular, the dry condition in Peninsular Malaysia is accentuated by the rain shadow effect of the Sumatran mountain range. Sabah is relatively wetter (exceeding 200 mm) due to the tail effect of typhoons which frequently traverse the Philippine islands in their journey across the South China Sea and beyond. During the intermonsoon periods, winds are light and variable. Morning skies are often clear and this favors thunderstorm development in the afternoon. In the west coast states of Peninsular Malaysia, thunderstorms contribute to a mean monthly rainfall maximum in each of the two transition periods.

On the other hand, the cold surges of the northeast monsoon cause the heavy rainfall which is occurred in the southern part of Peninsular Malaysia for several days in late December 2006 and in the middle of January 2007, causing massive floods in the region. The influences from the Borneo vortex, the Madden-Julian Oscillation, and the Indian Ocean Dipole also play an important role in contributing to the massive floods during those periods. During the northeast monsoon, the exposed areas on the eastern part of the Peninsula receive heavy rainfall. On the other hand, the areas which are sheltered by the mountain ranges known as a Titiwangsa Range are more or less free from its influence.

The average total annual rainfall index is found to be higher during northeast monsoon season than during the southwest monsoon season where the coast that is exposed to the northeast monsoon flow tends to be wetter than that exposed to the southwest monsoon.

Based on the total annual rainfall index, the ranges for eastern area is between 1200 mm and 1500 mm meanwhile in the southwestern and western areas recorded between 600mm and 900 mm during the northeast monsoon season. Otherwise, 300 mm and 600 mm recorded at all the northwestern stations. The rainfall patterns for the stations in the eastern areas are strongly influenced by the northeast monsoon, while there is a lesser impact at stations in the western part of Peninsular Malaysia, especially those in the northwestern areas. This probably occurs because the northeasterly winds, which are known to bring heavy rainfall, are blocked by the Titiwangsa Range, which possibly affects most of the stations along the western part of the Peninsula. Therefore, the eastern part of the Peninsular is considered the wettest area during the northeast monsoon season.

The decrease in extreme rainfall indices at most stations will reduce the risk of floods. In contrast, a decrease in the total amount of rainfall and the frequency of wet days during the southwest monsoon season could also create problems for the agriculture, forestry and energy sectors, public health and water resources. **Table 2.1** shows the general information regarding the precipitation that was recorded of 36 principal meteorological stations till year 2010 (Malaysian Meteorological Department, 2010). Meanwhile, **Appendix A** shows the rainfall rate in peninsular area for 18 December 2014 and **Appendix B** shows the monthly rainfall for peninsular region as described by Drainage and Irrigation Department (DID).

Highest rainfall in an hour	159.4mm	Recorded at Sandakan, Sabah on 27 October 2006.
Highest rainfall in a day	608.1mm	Recorded at Kota Bharu, Kelantan on 6 January 1967.
Highest rainfall in a year	5,687mm	Recorded at Sandakan, Sabah in 2006.
Lowest rainfall in a year	1,151mm	Recorded at Tawau, Sabah on 1997.
Highest average annual rainfall	4,159mm	Recorded at Kuching, Sarawak.
Lowest average annual rainfall	1,787mm	Recorded at Sitiawan, Perak.
Highest average number of rain day per year	279days	Recorded at Kuching, Sarawak

Table 2.1: General precipitation information

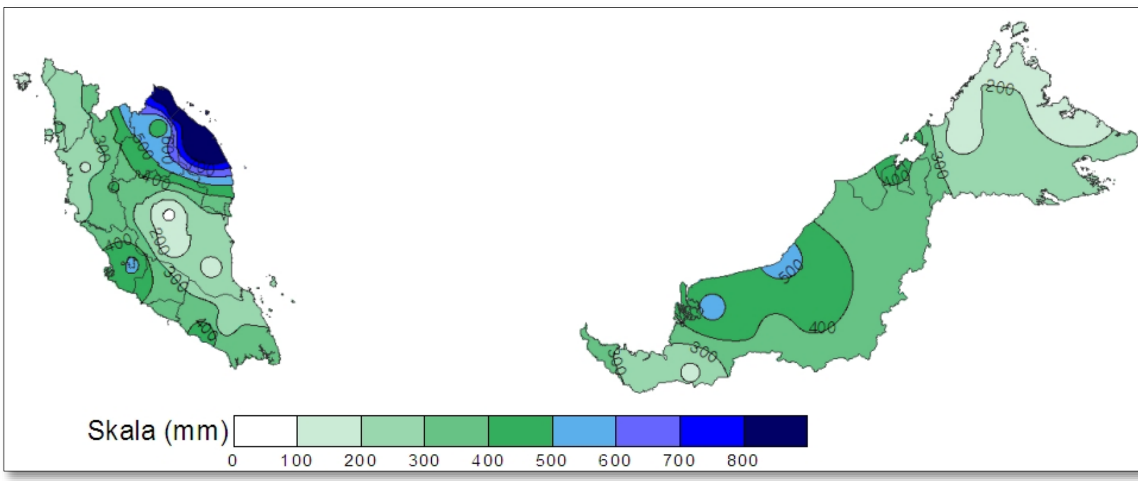


Figure 2.2: Rainfall amount in Peninsular, Sabah and Sarawak

2.3 The Comprehensive Study on the Flood Risk

Flood is the most common of all environmental hazards and it regularly claims over 20, 000 lives per year and affects around 75 million people worldwide and cause about one third of all damages from natural disaster.

Flood is an environmental hazard that occurs regularly every year in different parts of the country especially during the rainy season and it is usually occurs due to the increase in the volume of water within the water body such as rivers and lakes. This problem causes water to exceed the drainage channel capacity and overflow its bounds. Besides that, the flooding occurrences occurred due to the inability of soil layer to infiltrate water or when the water reached its maximum field capacity to accommodate the runoff water. It was form of flooding especially the urban area of the world which is too much of development and land use change are developed. The events of flooding can be viewed in two perspectives which are the impact on the natural environmental and impact on the built or artificial environmental [11].

According to [12] the flood event may cause the ecological disaster, with unsightly deposition of sediment and debris, destruction of plants and animals, and even local species extinctions. In addition, flood events that are part of the natural cycle will ensure the long-term viability of the plants and animals adapted to flood prone environments and the functioning of those ecosystems. The severity of floods is dependent on natural water movement across drainage divisions and river basins, and is affected by land use and management practices. Built infrastructure and land clearing can affect the natural flow of water across the landscape and can increase the velocity of surface water flows and consequential damage. Meanwhile the future developments may lead to a growth of the worldwide risks of flooding. The effects associated with global warming, such as sea level rise, more intensive precipitation levels and higher river discharges, may increase the frequency and the extent of flooding on a worldwide scale.

Increased urbanization in developing countries and invasion of coastal and river plain areas by agricultural, residential and industrial activities are some of the major factors that will contribute to the increased vulnerability to flood hazards. The river floods often cause the rivers to overflow their banks, sometimes with a velocity and enormously destructive surge. Global population growth, more intensive urbanization in flood prone areas and the limited development of sustainable flood-control strategies will increase the potential impacts of floods [13]. In the last decade of the 20th century floods killed about 100,000 persons and affected over 1.4 billion people.

The statistics shows the flood have a large impact on human well-being on a global scale. As a direct consequence floods may lead to economic damage and damages to ecosystems and historical and cultural values. Furthermore floods can lead to the loss of human life and other (non-lethal) human health effects.

Floods can cause the loss of economic and agricultural production and a decrease of socio-economic welfare. Natural disasters are inevitable and it is almost impossible to fully recoup the damage caused by the disasters. But it is possible to minimize the potential risk by developing early disaster warning strategies, preparing and implementing developmental plans to provide resilience and to help in rehabilitation. It is essential to study the character of floods and evaluate the existing adaptation measures to flood hazard in Malaysia, in order to measure the devastating impacts of floods and associated socio-economic consequences plus the potential impacts of extreme weather events occasioned by shift in climate. **Figure 2.3** illustrate the flood prone area in Malaysia.

Figure 2.3: Flood prone area in Malaysia

2.4 Rainfall-runoff model: HEC-HMS

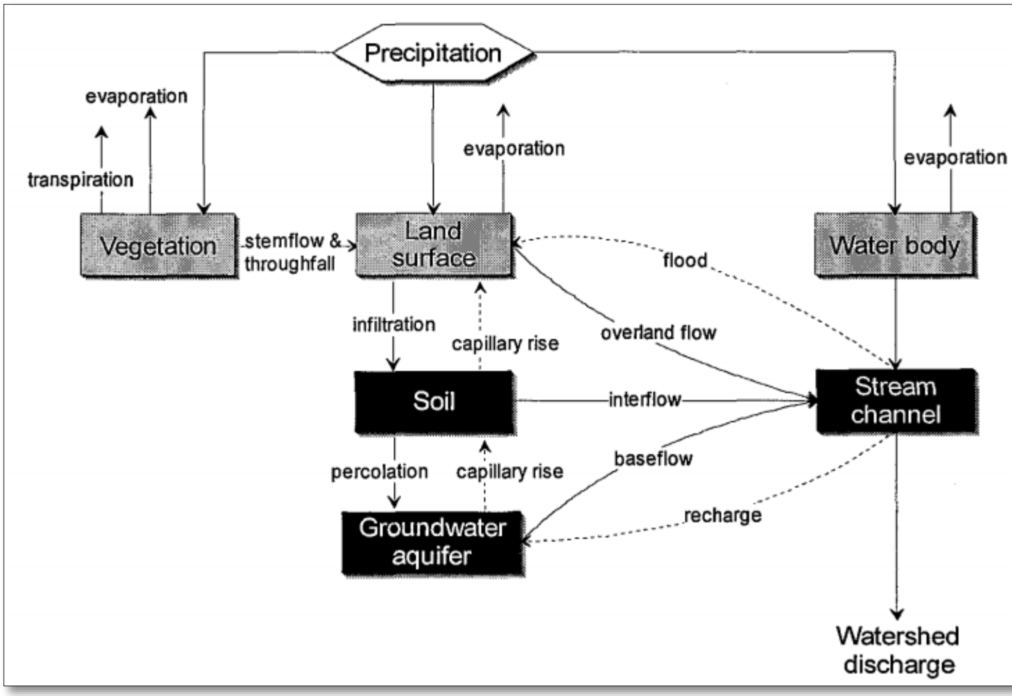


Figure 2.4: Systems diagram of the runoff process at local scale (after Ward, 1975)

Figure 2.4 illustrate the systems diagram of the watershed runoff process at a scale that is consistent with the scale modeled well with HEC-HMS and it is shows the processes begin with precipitation. Based on [14], the movement and quality of water can be predict and characterized through a modeling. Modeling can be conducted using physical scale models, empirical models and numerical models. Physical scale models utilize constructed representations of the system of interest. Empirical models synthesize collected field data and utilize statistical relationship to a study a system.

Meanwhile, numerical models typically make use of computer programs to solve mathematical approximations of governing physical equations for water movement. In addition, numerical models provide a means of moving beyond point-based measurement to develop a continuous and comprehensive picture of hydrologic conditions then to enhance our understanding of data collected in the study area.

To simulate the dendritic watershed systems, the professionals will use the Hydrologic Modeling System (HEC-HMS) and this software includes many traditional hydrologic analyses such as event infiltration, unit hydrographs, and hydrologic routing. According to [15] the gridded curve number (CN) techniques enables spatially distributed infiltration calculations.

The method used to determining storm runoff over an area based on land use, soil and land cover type and hydrologic soil group is Curve Number (US SCS, 1986).

$$Q = \frac{(P - Ia)^2}{(P - Ia) + S} \qquad \textbf{(Equation 2.1)}$$

Where;

Q = runoff (in)

P = rainfall (in)

S = potential maximum retention after runoff begins (in)

Ia = initial abstraction (in)

Initial abstraction (Ia) is all losses before runoff begins. This losses includes water retained in surface depressions, water intercepted by vegetation, evaporation, and infiltration. Ia is highly variable but it is correlated with soil and cover parameters. The combination of S and P is allowed to use to produce a unique runoff amount.

$$Ia = 0.2S \qquad \textbf{(Substitute into formula)}$$

$$Q = \frac{(P - 0.2S)^2}{(P + 0.8S)} \qquad \textbf{(Equation 2.2)}$$

S is related to the soil and cover conditions of the watershed through the CN. CN has a range to 0 to 100 and S is related to CN by:

$$S = \left(\frac{1000}{CN}\right) - 10 \qquad \textbf{(Equation 2.3)}$$

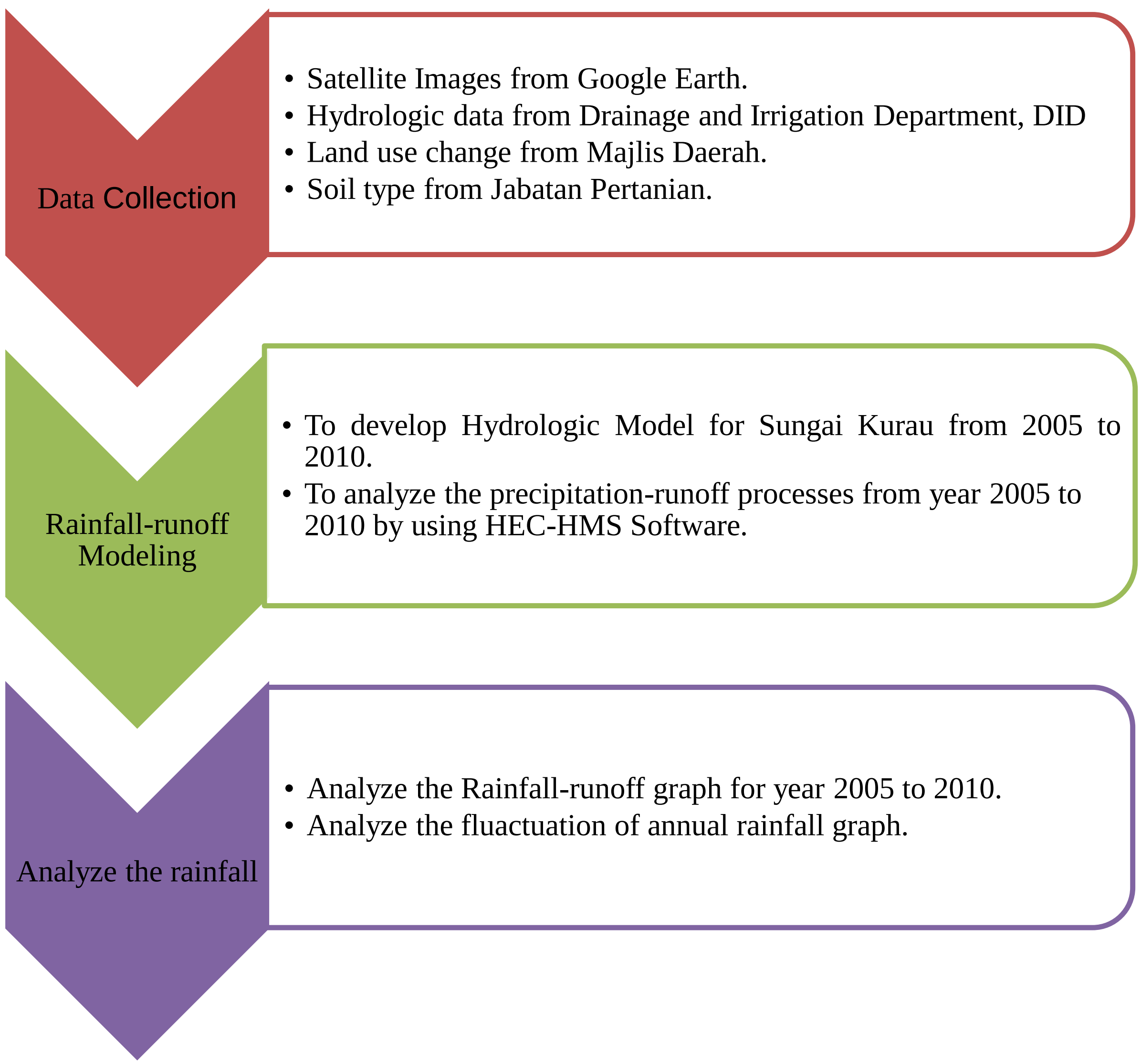
[16] States that there are major significant that related in determining the CN and there are the hydrologic soil group (HSG), cover type, treatment, hydrologic condition and antecedent runoff condition (ARC). Soil groups are determined based on type and infiltrability of a soil. On the other hand, ModClark algorithm is used to perform the translation of excess precipitation to runoff. Meanwhile the transformation of Clark unit hydrograph is modified to accommodate spatially distributed precipitation.

According to [17] HEC-HMS comes with an Arc-View extension which automates the construction of the model input and especially the averaging of soil type and local drainage delineation, through the full exploitation of GIS hydrographic delineation capabilities. The capabilities of HMS for rainfall-runoff simulation have been exploited for describing single events on which the rating curves to be estimated were tested.

CHAPTER 3

METHODOLOGY

3.1 Project Flowchart



Flowchart 3.1: Flowchart of the Research

3.2 Data Collection

Data collection is the process of gathering and measuring information in the research field that enables to answer and evaluate outcomes of the research project. The accuracy of data collection is essential to get an appropriate result and to reduce the likelihood of errors occurring. There are a few of data are needed in order to accomplish the project objectives:

3.2.1 Satellite Images from Google Earth.

The satellite images of Sungai Kurau, Kerian is essential to obtained before the rainfall simulation can be conducted by using HEC-HMS Software where the satellite images is gathered from Google Earth. The Sungai Kurau satellite images was digitized and used in HEC-HMS Software and the most common features to digitize are:

a) Points
b) Lines
c) Polygons

The concepts of digitizing include the following:

a) Points features are simply created by identify the x, y coordinate.
b) Lines can be snapped together by setting the snapping environment so that two lines can share the same node feature.
c) Polygon can be created using an Auto-complete function that automatically creates closed polygonal areas and facilitates the creation of polygon features that share a common line with an adjacent polygon.
d) The digitizing process is just one element in a series that contribute to the overall error present in a final database. It is important to acknowledge that a final digitized product is only as accurate as the map which is being digitized and is probably somewhat less accurate because of the error involved in the digitizing process.

3.2.2 Rainfall data collection from Drainage and Irrigation Department, DID

Sungai Kurau rainfall data for year 2005 to 2010 is gathered from Drainage and Irrigation Department, DID. The optimal selection of number and location of rainfall gauges is 4 rainfall stations gauges. **Table 3.1** shows the listing of Inventory Station Perak. **Appendix C** shows the list of precipitation data for year 2005 to 2010.

No	**Station No**	**Station Name**
1	RF 4904026	Ladang Gula at Kuala Kurau
2	RF 4905023	Ladang Gedong at Kuala Kerian
4	RF 5005003	Jln Matang Buloh at Bagan Serai
5	RF 5006021	Kolam Air Bukit Merah

Table 3.1: Inventory Station Perak

3.3 Digitizing Satellite Imagery

Digitizing is one of the task that has to do before the Hydrologic Modeling could be run. In Hydrologic Modeling, the satellite images of Sungai Kurau was taken from Google Earth and was digitized along 68 km length of river. The features used in digitizing this river is line and polygon. According to [18], line consists of two points that connecting straight line and the measurement is done by its length. Meanwhile for the polygon tool, it is consist two or three points in order to compute the perimeter and area of study area.

Figure 3.2 shows the elevation profile for Sungai Kurau. To display the elevation profile, the river path been selected and click then the elevation profile of river came out. The elevation of river is shown in Y-axis meanwhile the distance of river is shown in X-axis. The elevation and cumulative distance of river is displayed if the cursor moved along the river path.

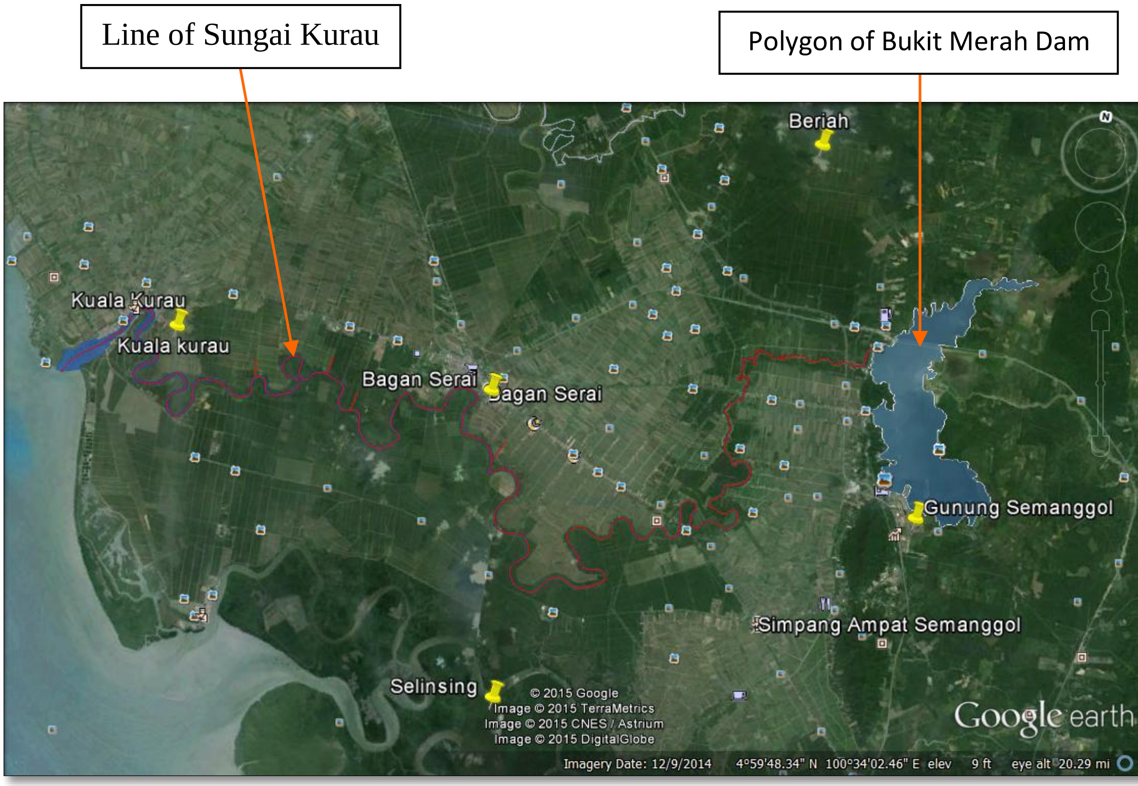


Figure 3.1: Satellite Image of Sungai Kurau

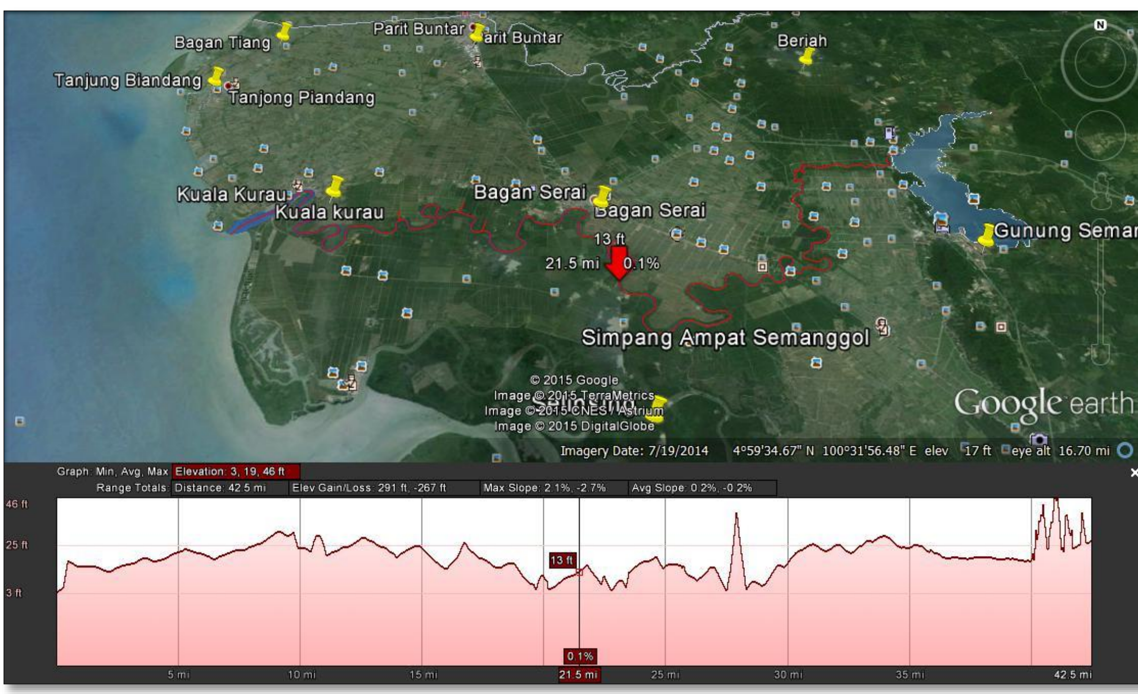


Figure 3.2: Elevation profile of Sungai Kurau

Other than that, the river also has been digitized by using the polygon tool in order to obtain the area of river by using the Earth Point. The area of river is needed in Hydrological Modeling.

3.4 Area of Sub-division in Kerian District

The area of each sub-division of Kerian District are calculated by using the QGis Software. In QGis Software, the icon of Vector selected, Geometry Tools then Export/Add Geometry Columns. When the Export/Add geometry columns pop-out, area of each sub-basin is calculated and saved. By using this method, the KML file from Google Earth has been saved in new shape file [19]. **Figure 3.3** shows the Export/Add geometry columns.

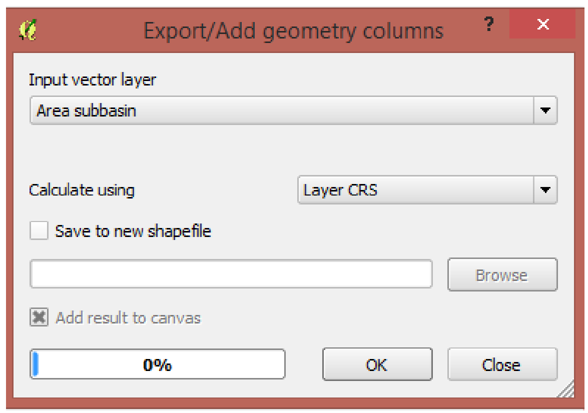


Figure 3.3: The Export/Add geometry columns

3.5 Create Thiessen Polygons by using ArcGis

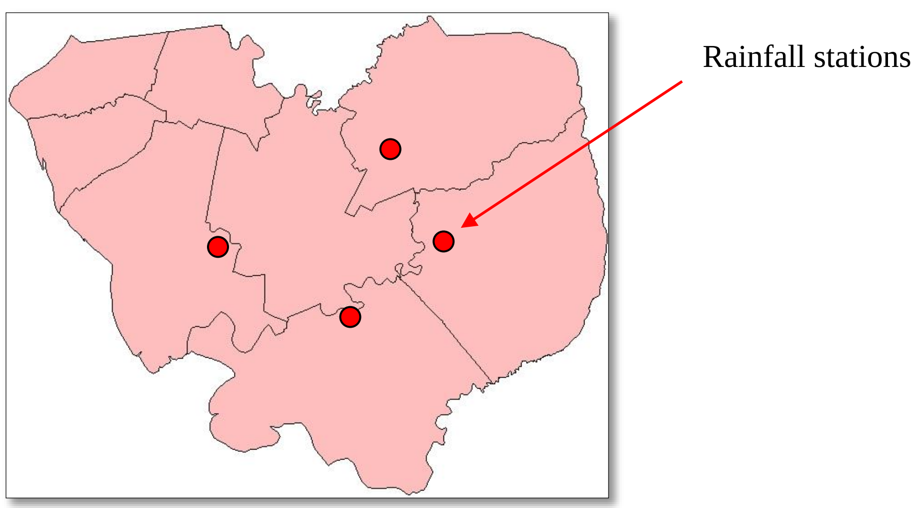


Figure 3.4: Rainfall station location

The Thiessen polygon method used to calculates station weights based on the relative areas of each measurement station in the Thiessen polygon network. The individual weights are multiplied by the station observation and the values are summed to obtain the areal average precipitation. The Thiessen polygon method can be done by manually or ArcGis software. In this project, the author use the ArcGis method in order to delineate the precipitation areas in Kerian district.

3.6 Hydrologic Modeling by using Hydrologic Engineering Center's Hydrologic modeling System (HEC-HMS)

The HEC-HMS is an appropriate software used to predict the water resources management (long-term) and flood management (short-term) and is running with windows appearance. The precipitation-runoff processes of dendritic watershed systems is simulating by using the HEC-HMS and it is applicable in a wide range of geographic areas in order to solve incoming problems [20]. **Appendix D** shows the parameter use in HEC-HMS.

3.6.1 Basin Model.

A new Basin model is created by clicking the **Component** and **Basin Model Manager** menu option. In the Basin Model Manager window, **Name** and **Description** is created. **Figure 3.5** shows the Basin Model Manager and **Figure 3.6** shows the basin model is created.

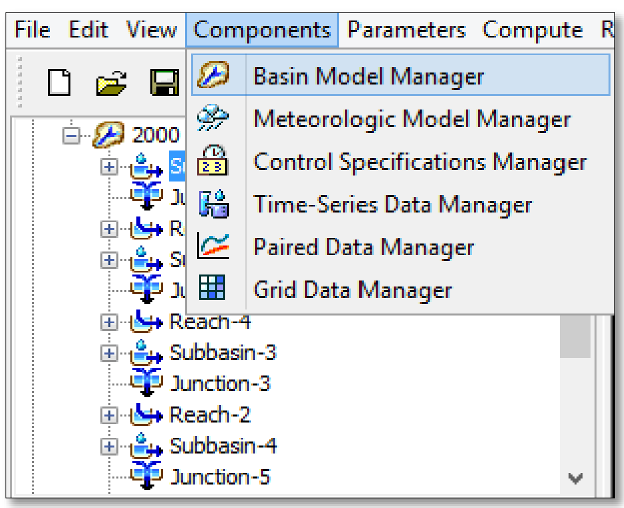


Figure 3.5: Open the Basin Model Manager

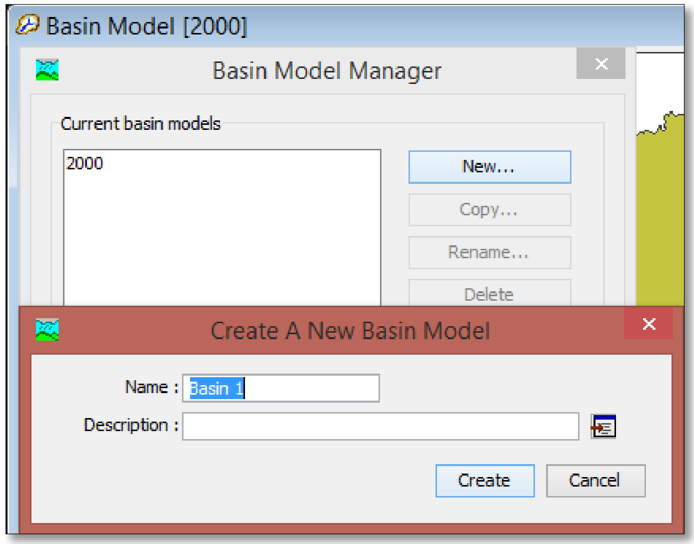


Figure 3.6: Create a new basin model

The hydrologic elements located at the top of menu option is added once a new basin model is created. The basin model map is added to reflect the real world watershed. Meanwhile, the hydrologic elements is selected once the basin model map added into the ***Desktop***. There are six of hydrologic elements used in HEC-HMS:

i. Sub-basin creation tool
ii. Reach creation tool
iii. Reservoir creation tool
iv. Junction creation tool
v. Diversion creation tool
vi. Source creation tool
vii. Sink creation tool

For Hydrologic Modeling of Sungai Kurau, only Sub-basin, reach and junction creation tools is used in order to discharge the runoff. The downstream and upstream elements connected by click the right mouse button and **Connect Downstream** option chosen from the popup menu. **Figure 3.7** shows the basin model map of Sungai Kurau that was created.

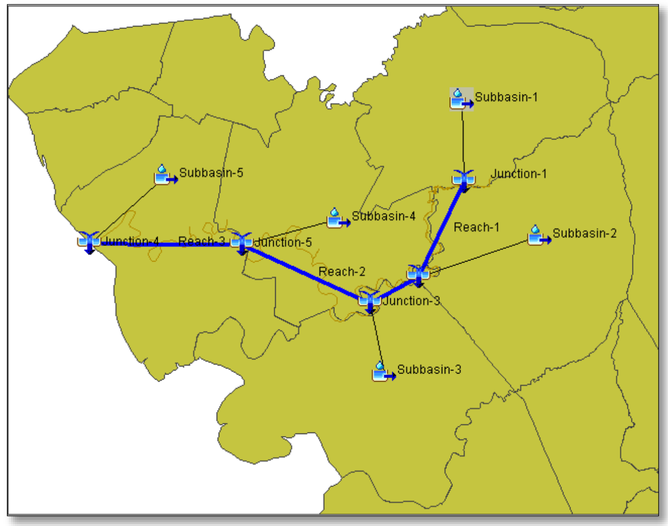


Figure 3.7: Basin model map of Sungai Kurau

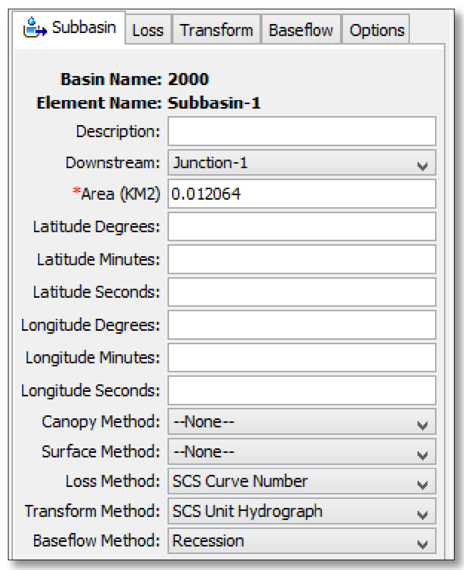


Figure 3.8: Component Editor for a sub-basin element

3.6.2 Meteorological Model.

A Meteorological model is created same as the basin model procedure. The Meteorological model created by click the **Component** menu, **Meteorological Model Manager** menu option then the '**New**' button is click.

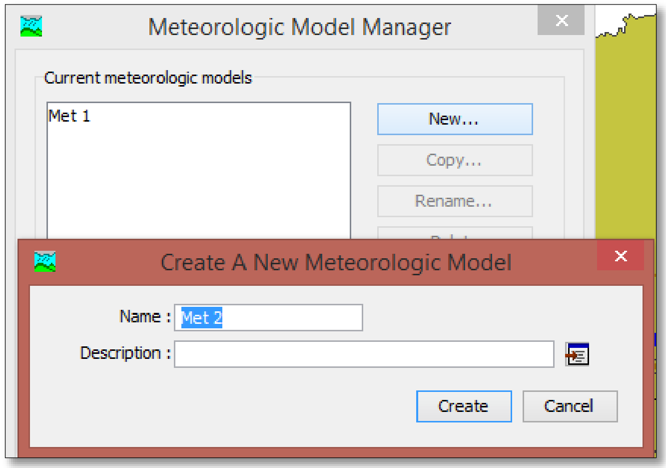


Figure 3.9: Open the Meteorological Model Manager

For the precipitation options, the Gage Weigths was chosen as shown in **Figure 3.10**.

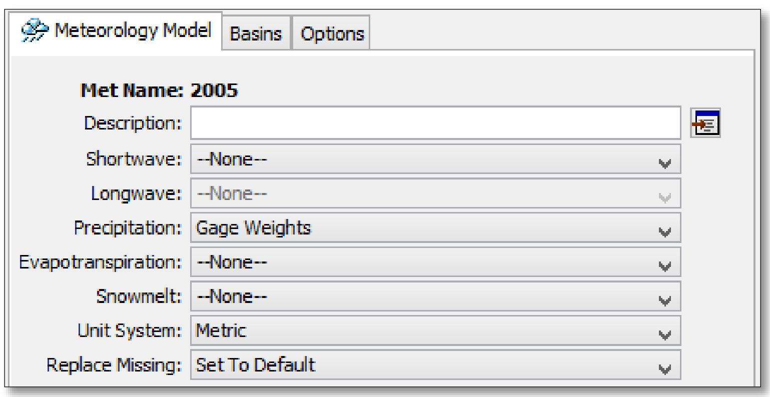


Figure 3.10: Component Editor for a Meteorological element.

In **Figure 3.11** shows the value inputted in time weight column whereby the value must be 1. Meanwhile, the value of depth weight is calculated as below;

i. Area in Jalan Matang Buloh + Area in Ladang Gedong = Total area
ii. Area in Jalan Matang Buloh /Total area = Ratio for Jalan Matang Buloh

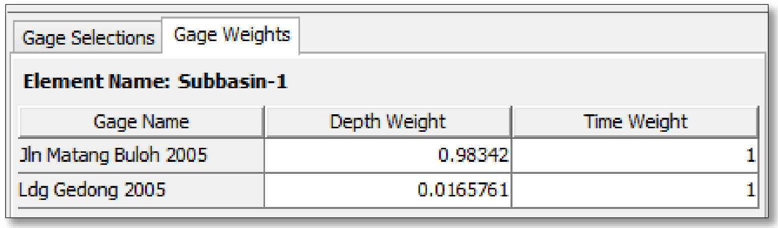


Figure 3.11: Gage weights window

3.6.3 Control Specifications.

The Control specifications of Sungai Kurau is added by selecting the Component, Control Specification Manager Menu option that provided at the top of Desktop. In this component, it is requires the start date and time, an end date and time step. It must be entered by using the 'ddMMYYYY' format. Which is 'd; represent for day, 'M' represents for month meanwhile 'Y' represent for year. **Figure 3.12** shows the Component Editor for a Control Specifications.

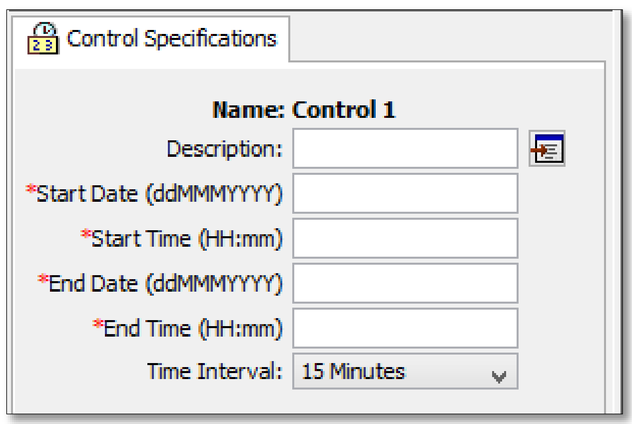


Figure 3.12: Component Editor for a Control Specifications

3.6.4 Compute a simulation run.

A simulation run is created by selecting the **Compute, Run manager** menu option. **New** button in simulation run manager window clicked. This step also provide the copy, **rename** and **delete** button. The simulation run can be rename in the Watershed Explorer or from the Simulation Run Manager.

The Compute toolbar also compute a simulation run. The simulation run is selected from a list of current simulation runs to compute current run button.

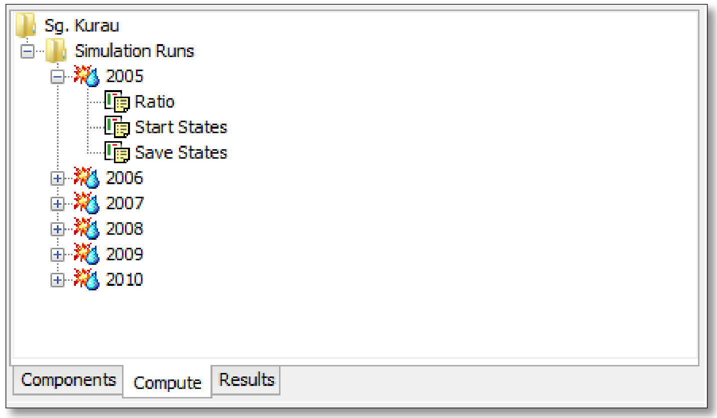


Figure 3.13: Simulation run

3.6.5 View Model Results

After the simulation, the graphical and tabular simulation results can be opened by clicked in the **Results** tab.

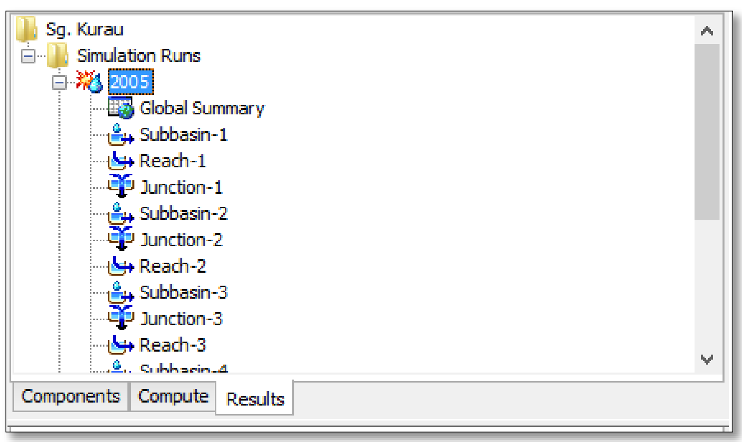
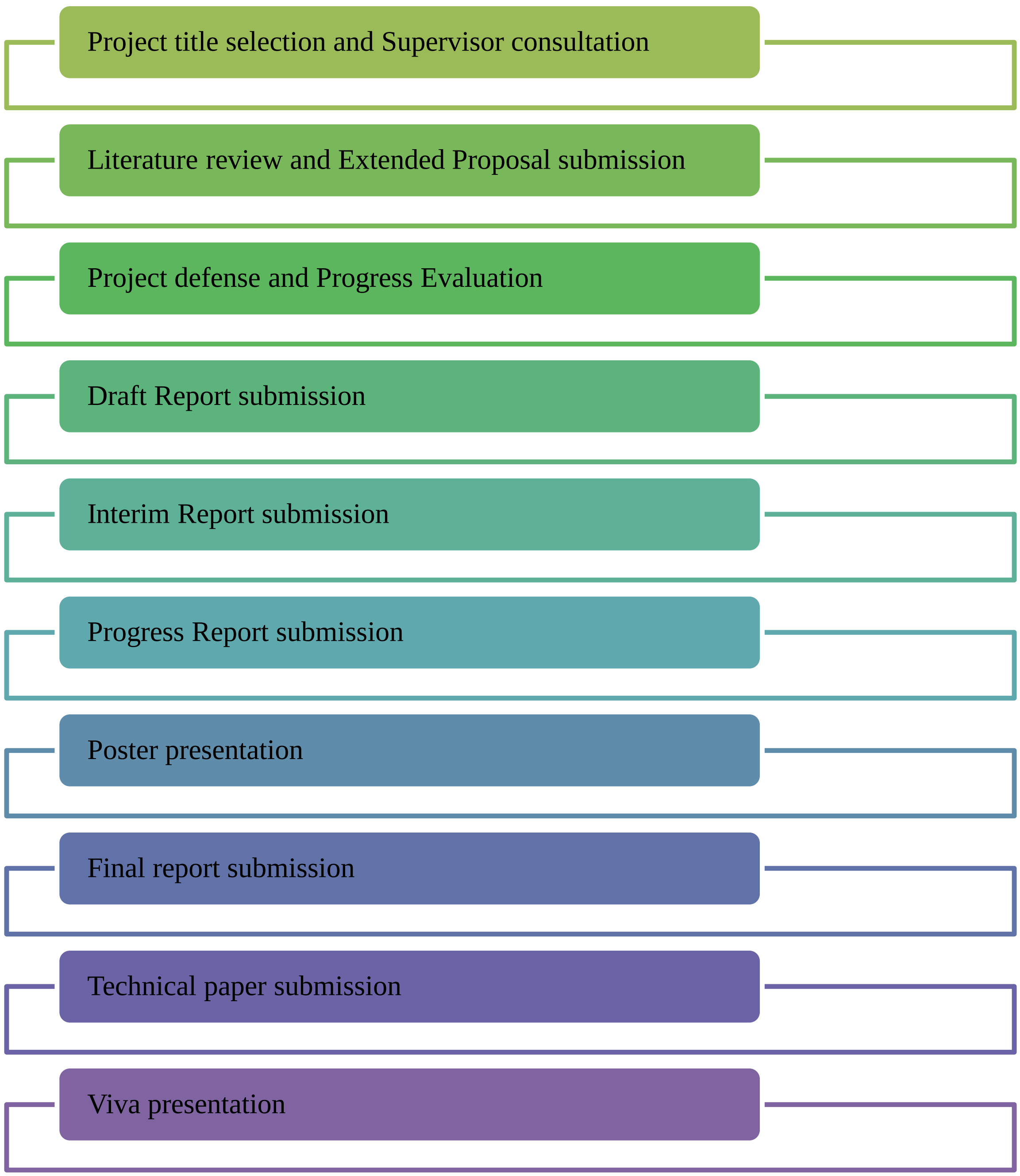


Figure 3.14: Viewing results

3.7 Project Key Milestones for Final Year Project 2



Flowchart 3.1: Final year project flowchart

3.8 Project Timeline (Gantt Chart) for FYP 1 and FYP 2

		SEMESTER 1 (FYP 1)														SEMESTER 2 (FYP 2)															
No	Subject	1	2	3	4	5	6	7	8	9	10	11	12	13	14	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	FYP Topic selection																														
2	Project Introduction																														
3	Extended Proposal																														
4	Extended Proposal Submission																														
5	Proposal Defense Preparation																														
6	Site Visit																														
7	Proposal Defense Evaluation																														
8	Collection of Data																														
10	Hands-on use with HEC-HMS																														
11	Submission of Interim Draft Report																														
12	Submission of Interim Report																														
13	Hands-on use with HEC-HMS																														
14	Data Collection																														
15	Digitization of Satellite Images and Hydrologic Modeling																														
16	Progress Report Preparation																														
17	Progress Report Submission																														
18	Pre-SEDEX																														
19	Preparation of Final Report																														
20	Submission of Draft Final Report																														
21	Submission of Dissertation (Soft Bound)																														
22	Submission the Technical Report																														
23	Viva																														
24	Submission of Dissertation (Hard Bound)																														

Table 3.2: Project Timeline for FYP 1 and FYP 2

CHAPTER 4

RESULT AND DISCUSSION

4.1 Simulation with HEC-HMS

The unusual rain and slow process of water being absorbed into the ground caused the floods in Kerian district. In this study, the HEC-HMS model is calibrated using a 6 years period data from 2005 to 2010. The calibration process was carried out using different sets of hydrologic data.

Hydrologic models are simplified, conceptual representations of a part of the hydrologic cycle. Some parameters such as curve number, imperviousness, lag time and initial discharge are determined through calibration process. The model parameter values and the event selected during calibration. The calibration was started on 01 January 07 January for each year. The simulated hydrographs comparisons from 2005 to 2010 shows whether there are a good agreement between them. Refer **Appendix E** for simulated hydrographs information.

4.2 Peak discharge at Sub-basin

The designated graph below shows the relationship between the peak discharge (m^3/s) and the peak of time for each of sub-basin which was plotted using the Microsoft Excel sheet. The x-axis denotes for the peak of time meanwhile the y-axis represented the peak discharge value. In Table 4.1 shows the peak discharge parameter and time of peak for sub-basin 1 until 5 for 2005 to 2010. The parameters were obtained from the simulation of HEC-HMS Software.

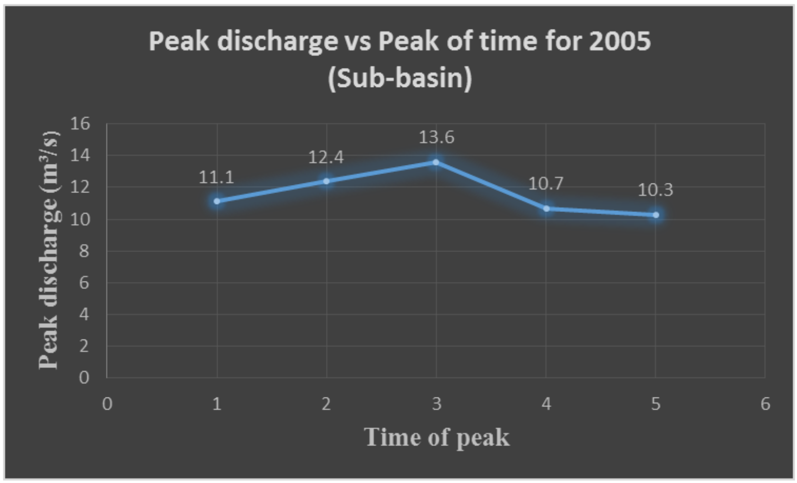
	Peak Discharge (m^3/s)				
Year	Sub-Basin 1	Sub-Basin 2	Sub-Basin 3	Sub-Basin 4	Sub-Basin 5
2005	11.1	12.4	13.6	10.7	10.3
Time of peak	01 Jan 2005, 00:00	01 Jan 2005, 00:00	01 Jan 2005, 00:00	01 Jan 2005, 00:00	01 Jan 2005, 00:00
2006	11.1	12.4	34.8	29.3	44.9
Time of peak	01 Jan 2006, 00:00	01 Jan 2006, 00:00	05 Jan 2006, 05:00	05 Jan 2006, 05:00	05 Jan 2006, 09:00
2007	11.1	46.8	31.8	27	35.8
Time of peak	07 Jan 2007, 00:00	07 Jan 2007, 00:00	07 Jan 2007, 00:00	06 Jan 2007, 00:00	06 Jan 2007, 00:00
2008	27.7	94.1	40.3	30.8	22.6
Time of peak	07 Jan 2008, 00:00	07 Jan 2008, 00:00	07 Jan 2008, 00:00	07 Jan 2008, 00:00	07 Jan 2008, 00:00
2009	11.1	16.2	33.2	28.9	24
Time of peak	07 Jan 2009, 00:00	07 Jan 2009, 00:00	07 Jan 2009, 00:00	07 Jan 2009, 00:00	02 Jan 2009, 10:00
2010	11.2	19.4	15.5	15.2	11.6
Time of peak	05 Jan 2010, 01:00	06 Jan 2010, 03:00	05 Jan 2010, 06:00	06 Jan 2010, 03:00	05 Jan 2010, 02:00

Table 4.1: Peak discharge parameter for Sub-basins 1 to 5 from 2005 until 2010

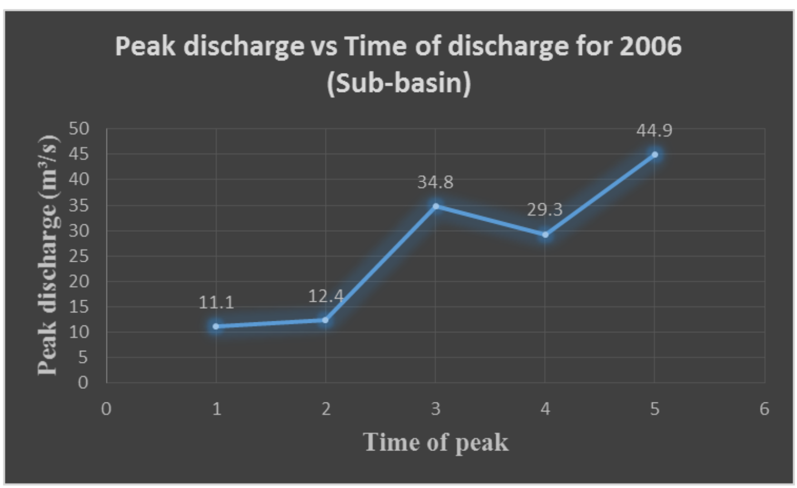
The detail of analysis on the Graphs 4.1 until 4.6 found that the discharge value obtained from simulation process. In simulation process, there are 5 sub-basins were used for each of sub-catchment. So, the value show in the graphs is the accumulated discharge for each of sub-basin. The discharge flowed from sub-basin 1 until sub-basin 5 and sub-basin 5 is the last sub-basin to collect the discharge from the upstream before it is discharge to the last junction which is junction 5.

In 2005, the accumulated discharge at sub-basin 1 is 11.1 m^3/s and increase sharply to sub-basin 3. The accumulated discharge at sub-basin 3 is 13.6m^3/s then drop at sub-basin 4 with 10.7 m^3/s and sub-basin 5 at 10.3 m^3/s. Refer to peak discharge in 2006, the accumulated discharge gradually increase from sub-basin 1 until sub-basin 5 with 11.1 m^3/s to 44.9 m^3/s. In 2007, the discharge rose sharply from sub-basin 1 to sub-basin 2 with 11.1 m^3/s to 46.8 m^3/s and then sudden decrease to 27 m^3/s at sub-basin 4. At sub-basin 5, the discharge increase to 35.8 m^3/s. Same goes to 2008, the accumulated discharge at sub-basin 2 increasing grammatically from sub-basin 1 with the parameter 27.7 m^3/s to 94.1 m^3/s and then decrease gradually from 40.3 m^3/s at sub-basin 3 to 22.6 m^3/s at sub-basin 5.

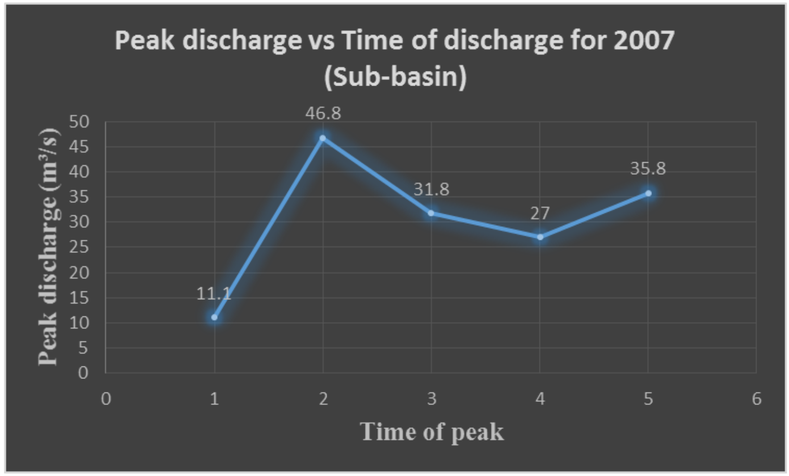
For 2009, the discharge was accumulated at sub-basin 1 is 11.1 m³/s then increase to 33.2 m³/s at sub-basin 3 then drop to 24 m³/s at sub-basin 5. Last year for this calibration is 2010, the peak discharge for this year is at sub-basin 2 with 19.4 m³/s then decreasing gradually to 11.6 m³/s at sub-basin 5. Sub-basin 5 is the last accumulated discharge sub-basin before the water discharge to the junction 5 then to the sea.



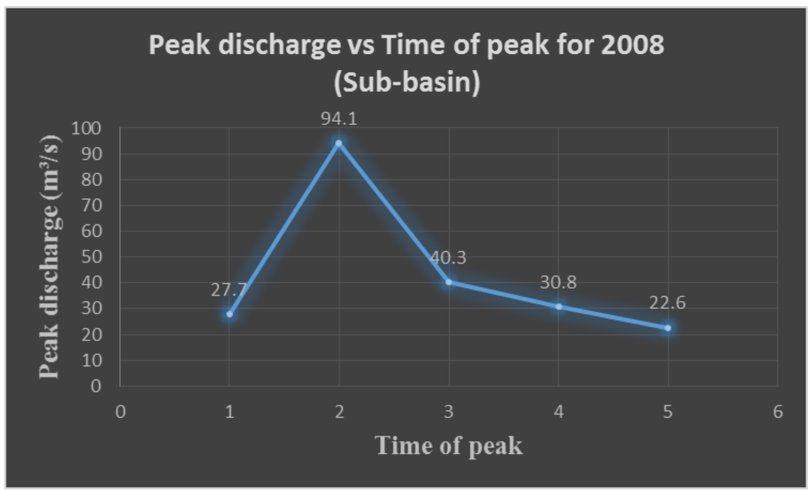
Graph 4.1: Peak discharge at Sub-basin for 2005



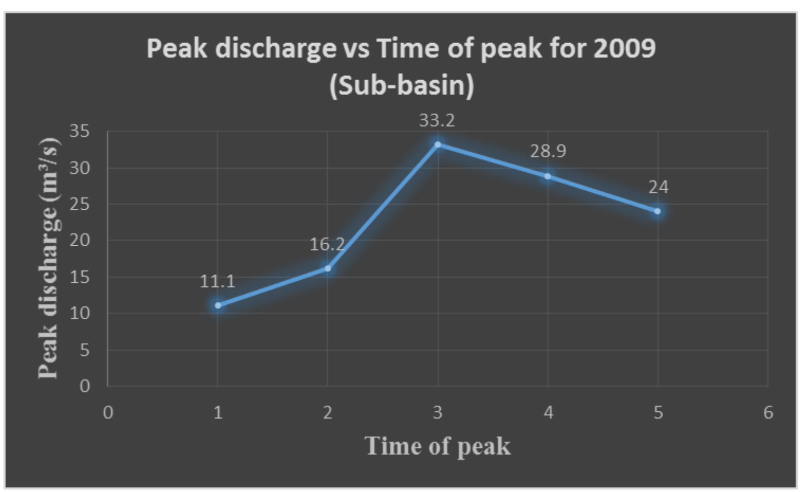
Graph 4.2: Peak discharge at Sub-basin for 2006



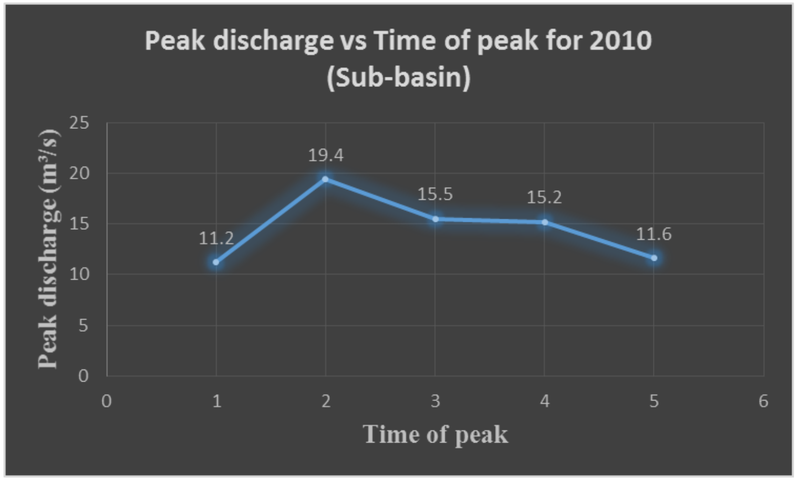
Graph 4.3: Peak discharge at Sub-basin for 2007



Graph 4.4: Peak discharge at Sub-basin for 2008



Graph 4.5: Peak discharge at Sub-basin for 2009



Graph 4.6: Peak discharge at Sub-basin for 2010

4.3 Peak discharge at Junction

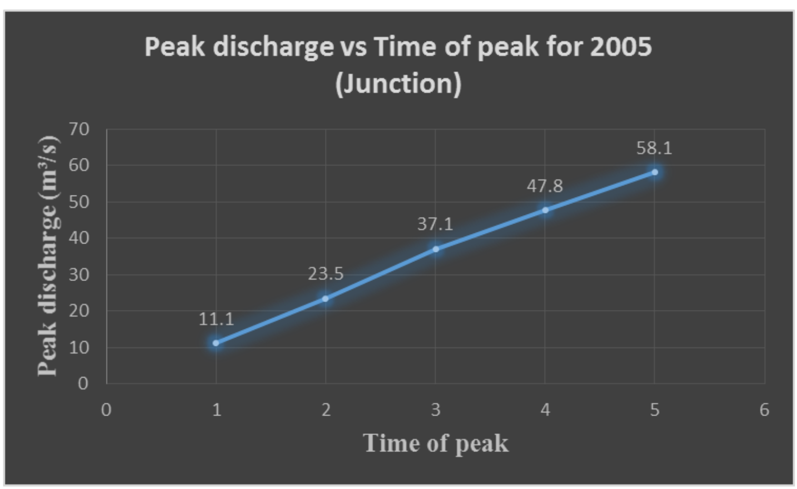
As shown in graph below the relationship between the peak discharge (m^3/s) and the peak of time for each of junction from 2005 to 2010 which was plotted using the Microsoft Excel sheet. The x-axis denotes for the peak of time meanwhile the y-axis represented the peak discharge value. The graph is generated in order to show the fluctuation of discharge from junction 1 until junction 5 before the river water is discharge to the sea. So from the graph, the amount of water flow to the sea be able to predict. In Table 4.2 shows the peak discharge parameter and time of peak for junction 1 until 5 for 2005 to 2010. The parameters were obtained from the simulation of HEC-HMS Software.

	Peak Discharge (m^2/s)				
Year	Junction 1	Junction 2	Junction 3	Junction 4	Junction 5
2005	11.1	23.5	37.1	47.8	58.1
Time of peak	01 Jan 2005, 00:00	01 Jan 2005, 00:00	01 Jan 2005, 00:00	01 Jan 2005, 00:00	01 Jan 2005, 00:00
2006	11.1	23.5	58.4	87.7	130.7
Time of peak	01 Jan 2006, 00:00	07 Jan 2006, 00:00	05 Jan 2006, 05:00	05 Jan 2006, 05:00	05 Jan 2006, 06:00
2007	11.1	58	89.1	111.5	140.4
Time of peak	07 Jan 2007, 00:00	07 Jan 2007, 00:00	06 Jan 2007, 23:00	06 Jan 2007, 23:00	06 Jan 2007, 13:00
2008	27.7	121.7	162	191	213
Time of peak	07 Jan 2008, 00:00	07 Jan 2008, 00:00	07 Jan 2008, 00:00	06 Jan 2008, 23:00	06 Jan 2008, 23:00
2009	11.1	27.3	60.5	89.4	113.1
Time of peak	07 Jan 2009, 00:00	07 Jan 2009, 00:00	07 Jan 2009, 00:00	07 Jan 2009, 00:00	07 Jan 2009, 00:00
2010	11.2	30.5	45.1	60.3	71.1
Time of Peak	5 Jan 2010, 01:00	6 Jan 2010, 03:00	06 Jan 2010, 02:00	06 Jan 2010, 02:00	06 Jan 2010, 02:00

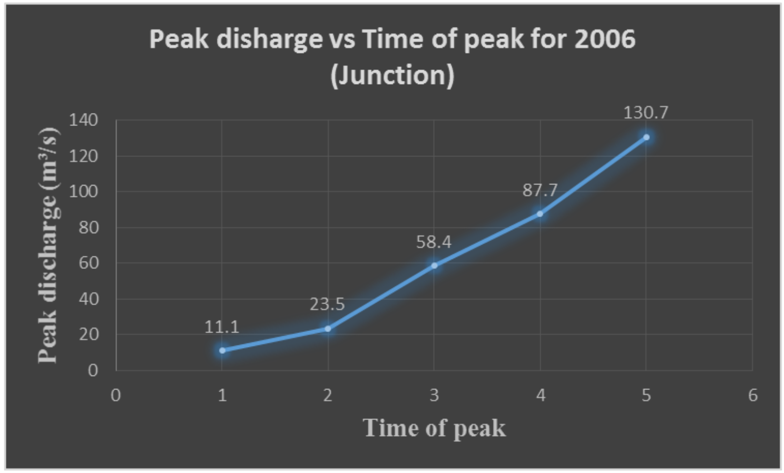
Table 4.2: Peak discharge parameter for Junctions 1 to 5 from 2005 until 2010

The parameter of discharge can be obtained by referring the Table 4.2, otherwise refer to peak discharge vs time of peak discharge graph. In 2005, the discharge is increasing sharply from junction 1 to junction 5 with the value is 11.1 m^3/s and 58.1 m^3/s. By referring in 2006, the discharge at junction is 11.1 m^3/s then increasing gradually to 130.7 m^3/s at junction 5. In 2007, at junction 1 the discharge accumulated is 11.1 m^3/s then goes to 58 m^3/s. The discharge is increasing bit a bit until it reach to junction 5 with accumulated discharge is 140.4 m^3/s. In addition, in 2008 the discharge from sub-basin 1 was flow to junction 1 then the accumulated discharge is 27.7 m^3/s the flow to junction 2 with 121.7 m^3/s. The discharge is increasing bit a bit until junction 5 with the value reached to 213 m^3/s.

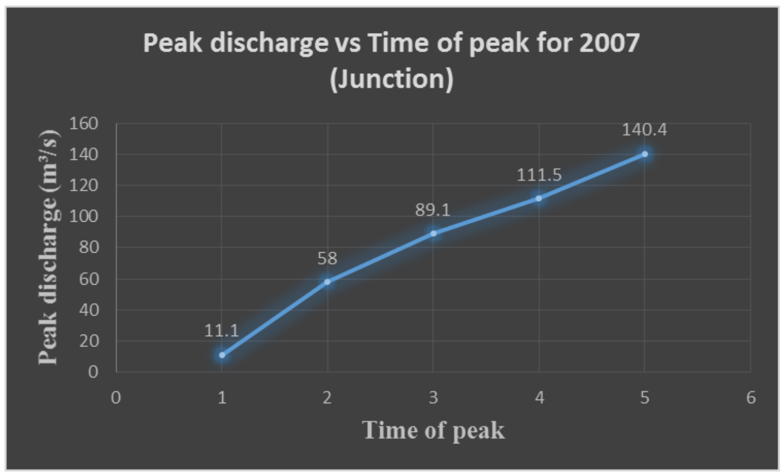
Meanwhile, in 2009, the junction able to collected the discharge at 11.2 m^3/s at junction 1 and then it was increasing grammatically at 113.1 m^3/s at junction 5. The last year is in 2010 where the sub-basin succeed to collected the discharge at 11.2 m^3/s at junction 1 then increase to junction 2 with 30.5 m^3/s, at junction 3 is 45.1 m^3/s, junction 4 is 60.3 m^3/s and then the last junction, junction 5 able to collected at 71.1 $m^3/3$. The discharge parameter is important to record in order to analyze the fluctuation of discharge from junction 1 to junction 5 for each year before it is discharge to the sea.



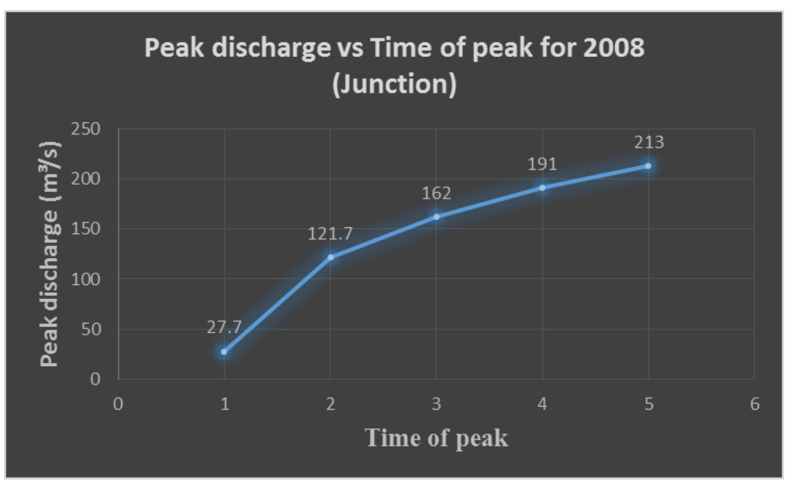
Graph 4.7: Peak discharge at Junction for 2005



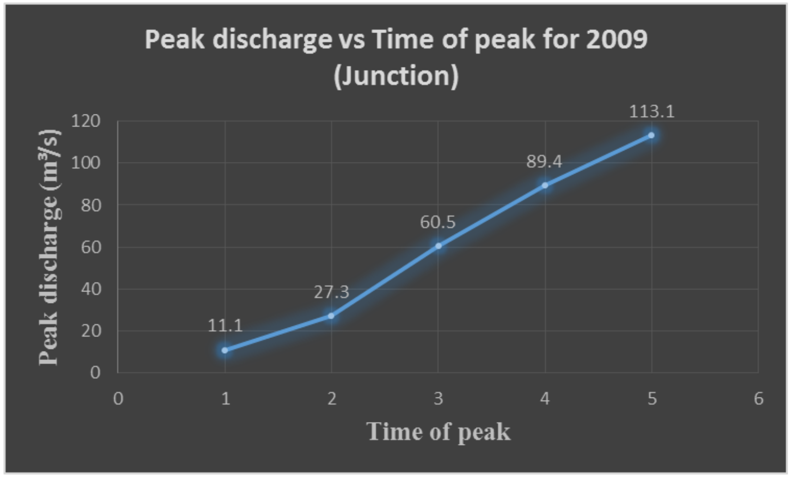
Graph 4.8: Peak discharge at Junction for 2006



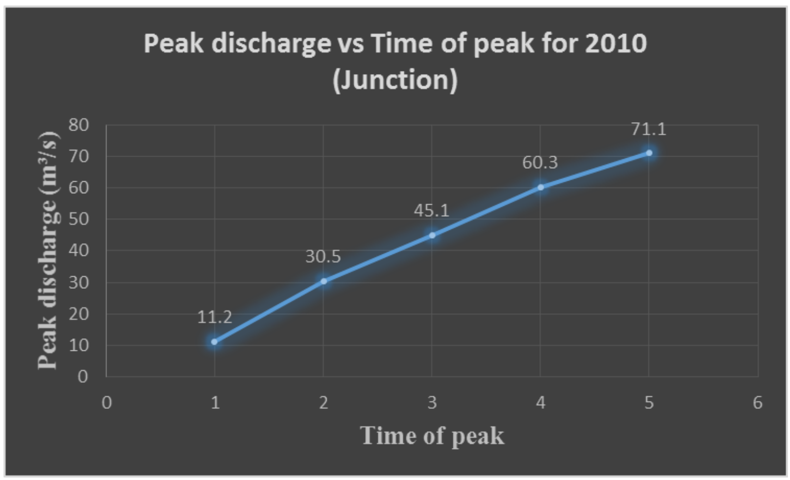
Graph 4.9: Peak discharge at Junction for 2007



Graph 4.10: Peak discharge at Junction for 2008



Graph 4.11: Peak discharge at Junction for 2009



Graph 4.12: Peak discharge at Junction for 2010

4.4 Discussion

The modelling was carried out in order to simulate the hydrologic parameters for Sungai Kurau, Perak. The generated hydrograph is compared from 2005 to 2010. The hydrologic modelling was run using weekly interval event rainfall of 01 January to 07 January for each year. The rainfall stations used for this modelling are stations (4904026) Ladang Gula, (4905023) Ladang Gedong, (5005003) Jalan Matang Buloh, (5006021) Kolam Air Bukit Merah.

According to the observation, in 2005 the maximum peak discharge is 13.6 m^3/s at sub-basin 3 and peak discharge at junction 5 is 58.1 m^3/s. The calibration process in 2006 shows the maximum peak discharge at sub-basin 4 is 44.9 m^3/s and peak discharge for junction 5 is 130.7 m^3/s, respectively. The event on 2007 was recorded that the maximum peak discharge at sub-basin 2 is higher than other sub-basin with accumulated amount of 46.8 m^3/s. Meanwhile the peak discharge at junction 5 is 140.4 m^3/s. In 2008, the sub-basin 2 yield the maximum peak discharge at 94.1 m^3/s and 213.0 m^3/s at junction 5. The simulation process for 2009, the maximum peak discharge at sub-basin is 33.2 m^3/s with 113.1 m^3/s at junction 5. Lastly for 2010, the maximum peak discharge at sub-basin is 19.4 m^3/s while the junction 5 yield the peak discharge at 71.1 m^3/s before the river water is discharged to the sea.

Year	**HEC-HMS Peak discharge (m^3/s) at sub-basin**	**Difference Peak discharge at sub-basin (m^3/s)**	**Peak discharge (m^3/s) at Junction 5**	**Difference Peak discharge (m^3/s) at Junction 5**
2005	13.6	0	58.1	0
2006	44.9	31.3	130.7	72.6
2007	46.8	1.9	140.4	9.7
2008	94.1	47.3	213.0	72.6
2009	33.2	-60.9	113.1	-99.9
2010	19.4	-13.8	71.1	-42

Table 4.3: Comparison of peak discharge based on HEC-HMS results for 2005 until 2010

According to Table 4.3, the comparison peak discharge at sub-basin and junction 5 were computed. The maximum peak discharge occurred in 2008 with 94.1 m^3/s and at junction 5 is 213.0 m^3/s. The lowest peak discharge for sub-basin is 13.6 m^3/s and at junction 5 is 58.1 m^3/s in 2005. The amount of peak discharge at sub-basin increasing sharply with the differences amount of 80.5 m^3/s and at junction 5 is 154.9 m^3/s in 2005 and 2008. The analysis was made after year 2008, the amount of peak discharge at sub-basin is decreasing grammatically from 94.1 m^3/s to 33.2 m^3/s and 19.4 m^3/s for 2008, 2009 and 2010. Meanwhile, the peak discharge at junction 5 for 2008, 2009 and 2010 are 213.0 m^3/s to 113.1 m^3/s then drop to 71.1 m^3/s before it is discharged to the sea.

Based on the analysis conducted, the computation of peak discharge differences was created as shown in table above in order to shown the differences amount of peak discharge from 2008 to 2010 for each sub-basins and junctions 5. Overall, the maximum peak discharge occurs in 2008 with the accumulated peak discharge is 94.1 m^3/s at sub-basin system and 213.0 m^3/s at junction 5.

The peak discharge is that flow which occurs when the maximum flood stage or depth is reached in a stream or water control structures. The peak discharge always occur after the period of maximum rainfall intensity and when most of the watershed is contributing runoff and combination of rain especially during heavy rainfall. Based on the observation made on the hydrologic graphs obtained (refer Appendix E), the fluctuations of peak discharge for Sungai Kurau may affected by complex interaction of many meteorological and watershed factors. An increase in the total amount of storm rainfall that occurs on a watershed within a specific time period should directly increase the peak discharge in the study area. Besides that, the duration of rainfall also one of the factor that affect the peak discharge. For a given amount of total storm rainfall, the shorter the time period it occurs, the greater the peak discharge should will be. Meanwhile, if the same amount of rainfall occurs in a longer period, the peak discharge should decrease. The fluctuation of peak discharge at sub-basin system and junction 5 for Sungai Kurau may also affects from the distribution of rainfall with time whereby the rainfall pattern within a given time period can have almost unlimited variations. The more constant rate rainfall should result in a lower peak discharge than the same amount of rainfall occurring over the same time period but starting at a low rate then increasing rapidly to a maximum rate before tapering off to another sub-basin and junction.

Further research have to be conducted in order to identify the main causes that lead to peak discharge and flood in Kerian district. The size of sub-basin or river in Kerian district should be measured because the smaller the sub-basin or river, the more significant individual watershed characteristics become in influencing peak discharges. So, there are a few factors need to be discussed regarding the watershed characteristics and there are the watershed size. The larger the watershed, given similar characteristics, so the larger the peak discharge occurs.

Second is the watershed or river shape. The more compact a watershed, the larger the peak discharge would normally be. This is related to the relative length of the major flow path and the size, duration and intensity of the rainfall. It takes a shorter time for the entire compact watershed to contribute runoff to the peak rate thus causing the higher discharge. According to the planning draft report in Kerian district, the authority planning for the new development in that area and the land use may change from time to time until the objectives achieved. So the type of cover, vegetation or impervious surfaces in Kerian district or nearby location at Sungai Kurau directly affects the amount of runoff and cause the peak discharge. So, the less vegetation cover, the higher impervious the surface in that area, the higher the peak discharge may occurs. Other than that, decreased density of vegetation will normally increase runoff by lowering the interception and infiltration potential in Sungai Kurau. In addition, the greater the surface storage, the smaller the peak discharge will be because the water able to trapped in surface depressions where it can be infiltrate over a period of time. The last factors should be take an account is the soil moisture content. The investigation at Sungai Kurau have to be conducted in order to identify the soil condition there. The soil moisture content is the prior factor that affect the peak discharge. The amount and distribution of prior rainfall and the infiltration potential contribute to the soil moisture content. The wetter the antecent runoff condition, the larger the amount of storm runoff and the larger the peak discharge.

Land use and other human activities also influence the peak discharge of floods by modifying how rainfall are stored on and runoff flows slowly through soil as subsurface flow. Based on the results obtained, the analysis of hydrographs can help hydrologists to predict the likelihood of flooding in a drainage basin.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

The current situation of flood occurrence at the study area presents quite different challenges based on the resident's outcry, in which some of the resident's houses were flooded and properties were intensively damaged. The comprehensive study on HEC-HMS Software is crucial task in order to accomplish the project objectives. Even so, the hydrologic data have been extracted in order to use as a parameters in the Hydrologic modelling. The comprehensive study has been conducted through an extensive literature review to aid the researcher in conducted the rainfall-runoff simulation. Flood duration can be significant for large floods in low and endyked area. So the flood duration can also have a significant impact on the damage especially during the heavy rainfall.

Hydrologic modelling has been widely used for various purposes. Most of the areas in Kerian District is low-lying areas, so the hydrologic modelling in the study area important to analyzed. This analysis presents a methodology and development of Hydrologic modelling that may help in future flood mitigation plan. Moreover, the vulnerable regarding the importance of flood study should be taken as a serious issue where it is related to human life, future impact in terms of economy, environment and human health. Because of this issues, research on floods study was come out so that there will be further research will be conducting in terms of how to mitigate the flood peak risk especially during the monsoon season.

5.2 Recommendation

The hydrologic of Sungai Kurau was conducted and further research have to be continue in order to identifying the cause of peak flood risk in the Kerian district. After the hydrologic modelling, the hydraulic modelling can be done by using HEC-RAS Software. So as a recommendation for this project, the flood mitigation plan for Sungai Kurau need to be conducted. The flood mitigation involves the managing and control of flood water movement in Sungai Kurau. So, the prevention and mitigation of flooding can be studied on a number of levels, individual properties, communities and whole towns in Kerian district. It is good if flood mitigation plan is able to conduct in Sungai Kurau whereby it is most effective way taken to reducing the risk to people and property through the production of flood mitigation plan.

In addition, study of land use changes and analyze of Sungai Kurau which located in Kerian district is a good way to identify the cause that lead to peak flood in that area. It might be because of rainfall or land use changes. According to Draf Perancangan Tempatan Daerah Kerian 2020 was reported in the Kerian District will be developed to urbanization areas. This shows, the progressive increase in landuse changes in that Kerian district may a dire impact to the hydrologic behavior of the Sungai Kurau, Perak. The impact will be serious within a river if the changes took place and no further research in the Kerian. If the detected changes, together with other spatial datasets were subsequently used to estimate the physically based catchment and hydrologic model parameters for runoff generation and transformation, and for channel flow routing in Sungai Kurau.

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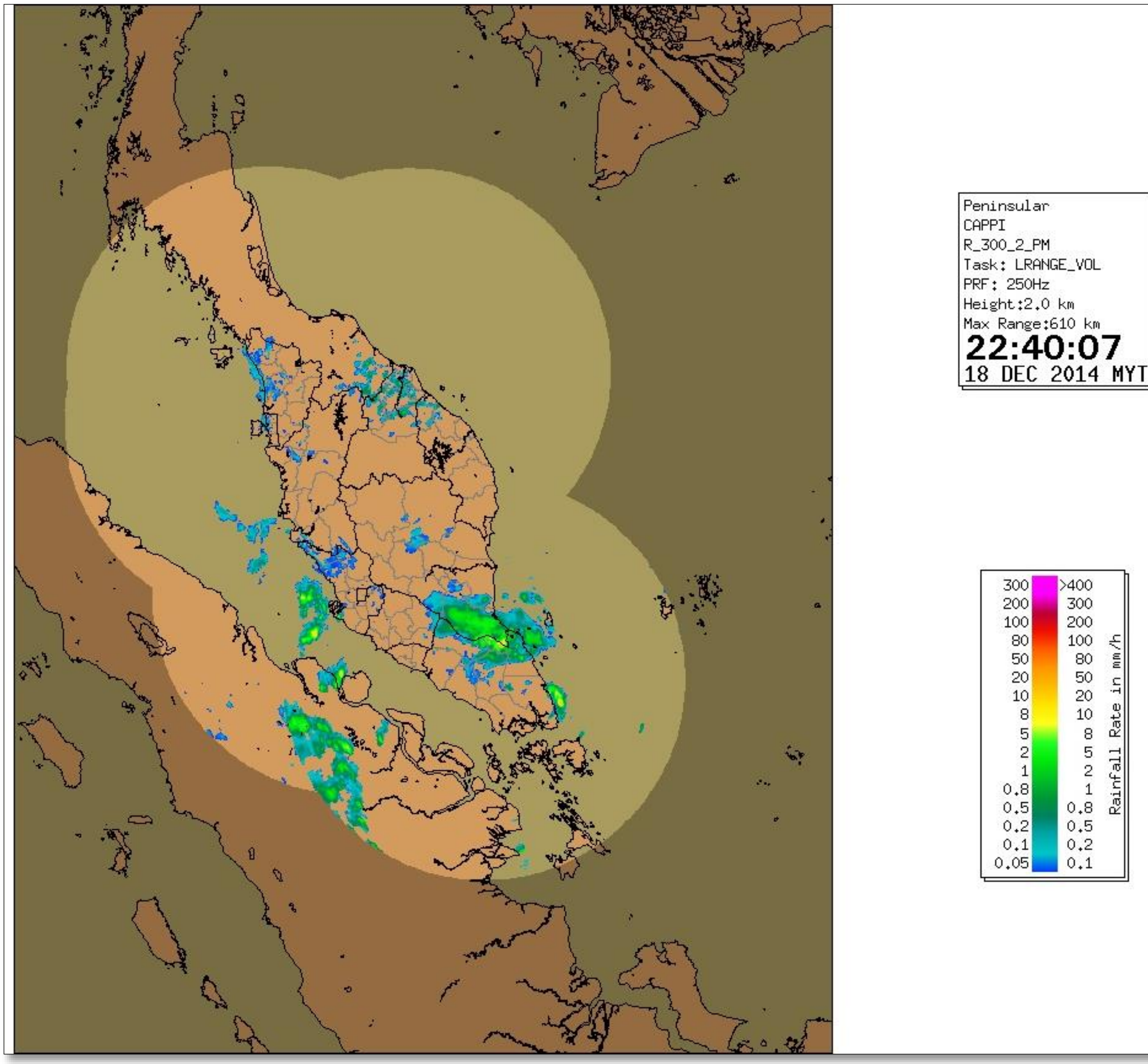
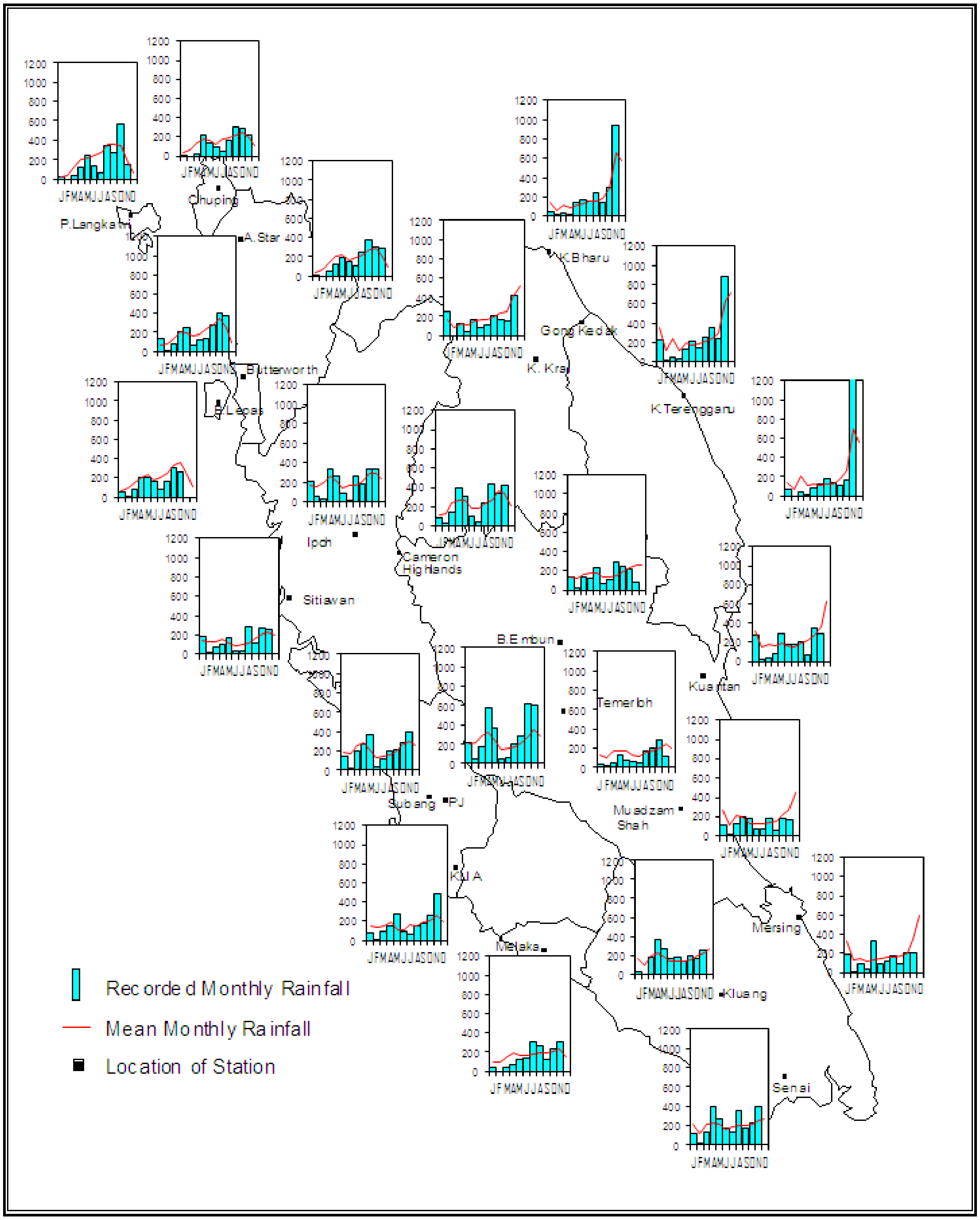
APPENDICES



Appendix A: Radar image of rainfall rate in Peninsular, Malaysia.



Appendix B: Monthly rainfall.

Rainfall station at Ladang Gula for 2005

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	0	0	0	0	0	0	0	0	0	58.5	1	8
2	0	0	0	5	0	0	0	8	0	0	13.5	0
3	0	0	0	13	0	0	0	0	0	0	28	0
4	0	0	23.5	4	5.5	0	0	0	0	20.5	0	0
5	0	0	0	38	0	0	0	0	0	0	0	0
6	0	0	0	0	19	0	0	0	0	0	0	6
7	0	0	0	16	0	0	0	0	0	11	11.5	9
8	12	0	0	0	0	0	0	0	0	0	0	0
9	0	10	0	8	0	0	39	0	0	0	18.5	0
10	13	0	0	0	0	0	3	4	0	0	0	0
11	0	0	0	0	0	0	0	2.5	0	15.5	0	41
12	0	0	8.5	0	43	0	0	0	3	8.5	14	4
13	0	11	0	0	5	39.5	15	0	0	0	0	0
14	26	6.5	0	17.5	24	25	22	0	0	0	0	0
15	1	20	0	9	0	0	0	3	0	0	0	0
16	0	0	47	0	0	16.5	8	0	2	0	6	185
17	0	0	0	0	13	0	18	0	93	8.5	36	0
18	0	0	12	3	0	0	0	0	0	0	45	0
19	0	0	0	30.5	0	2.5	0	0	0	48	6.5	0
20	0	0	0	0	0	0	0	7	0	0	40	0
21	0	0	0	0	0	0	16.5	3.5	0	0	23.5	0
22	7	0	0	0	0	0	0	0	0	0	0	0
23	0	0	0	0	9.5	0	0	29	0	35.5	35	0
24	0	0	0	0	0	0	0	7.5	22.5	0	0	0
25	0	20	4	0	0	0	0	9	0	5	0	0
26	0	0	20	0	0	0	0	19.5	0	6	0	0
27	0	0	0	0	0	0	0	0	4	0	23.5	0
28	0	0	8	0	0	0	0	0	9.5	0	7	0
29	0	78.5	0	0	0	0	0	5	29	93	0	
30	0	0	3.5	4.5	0	0	0	0	58	39	0	
31	0	0	0	0	0	2	3.5					

Appendix C-a: Precipitation data for 2005

Rainfall station at Ladang Gula for 2006

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	8.5	0	0	0	8	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	30	0
3	0	0	0	0	0	0	0	0	3.5	0	0	0
4	8	0	0	16	0	0	0	0	0	6.5	4.5	0
5	43	0	0	0	11	0	8.5	7.5	50	0	0	3
6	0	0	0	0	0	0	0	27.5	111	0	0	0
7	0	0	2.5	0	0	0	0	0	13	0	0	50
8	0	0	0	0	0	22.5	0	2.5	34	0	0	0
9	0	0	0	0	0	0	10	0	4.5	0	70	9
10	5.5	0	0	0	0	0	0	0	0	5	95	83
11	0	10	0	11	7	0	0	0	0	0	0	0
12	21	1	0	4.5	0	0	0	0	0	62	30	7
13	0	0	0	33	5	5	0	0	2	0	48	0
14	0	0	0	80	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	26	0	10	8	12
16	0	7	0	0	59	11.5	0	0	0	0	0	4
17	0	0	0	0	0	19.5	0	0	0	4	10.5	4
18	0	13.5	0	26	0	16.5	5.5	0	0	0	4	0
19	0	0	0	4.5	0	0	0	0	0	69	2	4.5
20	0	0	35	9.5	0	0	0	0	11	15.5	2	12.5
21	0	4	17	0	0	0	0	0	1	13	0	0
22	3.5	8	166	0	0	0	0	0	0	0	19	0
23	0	3	0	0	0	68	0	0	5.5	138	128	0
24	0	32.5	58	0	0	0	0	0	4	4.5	0	0
25	0	0	14	4	1.5	0	0	21	49	6	9	0
26	0	0	0	0	0	0	3	0	2	0	0	0
27	0	0	0	0	0	0	0	0	0	0	0	0
28	0	0	0	0	9.5	0	0	2.5	0	0	0	4
29	0	0	0	0	0	0	0	4	8	72	0	
30	0	0	0	0	0	0	90	16.5	10.5	19	0	
31	4	0	0	0	0	0	0					

Appendix C-b: Precipitation data for 2006

Rainfall station at Ladang Gula for 2007

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	0	0	50	0	0	0	0	0	32	0	0	0
2	3	0	19	0	0	64	0	0	3.5	0	13	0
3	0	7.5	0	0	0	3	0	0	0	0	0	0
4	0	0	0	0	0	77	0	0	0	0	0	0
5	0	0	0	0	0	8	11	0	0	0	0	14
6	37	0	0	0	0	0	0	0	17	3	0	0
7	0	0	0	5	29	0	0	0	0	103	0	0
8	0	0	0	0	35	0	0	0	11	0	0	41
9	7	0	0	0	13	2.5	0	0	0	35	0	3
10	9	0	3	50	0	0	0	0	51	23	0	0
11	1	0	0	93	0	0	0	0	0	1	0	0
12	0	4	49	0	0	55.5	0	0	2	1	0	13.5
13	6	21	14	0	39	11.5	0	0	25.5	69	10	0
14	0	0	0	0	3	4	0	0	38	11	0	17.5
15	0	0	18	6	0	5.5	0	28	21	0	0	0
16	0	57.5	0	0	18.5	0	73	3	0	0	0	0
17	0	0	0	0	0	5	3	9	0	30	0	9
18	3	0	29	9	0	2	4	0	0	18	0	3
19	71	0	0	0	0	0	31	0	0	25	0	34
20	5.5	5	21	0	0	0	173	0	0	0	14	0
21	0	6	0	11	0	0	32	0	0	15	2	3
22	0	0	1	12	0	3.5	14	3	0	0	0	0
23	0	0	0	0	0	26	0	0	3	63	0	0
24	0	3	0	0	0	24	0	17	1	1	0	0
25	0	0	0	12	0	0	21	0	0	0	0	15
26	23.5	0	0	0	7	0	0	0	0	0	0	0
27	0	31	1	3	4	0	0	14	0	0	0	0
28	0	0	4	9	0	0	4	45	0	9	0	0
29	0	4	0	0	0	0	0	0	32	5	0	
30	0	15	0	0	0	0	0	20	0	0	0	
31	0	0	76	4	5	14	0					

Appendix C-c: Precipitation data for 2007

Rainfall station at Ladang Gula for 2008

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	3	3	16	16	0	7	0	0	2	0	0	0
2	0	0	9	0	0	0	24	6	6	0	0	0
3	0	0	29	17	0	0	0	0	3.5	20	0	0
4	0	0	0	0	0	0	0	0	0	30	5	10
5	0	0	6	0	0	0	0	0	45	13	19	5
6	8	18	0	0	0	0	14	0	3	0	13	0
7	23	26	44	0	0	83	0	0	25	10	0	17
8	0	0	6	0	0	0	0	0	2	61	2	0
9	0	0	32	0	0	0	11	0	7	4	11	0
10	0	0	58	0	0	14	0	0	0	0	0	0
11	0	0	72.5	26	0	0	0	0	0	6	0	52
12	0	0	1	0	0	0	0	0	0	2	0	0
13	0	0	6	0	0	0	24.5	0	0	30	16	14
14	0	0	8	4	0	0	0	0	0	92	0	23
15	0	0	6	3	0	0	0	0	0	0	0	19
16	0	0	0	0	0	0	40.5	0	0	40	13	0
17	0	0	0	3	0	0	0	66	0	0	0	0
18	0	4	0	0	0	0	0	0	0	2	10	28
19	0	0	0	0	0	0	116	0	0	77	0	0
20	0	0	2	21	0	0	0	15	37	10	4	0
21	0	0	5	0	0	0	0	20	0	53	0	0
22	0	0	15	126	0	0	8	0	0	7	0	0
23	0	0	47	0	0	94	2	12	0	29	5	0
24	7	4	4.5	33	0	0	0	0	0	0	51	0
25	0	0	4	0	0	0	0	0	0	0	2	0
26	36	36	39	0	0	0	0	50	0	0	0	0
27	0	0	0	0	0	0	0	0	0	38	0	28
28	0	0	0	9	5	0	0	0	45	0	0	9
29	0	0	0	0	0	1	0	0	10	0	0	0
30	0	0	0	0	0	0	0	0	0	0	14	
31	0	39	0	0	21	0	17					

Appendix C-d: Precipitation data for 2008

Rainfall station at Ladang Gula for 2009

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	15	17	5	108	88	11	0	0	0	8	6	4
2	25	28	0	18	34	0	0	0	0	16	0	0
3	0	0	0	7	20	0	0	0	0	0	42	24.5
4	0	0	0	5	0	0	0	20.5	0	0	4	0
5	0	0	8	0	0	0	13	0	0	117	0	9.5
6	0	1	0	5	0	0	20	0	0	0	0	2
7	20	22	0	12	0	0	0	0	0	0	5	5
8	0	0	97	55	0	0	0	0	0	0	22	0
9	0	0	0	0	12	0	6	34	0	0	19	6
10	0	0	0	15	0	0	82	0	13	0	50	0
11	0	0	5	0	0	0	0	0	0	23	6	0
12	0	0	19	0	58	0	0	0	0	0	10	0
13	0	0	6	0	16	3	11	2.5	0	0	63	2
14	0	0	27	0	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0	0	0	1
16	0	0	7	0	0	0	0	27.5	59	16	6	10
17	0	0	0	0	0	0	0	53.5	42	0	0	47
18	0	0	0	41	0	0	0	0	6	0	0	0
19	0	0	27	110	0	0	0	0	0	0	24	0
20	0	0	0	0	0	0	0	18	40	0	13	0
21	0	0	0	0	0	6	0	0	0	0	31	0
22	0	0	0	21	0	5	26	41	0	0	3	0
23	0	0	7.5	0	0	0	0	9	3	0	0	0
24	0	0	34	0	17	0	0	17	0	6	0	0
25	0	6	5	0	0	0	0	0	26	0	0	0
26	15.5	18	0	0	0	0	0	50	0	0	0	0
27	0	0	125	0	0	0	17	10	18	0	6	0
28	0	33	0	0	0	0	0	16	9	0	10	1
29	0	0	0	10	18	0	0	61	0	0	0	
30	0	0	0	0	0	0	10	0	0	16	0	
31	20	19	0	5.5	0	6	10					

Appendix C-e: Precipitation data for 2009

Rainfall station at Ladang Gula for 2010

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	6	0	0	5	0	0	3	0	0	40	0	8
2	1	0	0	17	0	0	0	0	8	0	0	12
3	0	0	0	4	0	140	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	16	0	0
5	3	1.5	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	1.5	0	0	0	3	25
7	0	2.5	0	0	11	0	0	0	0	0	8	0
8	0	3	0	0	0	0	0	0	0	0	24	14
9	0	0	0	0	21	0	0	0	0	0	0	0
10	0	0	24	19	0	0	0	0	0	0	57	47
11	17	13	5	0	0	0	0	8	0	0	0	25
12	0	0	0	0	0	6	0	18	0	0	0	6
13	0	0	0	0	0	0	0	0	0	0	14	0
14	0	0	0	0	0	5	0	13	17	0	2	0
15	0	0	0	0	3	6	0	6	0	0	43	0
16	0	5	0	0	1.5	0	0	88	73	0	34	45
17	0	0	0	0	48	0	0	0	0	0	5	0
18	0	0	0	0	0	0	0	0	0	0	0	0
19	0	0	0	0	0	0	0	0	4	0	6	10
20	0	0	18	0	10	87	113	48	0	0	0	0
21	0	0	0	6	0	0	0	0	19	0	31	0
22	11	0	0	26	0	0	23	0	0	0	13	24
23	0	1	0	0	0	0	0	0	0	0	0	0
24	2	0	0	68	0	40	31	0	0	0	0	0
25	0	0	0	0	0	0	4	0	19	0	0	0
26	0	0	7	24	15	0	7	0	120	5	0	0
27	0	0	5	0	0	0	0	0	0	0	35	4
28	0	7	0	0	0	0	0	0	2	0	37	3.5
29	0	4	27	0	0	0	0	0	0	5	0	
30	5	8	24	0	76	0	6	18	0	4	12	
31	0	5	0	9	0	45	0					

Appendix C-f: Precipitation data for 2010

Rainfall station at Ladang Gedong for 2005

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	0	29	0	10	0	0	0	0	0	0	0	9
2	0	0	6	0	0	0	0	0	0	0	0	3
3	0	0	0	42	0	0	0	0	31	55	0	0
4	0	4	0	16	0	0	0	0	16	0	0	0
5	0	0	0	3	45	0	0	0	0	0	0	5
6	0	0	0	30	0	0	0	0	0	19	71	0
7	0	0	0	0	0	0	0	0	0	20	0	11
8	0	0	0	0	0	0	0	0	0	0	0	4
9	28	0	0	0	0	0	0	0	0	11	0	0
10	0	0	0	86	0	0	65	0	0	0	9	0
11	0	0	0	0	0	0	35	0	0	0	0	0
12	0	0	0	0	0	0	9	0	0	39	0	18
13	0	0	0	0	72	0	0	0	0	26	0	38
14	19	0	0	3	30	0	10	0	0	16	0	0
15	0	0	0	0	38	0	16	0	0	13	11	0
16	23	62	0	0	0	0	0	0	0	0	0	0
17	0	10	95	0	0	0	5	0	30	0	36	0
18	0	0	0	0	0	0	25	0	0	0	23	145
19	0	0	0	4	0	0	0	0	0	15	0	0
20	0	0	0	75	0	0	0	0	8	65	25	0
21	0	0	0	0	0	0	0	28	0	0	35	0
22	0	0	29	0	0	0	0	5	0	0	18	0
23	0	0	0	0	0	0	0	28	0	0	10	0
24	0	0	0	0	23	0	0	18	0	14	0	0
25	0	0	7	0	0	0	0	0	0	0	26	0
26	0	29	0	0	0	0	0	0	0	11	0	0
27	0	8	0	24	0	0	0	0	31	22	21	0
28	0	0	0	0	0	0	0	0	0	5	0	0
29	0	21	0	0	0	0	0	24	0	18	0	
30	0	13	0	0	0	0	0	29	0	60	0	
31	0	5	0	0	0	0	0					

Appendix C-g: Precipitation data for 2005

Rainfall station at Ladang Gedong for 2006

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	0	0	0	0	80	0	0	0	70	0	0	0
2	0	0	0	0	28	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	35	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	40	0
6	0	0	0	0	0	0	0	0	30	20	0	0
7	0	0	0	0	0	0	0	12	0	0	15	25
8	0	0	0	0	0	8	0	21	25	0	10	0
9	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	49	0	13	0	8	7	25	20
11	0	0	0	33	0	0	5.5	0	12	0	35	0
12	0	15	27	0	0	0	0	0	0	3	0	15
13	39	0	0	0	0	0	0	0	0	0	48	44
14	0	0	0	13	0	0	0	0	13	0	0	0
15	0	43	0	0	9	0	0	0	0	2	0	140
16	0	49	0	38	0	65	0	13	0	19	23	0
17	0	0	0	10	28	12	0	0	0	0	25	0
18	0	0	0	28	0	8	0	0	0	0	0	0
19	0	0	20	30	0	0	2.5	0	0	0	43	0
20	0	0	0	0	0	0	0	0	0	45	0	11
21	0	0	22	0	0	7	0	0	0	0	0	0
22	0	22	0	10	0	0	0	0	39	60	19	0
23	5	21	49	0	0	11	0	0	0	0	0	0
24	0	0	30	0	0	24	0	0	0	70	63	0
25	0	0	0	0	18	0	0	0	58	50	0	0
26	0	0	0	0	0	0	0	0	0	20	35	0
27	0	0	5	0	0	0	0	0	0	0	0	0
28	0	0	0	0	0	0	3	3	0	0	0	0
29	0	0	0	0	0	0	43	0	13	5	0	
30	0	0	75	0	0	0	0	0	0	0	0	
31	0	0	0	0	0	0	0					

Appendix C-h: Precipitation data for 2006

Rainfall station at Ladang Gedong for 2007

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	0	0	25	0	0	0	0	18	14	0	0	0
2	0	0	5	29	0	11	0	0	8	4	0	0
3	0	0	0	0	0	19	0	0	5	1	0	2
4	0	0	0	0	0	3	0	0	0	6	9	0
5	0	0	0	0	0	18	0	0	0	20	0	0
6	0	0	0	0	0	0	16	0	58	0	0	2
7	40	0	0	0	0	0	7	0	0	2	0	6
8	0	0	0	0	79	5	0	0	0	0	0	6
9	0	0	0	35	20	0	0	0	25	0	0	10
10	0	0	0	0	10	15	0	0	27	25	0	0
11	0	0	0	25	0	0	0	0	0	19	13	0
12	0	0	0	65	0	0	0	0	0	6	1	1
13	0	80	0	15	0	20	0	5	0	6	0	13
14	14	40	31	22	29	16	13	0	12	0	0	0
15	0	0	4	71	5	8	0	0	43	21	2	1
16	0	15	18	0	0	17.5	0	21	0	30	11	30
17	0	0	0	0	0	0	24	0	0	20	51	22
18	0	35	0	18	0	6	5	6	0	40	0	20
19	20	20	0	0	0	7	41	7	0	0	13	25
20	0	0	0	0	0	0	30	0	0	6	0	9
21	43	15	32	44	27	0	60	0	0	2	0	0
22	0	0	0	46	0	27	40	0	0	7	0	5
23	0	0	0	0	0	8	8	5	0	2	0	0
24	0	0	0	0	0	9	0	0	8	17	0	0
25	0	0	0	0	0	0	26	0	0	38	0	0
26	0	12	0	0	0	0	0	11	0	25	0	49
27	0	10	8	50	5	0	0	14	0	9	0	4
28	0	0	28	45	0	0	4	0	0	4	0	0
29	0	48	0	0	0	0	0	9	4	5	0	
30	0	0	0	0	0	0	0	8	8	0	0	
31	0	23	0	0	0	4	0					

Appendix C-i: Precipitation data for 2007

Rainfall station at Ladang Gedong for 2008

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	0	70	29	12	0	0	0	0	0	0	0	0
2	0	26	48	1	0	25	25	0	5	0	0	0
3	0	0	0	11	0	8	0	0	0	0	0	0
4	32	7	0	0	15	0	0	0	23	49	0	0
5	38	0	8	0	0	0	0	0	45	95	10	0
6	1	0	0	49	0	6	0	0	0	0	19	48
7	0	0	0	0	7	11	0	0	65	0	0	0
8	0	0	47	0	0	34	0	0	7	39	0	0
9	0	0	39	0	0	11	25	0	0	46	16	0
10	0	0	0	0	0	0	0	0	0	0	0	0
11	0	0	39	0	0	0	0	0	0	0	0	5
12	0	0	8	0	0	0	0	0	0	16	0	28
13	0	0	0	0	0	0	14	0	0	0	0	0
14	0	0	15	72	0	0	0	0	0	85	0	12
15	0	0	0	10	0	0	5	0	0	36	0	34
16	0	0	0	0	0	0	0	0	0	35	36	0
17	0	0	22	0	0	14	0	23	0	51	0	0
18	0	0	25	0	0	0	0	0	0	0	29	34
19	0	0	0	0	0	0	68	0	0	28	0	0
20	0	0	48	0	0	0	6	47	0	45	0	0
21	0	0	14	0	10	0	0	43	44	32	20	0
22	0	0	0	5	0	14	0	0	0	6	40	8
23	0	0	52	14	0	49	0	0	0	17	44	0
24	48	0	16	22	0	0	0	12	0	0	17	0
25	0	0	26	13	0	5	0	0	0	0	5	0
26	0	32	0	0	0	0	0	11	0	0	0	0
27	16	44	0	33	0	0	0	48	0	0	11	0
28	12	0	0	0	56	0	0	7	0	10	0	23
29	0	18	0	0	0	17	0	0	0	0	5	9
30	9	0	0	0	0	0	0	0	0	0	10	
31	0	15	0	0	70	0	29					

Appendix C-j: Precipitation data for 2008

Rainfall station at Ladang Gedong for 2009

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	43	0	49	45	30	0	0	0	0	0	45	22
2	2	0	5	36	35	0	0	0	0	11	15	46
3	3	5	0	39	0	0	0	0	0	0	49	0
4	0	2	0	50	8	0	15	48	0	0	10	5.5
5	0	16	11	15	0	0	0	0	15	174	0	13
6	0	0	50	8	0	0	35	0	0	0	0	0
7	23	0	0	0	0	0	0	0	0	0	0	0
8	0	0	70	0	0	0	8	29	0	0	0	13
9	0	0	10	16	0	0	8	0	0	0	48	0
10	0	0	0	7	0	0	20	0	8	0	28	0
11	0	0	5	9	0	0	28	0	0	0	17	0
12	0	0	17	16	0	0	0	0	0	0	23	0
13	20	0	80	0	18	8	38	0	0	0	25	0
14	0	0	60	6	12	0	0	15	0	0	31	17
15	0	0	80	0	52	0	0	0	0	0	37	7
16	0	5	0	0	0	0	0	0	49	22	11	0
17	0	0	50	0	0	0	0	15	8	26	0	0
18	0	15	20	0	0	0	0	49	0	0	0	14
19	0	24	30	65	0	0	0	0	0	0	0	33
20	0	3	0	5	8	0	0	8	16	0	0	0
21	0	2	0	0	0	0	0	7	0	0	8	17
22	0	39	0	0	0	8	0	30	0	0	15	0
23	0	0	0	7	0	0	0	25	0	0	8	0
24	0	5	50	0	0	0	0	28	0	25	19	0
25	10	17	35	0	18	48	10	23	0	0	0	7
26	15	0	23	0	0	0	0	49	0	5	0	19.5
27	0	0	17	0	0	0	0	0	0	0	11	35
28	0	0	22	0	0	0	0	11	41	46	0	0
29	0	25	0	15	35	0	6	16	0	0	0	
30	0	0	24	0	35	0	0	17	0	32	0	
31	5	0	0	0	6	50	0					

Appendix C-k: Precipitation data for 2009

Rainfall station at Ladang Gedong for 2010

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	0	0	6	15	0	0	0	0	0	0	0	0
2	6	0	0	37	0	0	0	0	0	6	0	12
3	10	0	0	7	12	0	0	0	0	10	0	8
4	0	52	0	5	7	27	0	0	0	0	0	0
5	21	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	27.5	0	0	0	3	10	0	0
7	0	33	0	0	0	0	9	5.5	0	0	4.5	0
8	0	8	0	8	0	0	0	0	0	0	14	10
9	0	0	0	0	9	20	0	0	0	0	0	0
10	5	0	37	0	0	0	21	16	0	0	0	0
11	0	0	3	1.5	0	24	6	4	0	0	34	5
12	0	0	0	0	0	0	0	0	9	0	5	0
13	15	0	2	0	23	17	0	0	7	0	0	35
14	0	0	10	0	0	6	0	0	0	5	11.5	23
15	0	0	0	14	0	24	0	0	0	3	20	23
16	0	22	0	17	0	0	0	0	6.5	0	22	0
17	0	0	0	0	0	0	12	8	1.5	0	31	0
18	0	0	4	0	0	0	0	0	0	0	7	29
19	0	0	46	0	35	0	0	0	0	0	0	16
20	0	0	5	2	0	23	0	0	0	16	0	0
21	0	0	0	7.5	0	0	0	0	0	0	21	23
22	15	0	0	4	0	13	26	27	0	0	0	0
23	38	0	0	15	0	0	10	0	0	0	7	28
24	25	0	1	24	0	34	0	7.5	0	0	1	12
25	20	0	0	0	0	0	0	0	0	0	3	24
26	20	0	14	0	37	6	0	0	3.5	4.5	6	0
27	0	0	13	0	7	0	6	5	0	12	16	0
28	0	0	6	0	0	0	0	0	0	2	26	18
29	0	0	17	0	0	0	0	15	0	28	7	
30	0	1	0	0	0	0	0	4	0	0	4	
31	0	0	66	0	3	17	0					

Appendix C-l: Precipitation data for 2010

Rainfall station at Jalan Matang Buloh for 2005

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	0	0	0	6.8	0	0	0	0	8	10	12	1
2	0	0	6.4	0.5	0	0	0	3.5	0	43.5	5	0
3	0	0.9	0.3	14.7	0	0	3.5	0	0	13	0	2
4	0	0	0	3.2	20.5	0	0	0	0	23	3.5	3
5	0	0	21	1.5	0	0	0	0	0	23	0	0
6	0	0	0	8.1	40.5	0	0	0	0	0	0	5
7	0	0	0	0	0	0	0	0	0	25	0	17.5
8	0.9	0	0	9.3	0	0	0	0	0	0	0	0
9	7.4	0	0	0	0	0	13.5	0	0	0	0	0
10	0	0	0	29.8	0	0	1	4	3.5	19	38	0
11	2.7	0	0	0.2	0	0	0	0	4	15	0	3.5
12	0	0	0	0.7	25.5	0	24.5	0	23.5	16.5	0	38.5
13	5	0	2.3	0	25	44.5	35	0	0	0	0	1
14	21.4	0	0	3.5	1.5	11.5	0	0	0	0	3.5	0.5
15	0	0	4.3	29.7	2.5	0	0	2	0	0	3	63
16	1.6	26.5	0	6.5	0	28.5	2.5	0	79	5	1.5	8.5
17	0	2.8	22.7	0	0	0	28.5	0	0.5	2	39.5	0
18	0.6	0	0	9	0	0	0	0	0	2.5	15.5	0
19	0	0	0	33	0	3.5	0	12	0	0	11	0
20	0	0	0	0	0	0	0	3.5	0	132	2.5	0
21	0	0	0	0	0	0	1.5	2	0	23	16.5	0
22	37.3	0	3.7	11	0	0	0.5	10.5	0	0	2	0
23	0	0	0	0	4	0	0	0	0	132	8.5	1.5
24	0	0	0.6	0	0.5	0	0	0	14	23	0.5	1
25	0	0	0	0	0.5	0	0	2	0	74	0	0
26	0	24.2	6.6	0	5	0	0	20	2	0	2	0
27	0	0	3.9	0	0	0	0	0	5	8.5	19	0
28	0	0.7	0	24.5	0	0	0	0	0	13	0	0
29	0	7.3	0	0	0	0	0	0	0	0	0	
30	0	16.4	0	0.5	0	0	0	0	0	6.5	20	
31	0	0.5	0	0	0	5.5	?					

Appendix C-m: Precipitation data for 2005

Rainfall station at Jalan Matang Buloh for 2006

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	?	2.5	0	0	8	0	0	0	47.5	0	0	15
2	?	0	0	0	0.5	0	0	0	0	0	20	0
3	?	0	0	0	4	0	0	0	0	0	18	0
4	?	5	0	0	0	0	0	0	0	0	4.5	0.5
5	?	0	0	0	0	2	0	2	0.5	0	22.5	10
6	?	0	0	0	0	1.5	0	5.5	85	0	0	5
7	?	0	15	5	0	15	0	6	17.5	0	7	98
8	?	0	0	0	1.5	5	0.5	22.5	0	0	0	37
9	?	0.5	0	0	0	35	7.5	0	0	0	45	1
10	?	0.5	0	0	27	0	0	0	0	0	30	75
11	?	13.5	0	6.5	0	0	0	0	10.5	0	50	10.5
12	?	0.5	0	5.5	0	0	5	0	1.5	0	5	30
13	?	0	0	3	5.5	5	0	0	3	18	35	0
14	?	17.5	0	28.5	0	0	0	15	0	0	3.5	0
15	?	44.5	0	1	1.5	0	0	0	0	5	20.5	3
16	?	56.5	0	9.5	75	43.5	0	0	0	0	5	0
17	?	0	2	0	0	22	0	0	0	0	5	0
18	?	7	8.5	49	0	9.5	5.5	0	0	2	18	7.5
19	?	1.5	2.5	2.5	0	0	0	0	0	2	22.5	0
20	?	4.5	46	0	0	2.5	0	0	3.5	95	5.5	4
21	?	5	2.5	0	0	0	0	0	0	18	5	0
22	?	17	55	0	0	0	0	0	4.5	9	5	0
23	?	4.5	1.5	0	0	12	0	0	8	19	0	0
24	?	2	64.5	0	0	28	0	0	22.5	4	53	0
25	?	2	1	3	8.5	0	8.5	0	21.5	4	0	0
26	?	0	0	0	0	0	0	0	0	0	0	18
27	?	0	0	0	0	0	0	3	0	5	50	0
28	?	0	0	0	8.5	0	2	8	0	0	0	0
29	?	0.5	0	0	0	1.5	1.5	0	4	55	0	
30	?	0	55.5	0	0	0	0	2.5	0	35	0	
31	?	0	0	0	37	5.5	0					

Appendix C-n: Precipitation data for 2006

Rainfall station at Jalan Matang Buloh for 2007

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	0	0	43.5	0	0	11	0	2.5	8.5	22	2.5	0
2	0	0	0.5	0	0	0	0	5.5	9.5	0	0	0.5
3	0	74	0.5	24	0	5.5	0	0	2	0	0	0
4	0	0	0	0	0	0.5	0	0	0	0	0.5	0
5	0	0	0	0	0	42	0	0	0	0	3.5	0.5
6	0	0	0	0	0	0	14.5	0	1	3	0.5	11
7	0	0	2.5	0	0	0	0	0	31	15	3	2
8	0	0	0	0	5	1	1.5	0	0	3.5	0	14.5
9	1.5	0	0	0	21.5	0.5	0	0	59	0	0	31
10	0	0	0.5	0	4.5	3.5	0	0	31.5	0	0	3.5
11	0	0	5.5	34	0	0.5	0	0	2	1	7	1
12	0.5	22.5	27.5	10.5	0	0	0	0	0	0	0	0.5
13	0.5	23.5	3.5	0	0	11	0	0	0.5	1.5	0.5	18
14	7.5	0	0	0	14.5	11.5	9	13	12	45.5	5	1
15	0	0	9.5	12	8	2	18.5	0	16	20	0	0
16	2	5.5	0	50.5	0	5	0	33	13.5	0	7.5	8
17	0	2.5	0	0.5	38.5	1	2.5	0	0	4	0	0
18	0	1.5	4.5	0	16	8.5	4	2.5	0	12.5	16.5	8.5
19	0	0	0	7.5	0	2	7	5	0	0	1	3
20	79	12.5	52	0	0	0	9	2.5	0	1	5.5	33
21	29	10.5	4.5	7.5	0	0	16.5	0	0	0.5	3.5	0
22	5	1	1.5	25	9.5	11.5	68.5	0	0	7	0	0
23	0	0	0	13.5	0	0	47.5	2	15.5	14	0	0
24	0	47.5	0	3	0	29	2	1.5	2	3	0	0
25	5	0.5	0	3.5	0.5	6	0	18	2.5	0.5	0	0
26	0	0	?	17.5	0	0	14.5	0	0	0.5	0	12
27	5	18.5	0	9	0	0	0	7.5	0.5	0	0	11
28	0	16.5	2.5	0	1	0	0.5	27.5	0	3	0	0
29	0	6	16.5	0	0	0	0	0	10.5	0	0	
30	0	9.5	0	0	0	0	0	3.5	13	6.5	0	
31	0	57	0	2	0	2.5	0					

Appendix C-o: Precipitation data for 2007

Rainfall station at Jalan Matang Buloh for 2008

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	0	0	0.5	3	0	0	0	0	0	0	0	0
2	1.5	10	28	0	0	0	22	0	0	0	0	0
3	0	3	8.5	1	0	9.5	4.5	0	0	0	0	0
4	0	0	1.5	3	0	1	0	0	0	0	0	0
5	4	0.5	0	0.5	22.5	10	0	0	0	0	0	0
6	12	0	8	0	0	3	0	0	0	22.5	0	0
7	43.5	0	0.5	9.5	0	3	0	0	2.5	0	0	0
8	5	3	12	0	0	0	0	0	2.5	0	0	0
9	0.5	0	7	1	0	0	0	0	4	16.5	0	0
10	0.5	0	6	43.5	0	0.5	0	0	20	30	0	0
11	1.5	0	1	1	0	5	0	0	0	0	0	0
12	0	0	20.5	11	0	0	0	0	0	0	0	0
13	0	0	1	0.5	0	0	0	0	0.5	0	0	0
14	0	0	6.5	0	0	0	12.5	0	0	0	0	0
15	0	0	5.5	7	0	0	0	0	0	0	0	0
16	0	0	0.5	7	0	0	0	0	0	0	0	0
17	0	0	4	0	0	0	0	0	0	0	0	0
18	0	0	1	1.5	0	0	0	0	0	0	0	0
19	0	0	3	0	3	0	0	0	0	0	0	0
20	0	0	0.5	0	0	0	0	0	0	0	0	0
21	0	0	7.5	19	0	0	0	40.5	0	17.5	0	0
22	0	0	3.5	0	11.5	0	0	14	0	3	0	0
23	0	0	1	4.5	0.5	1.5	0	1	0	3.5	0	0
24	0	0	17.5	11.5	18.5	0	0	16.5	0	5.5	0	0
25	0	0	6.5	4	0	5	0	2	0	0	0	0
26	1	0.5	6	0	0	3	0	19	0.5	0	0	0
27	15.5	0	0	0	0	0	0	21	0	0	0	0
28	1.5	8	0	31	0	0	0	0	0	0	0	14.5
29	0	3.5	0	0.5	11.5	4.5	0	0	32.5	0	0	12.5
30	0.5	3.5	0.5	0	0	0	0	0	0	0	0.5	
31	2	1	0	0	0	0	0					

Appendix C-p: Precipitation data for 2008

Rainfall station at Jalan Matang Buloh for 2009

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	0	21	19.5	2.5	0	0	0	2.5	0	0.5	6.5	21
2	0	0	6	67	46.5	0	0	0	0	7	0.5	21
3	0	0	6	53	30	0	0	0	0	14	0	3
4	0	0	0	12.5	11.5	0	18.5	4.5	0	8.5	46.5	2.5
5	0	0	0	10.5	0	0	0	24	13.5	79	9	20
6	0	0	0	9.5	0	0	0	0	0.5	0.5	2	1.5
7	0	0	11.5	4.5	0	0	11.5	7	0	0	0	0.5
8	0	0	0.5	3	0	0	0.5	11.5	0	0	2.5	0
9	0	0	25.5	1	0	0	14.5	1	4.5	0	12.5	0
10	0	0	0	12	0	0	8	18.5	2	0	14.5	13
11	0	0	3	7	0	0	62	0	0	0.5	40.5	0
12	0	0	3.5	1.5	0	0	0	0	8.5	22.5	5	0
13	0	0	6.5	0	17.5	0	0	0	0	0	8.5	0
14	0	0	22.5	0	3.5	0	6.5	3	0	0	54	4.5
15	0	0	53	0	61	0	0	1	0	0	1	0.5
16	0	0	11	0	0	0	0	0	0	3	1	2.5
17	0	13	0.5	0	0.5	0	0	57	26	5.5	3.5	10.5
18	0	0	0	0	0	0	3	10	16	0	0	17
19	0	13	0	0	0	0	0.5	0	2.5	0	0	0.5
20	0	5.5	26.5	37.5	0	0	0	3	0	0	2	0
21	0	1.5	2	14.5	0	0	0	10.5	17.5	6	0.5	0
22	0	7	0	2	0	1	0	33.5	0	2.5	1.8	0
23	0	24	2	0	0	18	0	14.5	9	0	13.7	1
24	0	2	0.5	0	0	0	0	25.5	0	0	0	0.5
25	4	0.5	35.5	0	0	0	0	2	0	2.5	0	0.5
26	1	4	10	0	31.5	2.5	0	20.5	0	0	0	20
27	9	4	6.5	0	0	0.5	0	47.5	0	0.5	0	0
28	0	4.5	22.5	0	0	0	0	10	54	12.5	8	18.5
29	0	3.5	0	8.5	0.5	0	2	12	5	1.5	0.5	
30	0.5	23	0	1	13.5	0	4	35.5	0	0.5	0	
31	0.5	0	0	1.5	23.5	0	0					

Appendix C-q: Precipitation data for 2009

Rainfall station at Jalan Matang Buloh for 2010

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	5.5	0	0	4	33	24	21.5	0	0	0.5	10	8.5
2	9	0	5	8	0	0	0	0	0	20.5	0	2.5
3	0.5	0	0.5	27.5	0	0	0	0	1	0	0	0.5
4	1	0	0	2.5	14	21.5	0	0	0.5	0	0	0
5	0.5	30	0	0	0	0.5	0	0.5	0	30	1	0
6	6.5	0	0	0	5	0	0	0	0	1.5	0.5	0
7	0.5	0	0	0	0	0	1.5	0.5	0	0	6	2.5
8	0	0	0	1.5	8.5	0	0	2	0	0	12	55.5
9	0	10	0	0.5	0	0	0	0	0.5	0	2	12.5
10	2.5	0	0	0	0	0	51.5	0	0	0	0	0
11	0	0	37.5	2.5	12.5	0	0.5	0	0	0	42	11
12	0	0	0.5	0.5	5.5	6.5	0	0	0	0	3.5	4.5
13	0	0	0	0	4.5	1	0.5	30.5	0	0	25.5	0.5
14	0	0	1.5	0	2	2.5	0	1.5	1	0	6.5	22
15	0	0	12	0	0	5	0.5	4	2	0	23	0
16	0	0	0	3	2	4.5	0	0	0.5	0	19.5	0
17	0	24	0	0	0	0	1.5	31.5	24	0	27	17
18	0	0.5	0	0.5	26.5	0	0.5	2.5	0	0	2.5	0
19	0	0	0	0	0	0	0	0.5	0	0	1	0
20	0	0	28	0	2	0	12	0	3	0	24	0.5
21	0	0	0.5	0	2	0	0.5	1	0.5	0	4.5	1
22	0	0	0	28.5	5	0	0	0	35	0	5	21.5
23	10.5	0	0	3	0	0	0.5	0	5	9	4.5	0.5
24	28	2.5	0	4	0	0	0	0	2	0.5	1	0.5
25	15	0	0	50	0	0	15	0	0.5	1	4.5	0
26	27	0	0	0.5	0	0	6.5	0	6	0	0.5	0
27	0	0	13.5	5	0	0	1	27	149.5	1.5	5	0
28	0	0	25.5	0	0	0	0.5	0	0.5	0	5.5	3.5
29	0	0.5	0.5	0	0	0	0	4.5	0	29	2	
30	9	0.5	18	0	0	4.5	1	0	0.5	33.5	0	
31	0.5	0	2.5	0	15.5	0.5	28					

Appendix C-r: Precipitation data for 2010

Rainfall station at Kolam Air Bukit Merah for 2005

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	0	?	?	12.5	0	0	0	0	0	0	0	0
2	0	?	?	23	0	0	10	3.5	0	0	4.5	0
3	0	?	?	5.5	0	0	0	0	0	7.5	9	5
4	0	?	?	4	0.5	0	3	0	0	13	9.5	2
5	0	?	?	2.5	0	0	0	0	0	0.5	17	0
6	0	?	?	35.5	35	0	0	0	0	14	0	8
7	0	?	?	0	0.5	0	0	0	0	24.5	0	15
8	0.5	?	?	0.5	0	0	0	0	0	5	6	0
9	0	?	?	73.5	0	0	4	0	0	37	0	0
10	0	?	?	0	0	0	45	0	17	0.5	20	0
11	15	?	?	0.5	0	0	3	0	11	58	0.5	13.5
12	2	?	?	0	18.5	0	0.5	0	17.5	40.5	19	77.5
13	0.5	?	?	57.5	26	5	71	6	38.5	12	0	6.5
14	0	?	?	44	3.5	15	72.5	0	0	8.5	0.5	0
15	11	?	?	30.5	2.5	0	0	0	18	0	7.5	38.5
16	0	?	?	0	0	12	27	0	1.5	0	0	18
17	0	?	?	0	0	0	7.5	?	24	0	20	0
18	0	?	?	24.5	0	8.5	0.5	0	0.5	13.5	36	0
19	0	?	?	7.5	0	4.5	0	0	40	5.5	21	0
20	0	?	?	7	0	0	0	0	3	78	4	0
21	16.5	?	?	0	0.5	5	17	0	21	16.5	15	0
22	0	?	?	18.5	0	0	4.5	0	8	0	3	0
23	0	?	?	1	48.5	0	0	0	76	0	3	0
24	0	?	?	0	0.5	0	0	0	3.5	2	0	43.5
25	0	?	?	0	0	0	0	0	43	0	15.5	0
26	0	?	?	2	5	0	0	0	43.5	4	0	0
27	0	?	?	13.5	0	0	0	0	51	11	8	0
28	0	?	?	0	1	0	0	0	11	0	0	0
29	0	?	15.5	0	0	0	0	23.5	0	31.5	0	
30	0	?	0	4.5	0	0	0	0.5	0.5	3	17	
31	?	?	0	0	0	97.5	?					

Appendix C-s: Precipitation data for 2005

Rainfall station at Kolam Air Bukit Merah for 2006

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	?	0	0	0	24	1	0	0	0	0	2	15
2	?	13.5	0	0	22	0.5	0	0	0	0	0	0
3	?	3.5	0	0	1	7	0	0	19	0	18.5	0
4	?	0.5	0	0	3	0	0	0	2	0	71	0.5
5	?	0	0	1	1	0	0	0	1	0	1.5	8
6	?	5	0	0	3	0	0	6.5	34.5	1	1	4
7	?	0	10.5	5.5	0.5	0	0	10.5	16.5	0	1	117.5
8	?	0	0	0	0	0	0	0.5	6	0	33	39
9	?	0.5	0	0	0	0	0	23.5	10	0	16	1
10	?	10.5	0	20.5	26.5	0	9.5	0	4.5	1	34	52
11	?	3	0	0	10	0	1	0	16	6	17.5	0
12	?	16.5	0	28	0	0	0	0	0	0	12	10.5
13	?	2.5	0	7.5	0	1	10	0	3	13.5	5.5	28
14	?	0	0	13.5	0	0	0	0	0.5	9	3.5	10
15	?	8	0	5.5	0	18.5	0	0.5	9	13	30	33
16	?	20	0.5	3.5	38.5	26	0	0.5	0	11	41	4
17	?	0	0	12.5	1.5	8	0	39	0	36	4	0
18	?	1	10	48	0	6	0	0	0	8.5	13.5	0
19	?	0	10.5	5	1	3	9.5	0	0	0	24	8
20	?	12	7	0	0	0	1.5	0	0.5	16	21	5
21	?	8	9.5	3.5	0	?	0	0	9.5	38	1	0
22	?	18	39.5	6	0	0	7.5	0	35	23	15	0
23	?	0	6.5	0.5	0	19.5	35	10.5	2.5	6.5	22.5	0
24	?	0	16.5	7.5	0	36.5	0	0	2	71	32.5	0
25	?	5	0	0	5.5	0	0	0	32	5.5	2.5	16
26	?	0	0	0	0	0	7	16	0	5.5	23.5	0
27	?	0	0	0	0	0	0	0	0	0	0.5	0
28	?	0	0	0	1.5	0	0	1.5	?	42	3	0
29	?	1	7	0.5	0	24	51.5	11	0	17	0	
30	?	0	0	0	0	3.5	0.5	0.5	12.5	36.5	0	
31	?	0	3.5	0	80.5	11.5	20					

Appendix C-t: Precipitation data for 2006

Rainfall station at Kolam Air Bukit Merah for 2007

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	0	0	38.5	0	0	0	0	0	12.5	0	2.5	0
2	0	0	4	0	0	11	0	23.5	20.5	0	28	0
3	0	0	1	60.5	0	2	23.5	0	7	0	1	0
4	1	0	0	0	0	19	0	0	0	0	2	2
5	53.5	0	0	0	3	6.5	0	0	0	36	2	20.5
6	39	0	0	0	0	3	0	0	28.5	38	4	4
7	0	0	0	13.5	0	0	0	0	163	5	1.5	0.5
8	1	0	0	1	1.5	3.5	22.5	0	0.5	0	0	12
9	5	0	0	32.5	8.5	9.5	8	0	47	0	27.5	5.5
10	0	0	0	4	4	0	0	0	27.5	1.5	0	2
11	0.5	0	0	6.5	0	0	0	0	0.5	38.5	2.5	0
12	0	39	40.5	44.5	0	22	0	0.5	0	33	27.5	21.5
13	7.5	69.5	23	0.5	0	5.5	0	0	0	26.5	2.5	2
14	20	0	4.5	0	24	31.5	0	31	19	58	1	0
15	13	6.5	18	1.5	3.5	9.5	0.5	0	18.5	26.5	0	63
16	24	0	2.5	3	0	5.5	0	26.5	0	25.5	1.5	0
17	74	1.5	0	0	27.5	6	0	0	0	7.5	11.5	43.5
18	?	56	0	0.5	2.5	1	25	7	0	0	18	18.5
19	86.5	18.5	20.5	9.5	9.5	0	37	0	0	12.5	0	26.5
20	27	0	0	0	0	0	51.5	62	0	2	0	0
21	3.5	78	11.5	32.5	1.5	13.5	51.5	0	0	4	0	0
22	0	32.5	8.5	44.5	36	0	57.5	0	0	21.5	0	0
23	0	2	0.5	35	0	3	25	3	15	4	0	0
24	2.5	0	0	1.5	0	0.5	0	6	0	0	0	0
25	0	21.5	5	14.5	1	0	0	9.5	0	4.5	0	3
26	0	0	0	23	0	0	38	0	0	0	0	0
27	2.5	0	0	29.5	0	0	0	31	0	7	0	0
28	0	2	25	0	0	0	2.5	15.5	0	5	16	0
29	0	22	28.5	0	0	0	0	0	5	21.5	0	
30	0	35	2	0	0	0	0	11	6	0	0	
31	0	3	75	0	0	5.5	0.5					

Appendix C-u: Precipitation data for 2007

Rainfall station at Kolam Air Bukit Merah for 2008

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	8	12.5	70	6.5	0	0.5	0	0	23.5	0	0	1
2	8	9	13.5	1	0	0.5	76	0	4	0	0.5	0
3	0	5	5.5	23	0	40	8	11	6.5	0.5	0	0
4	2.5	13	0	1	?	19	0	1	4	0	14.5	0
5	21.5	0.5	11	0	0.5	3.5	0	0	46	34	23.5	0
6	44.5	0	7.5	8.5	0	0	0	20.5	39.5	68	13	0
7	64.5	0	18.5	3	0	11	8	0	0.5	5	2	0.5
8	4	0	10	0	2	0	0.5	0	4	18.5	0.5	30.5
9	4	0	11	21	0	40	0	0	0	12.5	0	0
10	0	0	7	1	0	19.5	15	0	20.5	73	2	0
11	0	0	35	23	0	0	0	0	0	4	0	0
12	0	0	6.5	13	0	0	0.5	0	0	3.5	0.5	33
13	0	0	0	6.5	0	0	1	0	1	7	0	2
14	0	0	4	2	0	0	1.5	0	0	16	13.5	18.5
15	0	0	4	0.5	0	0	0	0	0	23.5	32	36.5
16	0	0	8.5	0	0	0	0	0	0	2	0	60
17	0.5	0	28.5	2	0	0	1	0	0	208	26	0.5
18	7.5	0	36	0	0	5	1	24.5	0	0.5	0.5	44.5
19	4	0	0	0	0	0	0	9	0	5.5	10	2
20	2	0	37	22	0	0	57.5	22	0	24.5	0	0
21	0	0	10	0.5	0	0	5.5	4.5	39	37	2	0
22	0	0	7	10.5	21	24.5	0	18	0	21	1	0
23	0	0	57.5	40	13.5	0	4	5	0	24.5	1	0
24	0	0	61	0.5	5.5	31	9.5	6.5	0	16.5	6.5	0
25	1	0	27	0	3.5	2	0	2	0	0	23	0.5
26	39.5	1	0	0	0	13	0	39	0	0	3.5	0
27	15	13.5	0	2.5	29.5	0	0	70	0	0	0	28.5
28	1	59	0.5	1	0	0	0	1.5	0	8.5	13	9
29	43	0	7.5	0	20.5	52.5	0	0.5	15	17	0.5	2
30	4	2.5	0	0	0	0	87.5	13.5	0	17	39.5	
31	54	10.5	0	0	1	0	37.5					

Appendix C-v: Precipitation data for 2008

Rainfall station at Kolam Air Bukit Merah for 2009

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	20.5	0	6.5	85.5	35	0	0	20	0	0.5	25	5
2	1.5	0	4	8	41	0	0	0	0	39.5	2	4
3	8	0	0	56.5	7	0	3.5	0	0	15.5	1.5	19
4	5.5	0	1.5	2	5	0	5.5	4	0	5.5	39	1
5	0	0	0.5	26	0	0	0	20	13.5	42	12	0
6	0	0	9	24	0	0	0	0	0.5	1.5	2.5	7
7	9	0	0.5	2.5	1	0	19.5	2	0	0	1	9.5
8	0	0	31	5.5	0	0	0	0	0	43	12	0
9	0	0	0	34	0	0	0	6.5	9	0	0.5	0
10	0	0.5	31	7	0	0	35	12.5	7.5	15.5	31.5	11
11	0	0	5	2	0	0	104.5	0	0	0	46	0
12	3.5	0	15	30	0.5	0	0.5	0	0	0.5	6.5	0
13	10	0	7	0.5	4	0	0.3	12.5	0	0.5	1	0
14	0	0	20.5	27	27	0	1.7	11	0.5	0.5	53	13.5
15	0	0	53	0	2.5	0	0	1.5	0.5	0	2	0
16	0	25.5	0	0	11	0	0	4	0	29.5	19.5	19
17	0.5	0	0	0.5	0	?	0	25	42.5	4.5	15.5	53
18	0	1.5	5	0	0	0	5	47	5.5	0	0.5	17.5
19	0	1.5	25	46.5	0	0	0	0	6.5	0	0	0.5
20	0	5	3.5	7.5	0	0	0	17.5	3	7.5	0	0
21	0	16	0.5	0	0	0	0	45	4.5	0	0.5	0
22	0	40	0	0	0	26.5	6	32	0	0	1	0
23	9	2	4	3	0	26	0	8.5	34.5	0	33	4
24	21	21	55	0	0	0	0	14.5	0	0	0.5	0
25	34	21	2.5	0	21	0	5	0	0	118	0.5	0
26	19	0.5	0	10.5	0	5.5	0	19	0	0	0	0
27	5	21	30.5	0	0	0	0	55	0	1	0.5	4.5
28	0	10.5	48	8.5	7.5	1	0	5.5	38.5	2.5	19	2.5
29	0	0	8.5	0	0	0	3.5	27	0.5	0	1.5	
30	13	0	3	0	47	0	17.5	38	0	0	0	
31	20.5	0	0	1.5	13.5	6.5	0					

Appendix C-w: Precipitation data for 2009

Rainfall station at Kolam Air Bukit Merah for 2010

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	0	0	2.5	13.5	82.5	2	40	2	0	18	5	3
2	0.5	0	4	12	0	0	0	0	0	37.5	0	34
3	2.5	0	0	32.5	0	0	0	0	3.5	0	0	0.5
4	3.5	1	0	4.5	0	41	0	0.5	0	0	0	0
5	0	65.5	0	5	0	0.5	0	0	0	22	0	0
6	22.5	1.5	0	0	10.5	10	0	0	5	8.5	2.5	1
7	1	0	0	9.5	0	0	3	0	0	0	1.5	5.5
8	0	12.5	0	0.5	39.5	0	0	0	0	0	36.5	43.5
9	0	0	20.5	8.5	0	0	1.5	0	0	0	1	6.5
10	20	0	0.5	0	0	0	0	0	0	0	0	2
11	0	0	14.5	0	5.5	0	0	0	0	0	25.5	10.5
12	0	0	0.5	0.5	11	26	0	3	0	0	1	7.5
13	5	0	0	0	43.5	6	0	12	0	0.5	4.5	0
14	29.5	0	33.5	0	4	15.5	0	0	5	0	7	3.5
15	0	0	12	0	0	3.5	3	10.5	2.5	0	33	0.5
16	0	0	0	2.5	3	3.5	0	1.5	0	0	83.5	3.5
17	0	2.5	0	0	0	0	3	?	29	0	7	6
18	0	0	0	11	9.5	0	0	9	1	0	14	0.5
19	0	0	0	6.5	0	0	0	9	21	0	4	0
20	0	0	33.5	11.5	18.5	0	3	0	49	0	3	4
21	0	0	1	0.5	17.5	28	0	0	0.5	0	0	0
22	0	0	21	4.5	4	0	1.5	0	36	0	0	0
23	11	0	0.5	14	0	0	0	0	50	0.5	12	9
24	15.5	0	0	13.5	0	0	0	0	4.5	4.5	9.5	6.5
25	29.5	0	27	1.5	0	0	9	0	13	0	27.5	0
26	11	0	0	0	0	0	10.5	0	32	8	1.5	0
27	9.5	0	11.5	14	0	0	0.5	28.5	86	1	2.5	0.5
28	0	1	43	0	0	0	0	0	1	0	8	15
29	22.5	12	0.5	3	0	0	0.5	10.5	0	73	?	
30	40	0	22.5	2	0	1.5	2.5	0.5	4	14	0	
31	0	0	16.5	0.5	7	1	25					

Appendix C-x: Precipitation data for 2010

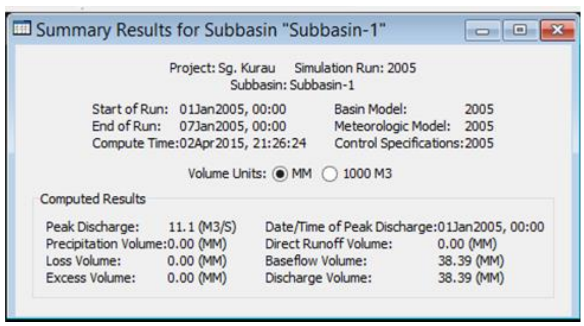
Catchment	Area		Baseflow	Hydraulic Length		CN*	Lag Time	Rise (m)	River Slope (m/m)	Impervious (%)
	km²	m	0.11 A^0.85889	km	m		min			
Sub-Basin 1	149.9824	149982.4	11.10813158	6.6	6600	74	483.35		0	0.7821
Sub-Basin 2	170.549	170549	12.40436975	10.8	10800	82	528.68	1.8288	0.169333333	0.5276
Sub-Basin 3	189.7627	189762.7	13.59547173	13.84	13840	87	589.89	2.4384	0.176184971	35.52
Sub-Basin 4	143.7124	143712.4	10.70808951	15.45	15450	83	697.59	1.524	0.098640777	0
Sub-Basin 5	137.6143	137614.3	10.31664563	21.57	21570	83	1056.28	7.9248	0.367399166	36.01

Appendix D: Parameter used in HEC-HMS

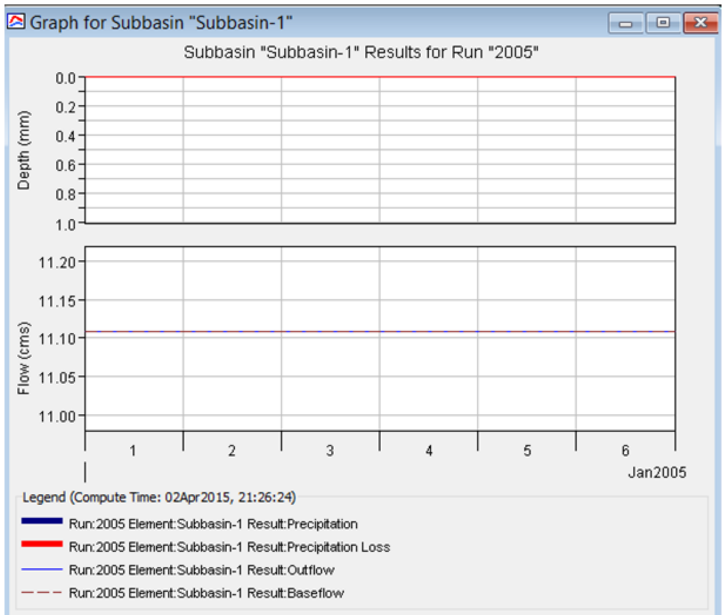
Appendix E

a) Calibration results for 2005

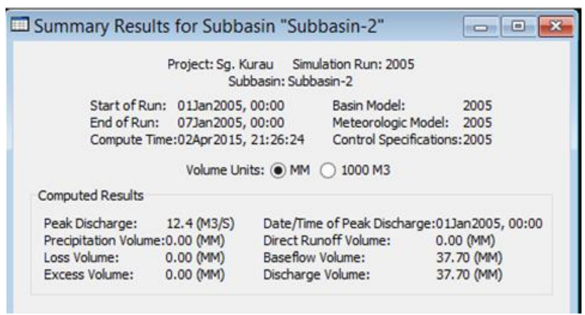
Graph below show the generated hydrographs resulted from the calibration process for 2005. Meanwhile, Summary 1 to 5 show the parameters for sub-basin 1 to 5.



Summary 1



Sub-basin 1



Summary Results for Subbasin "Subbasin-2"

Project: Sg. Kurau Simulation Run: 2005
Subbasin: Subbasin-2

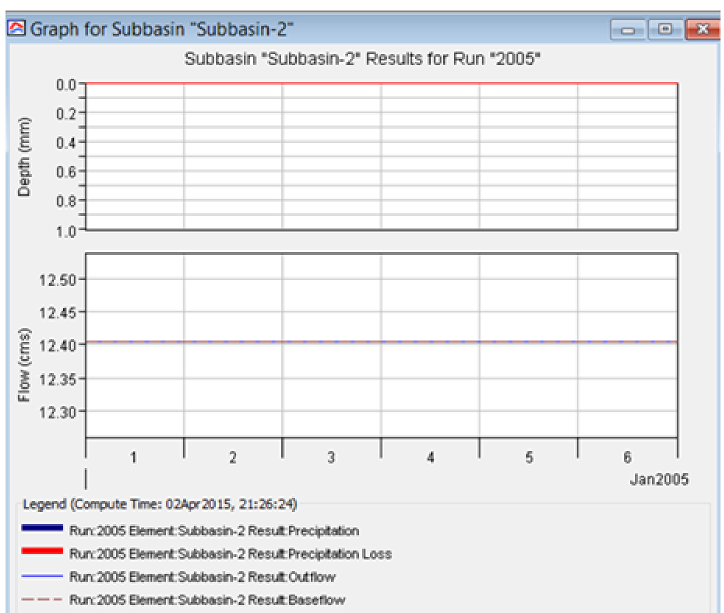
Start of Run:	01Jan2005, 00:00	Basin Model:	2005
End of Run:	07Jan2005, 00:00	Meteorologic Model:	2005
Compute Time:	02Apr2015, 21:26:24	Control Specifications:	2005

Volume Units: (•) MM ( ) 1000 M3

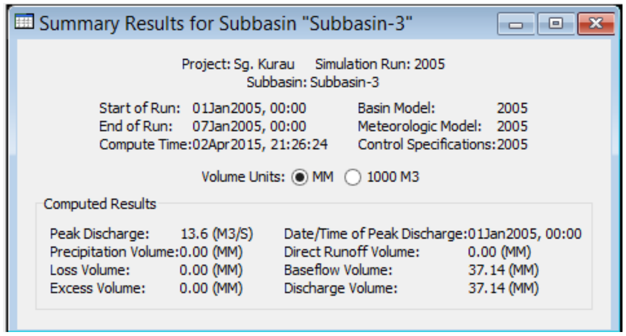
Computed Results

Peak Discharge:	12.4 (M3/S)	Date/Time of Peak Discharge:	01Jan2005, 00:00
Precipitation Volume:	0.00 (MM)	Direct Runoff Volume:	0.00 (MM)
Loss Volume:	0.00 (MM)	Baseflow Volume:	37.70 (MM)
Excess Volume:	0.00 (MM)	Discharge Volume:	37.70 (MM)

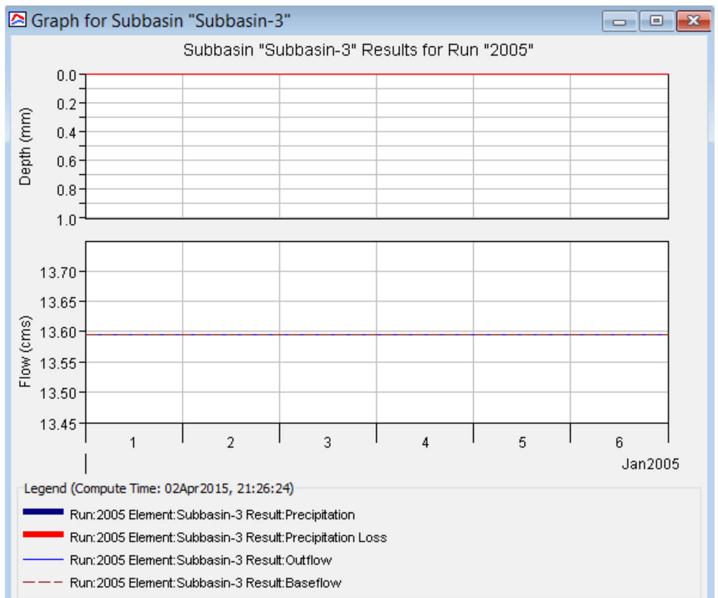
Summary 2



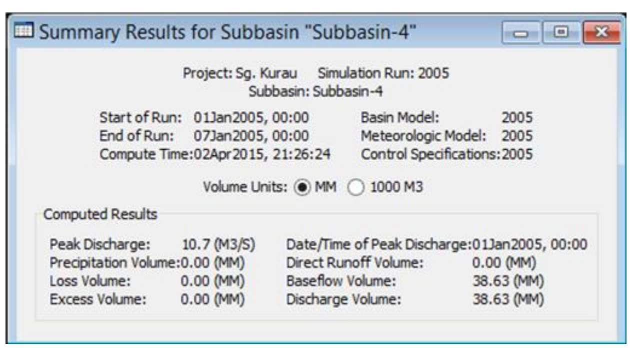
Sub-basin 2



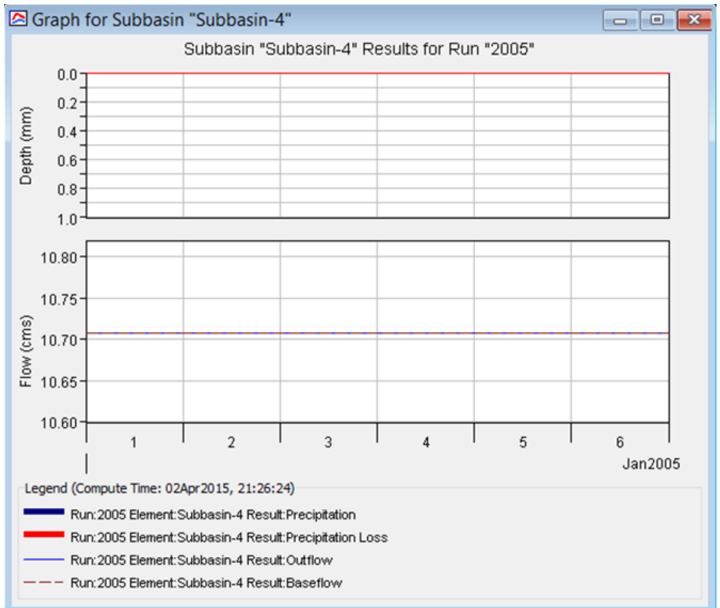
Summary 3



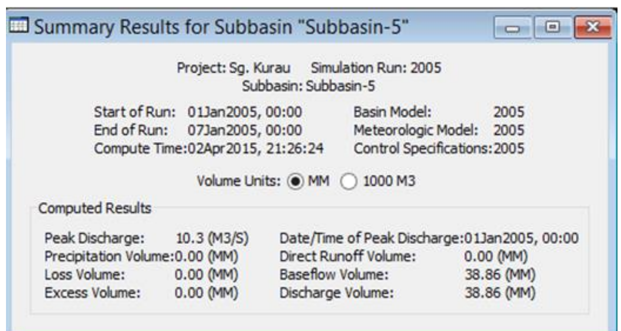
Sub-basin 3



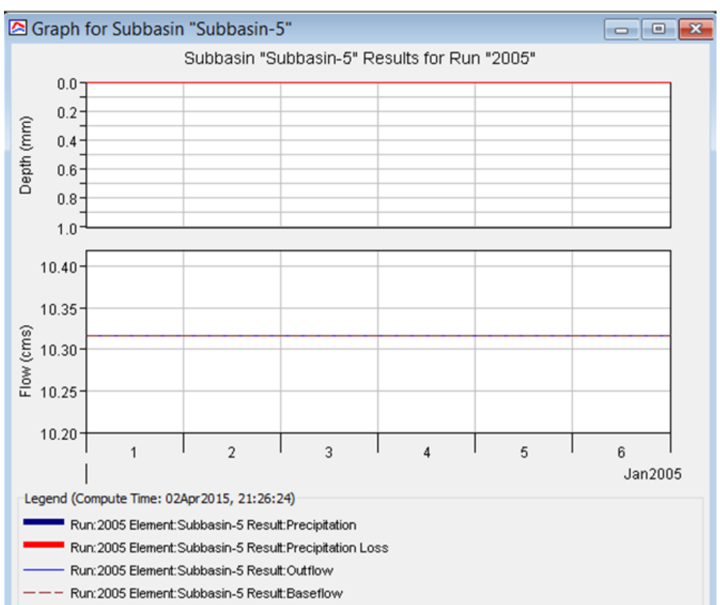
Summary 4



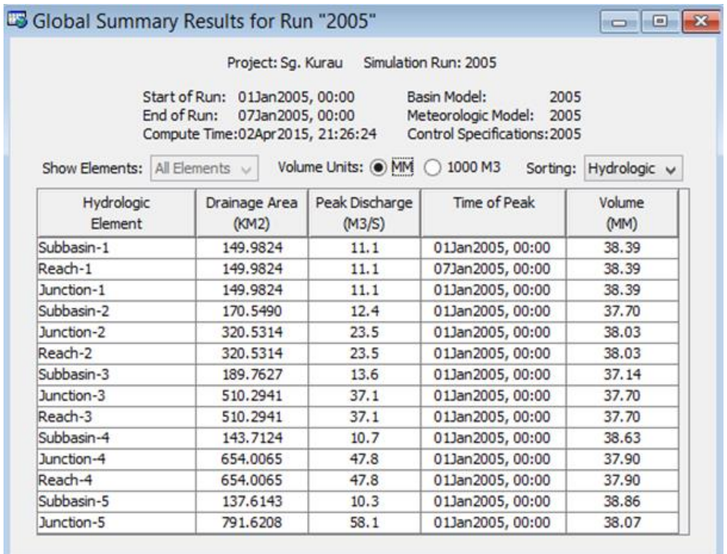
Sub-basin 4



Summary 5



Sub-basin 5



Global Summary Results for Run "2005"

Project: Sg. Kurau Simulation Run: 2005

Start of Run: 01Jan2005, 00:00 Basin Model: 2005
End of Run: 07Jan2005, 00:00 Meteorologic Model: 2005
Compute Time: 02Apr2015, 21:26:24 Control Specifications: 2005

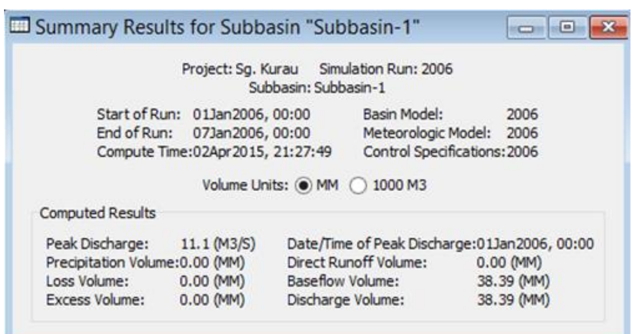
Show Elements: All Elements Volume Units: MM 1000 M3 Sorting: Hydrologic

Hydrologic Element	Drainage Area (KM2)	Peak Discharge (M3/S)	Time of Peak	Volume (MM)
Subbasin-1	149.9824	11.1	01Jan2005, 00:00	38.39
Reach-1	149.9824	11.1	07Jan2005, 00:00	38.39
Junction-1	149.9824	11.1	01Jan2005, 00:00	38.39
Subbasin-2	170.5490	12.4	01Jan2005, 00:00	37.70
Junction-2	320.5314	23.5	01Jan2005, 00:00	38.03
Reach-2	320.5314	23.5	01Jan2005, 00:00	38.03
Subbasin-3	189.7627	13.6	01Jan2005, 00:00	37.14
Junction-3	510.2941	37.1	01Jan2005, 00:00	37.70
Reach-3	510.2941	37.1	01Jan2005, 00:00	37.70
Subbasin-4	143.7124	10.7	01Jan2005, 00:00	38.63
Junction-4	654.0065	47.8	01Jan2005, 00:00	37.90
Reach-4	654.0065	47.8	01Jan2005, 00:00	37.90
Subbasin-5	137.6143	10.3	01Jan2005, 00:00	38.86
Junction-5	791.6208	58.1	01Jan2005, 00:00	38.07

Global summary results for hydrologic modelling

b) Calibration results for 2006

Graph below show the generated hydrographs resulted from the calibration process for 2006. Meanwhile, Summary 6 to 10 show the results for sub-basin 1 to 5.



Summary Results for Subbasin "Subbasin-1"

Project: Sg. Kurau Simulation Run: 2006
Subbasin: Subbasin-1

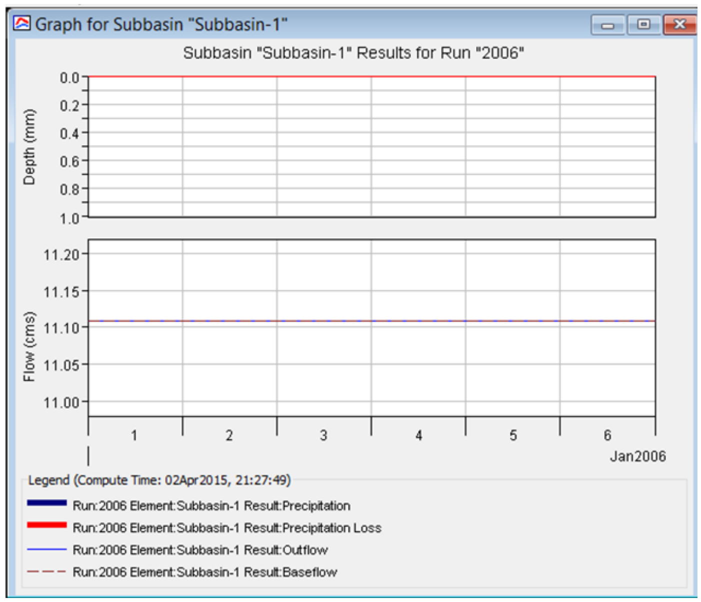
Start of Run: 01Jan2006, 00:00 Basin Model: 2006
End of Run: 07Jan2006, 00:00 Meteorologic Model: 2006
Compute Time: 02Apr2015, 21:27:49 Control Specifications: 2006

Volume Units: MM 1000 M3

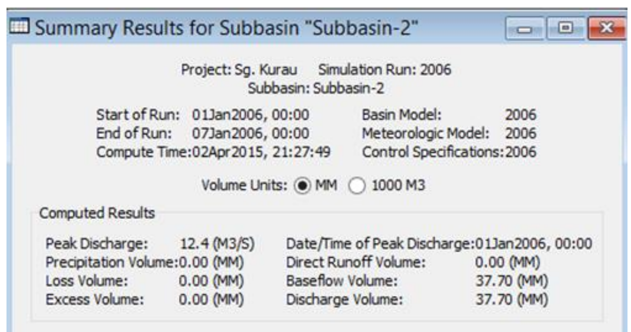
Computed Results

Peak Discharge: 11.1 (M3/S) Date/Time of Peak Discharge: 01Jan2006, 00:00
Precipitation Volume: 0.00 (MM) Direct Runoff Volume: 0.00 (MM)
Loss Volume: 0.00 (MM) Baseflow Volume: 38.39 (MM)
Excess Volume: 0.00 (MM) Discharge Volume: 38.39 (MM)

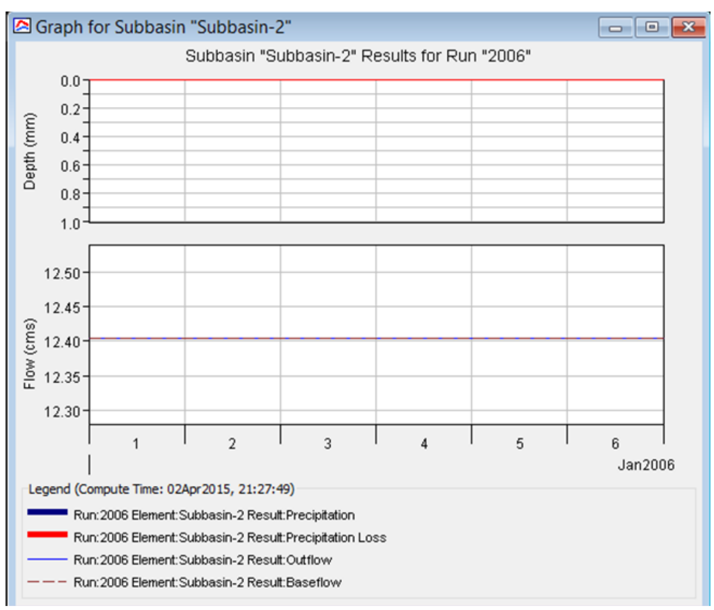
Summary 6



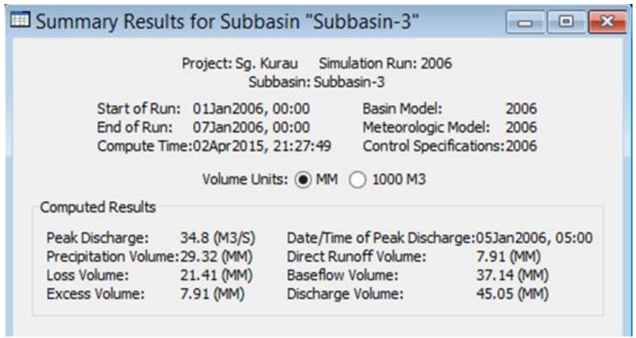
Sub-basin 1



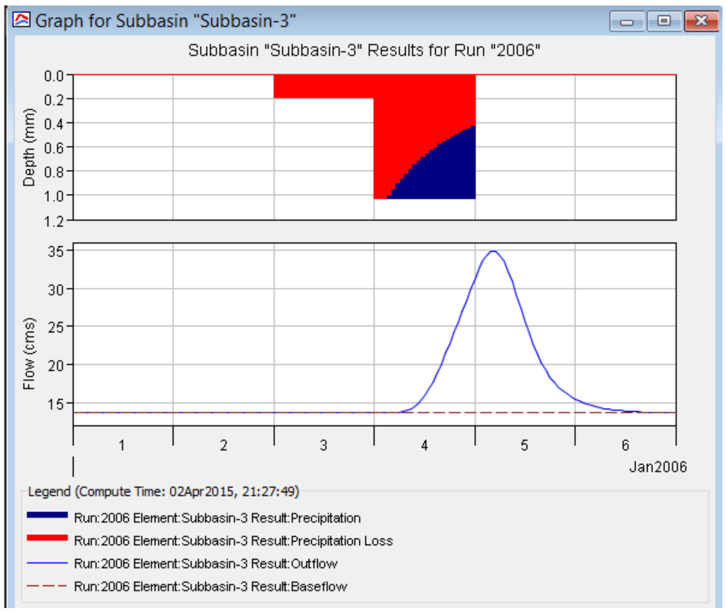
Summary 7



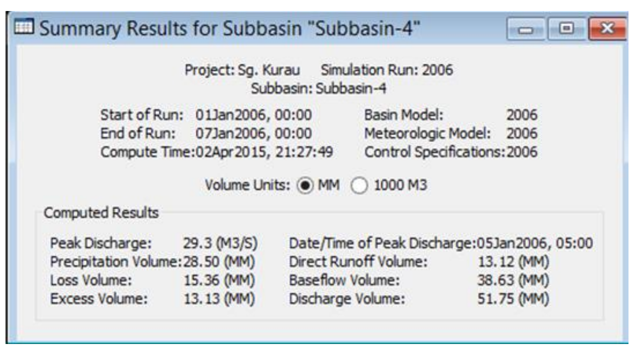
Sub-basin 2



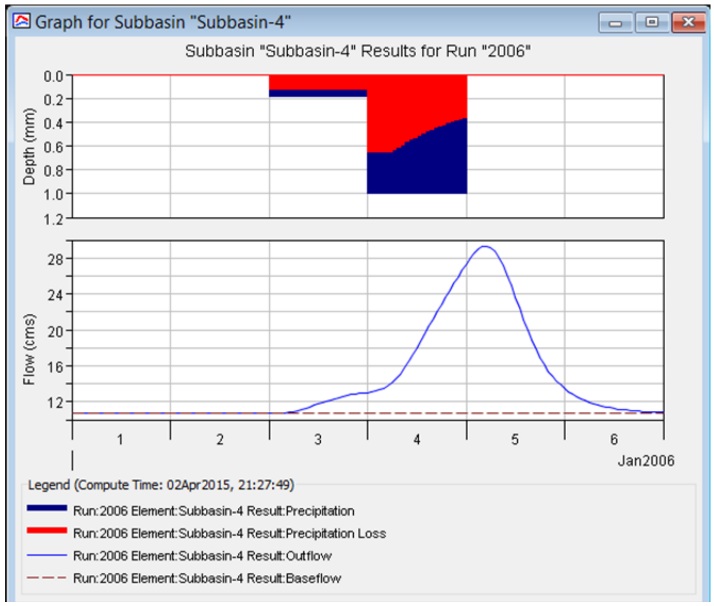
Summary 8



Sub-basin 3



Summary 9



Sub-basin 4

Summary Results for Subbasin "Subbasin-5"

Project: Sg. Kurau Simulation Run: 2006
Subbasin: Subbasin-5

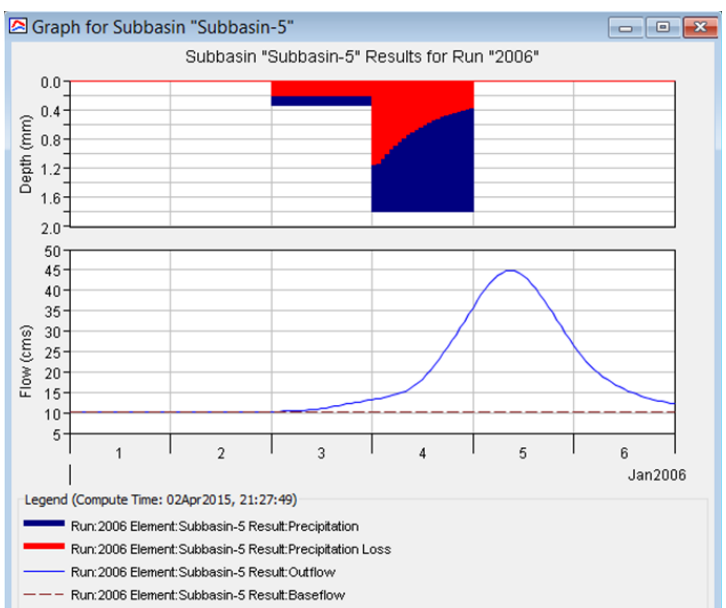
Start of Run:	01Jan2006, 00:00	Basin Model:	2006
End of Run:	07Jan2006, 00:00	Meteorologic Model:	2006
Compute Time:	02Apr2015, 21:27:49	Control Specifications:	2006

Volume Units: (•) MM ( ) 1000 M3

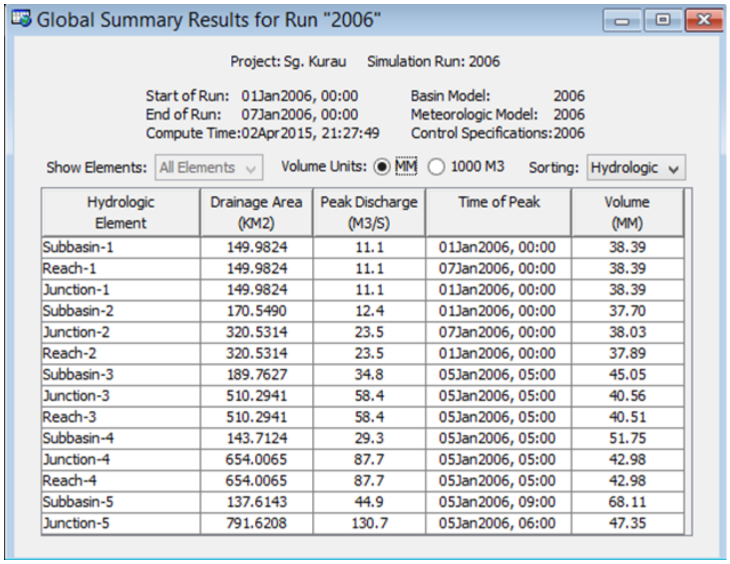
Computed Results

Peak Discharge:	44.9 (M3/S)	Date/Time of Peak Discharge:	05Jan2006, 09:00
Precipitation Volume:	51.00 (MM)	Direct Runoff Volume:	29.25 (MM)
Loss Volume:	21.25 (MM)	Baseflow Volume:	38.86 (MM)
Excess Volume:	29.75 (MM)	Discharge Volume:	68.11 (MM)

Summary 10



Sub-basin 5



Global Summary Results for Run "2006"

Project: Sg. Kurau Simulation Run: 2006

Start of Run: 01Jan2006, 00:00 Basin Model: 2006
End of Run: 07Jan2006, 00:00 Meteorologic Model: 2006
Compute Time: 02Apr2015, 21:27:49 Control Specifications: 2006

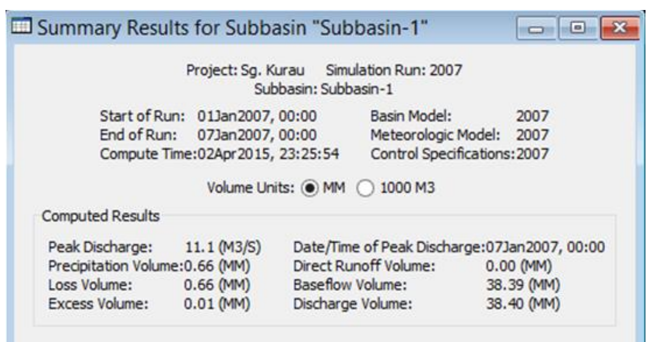
Show Elements: All Elements Volume Units: MM 1000 M3 Sorting: Hydrologic

Hydrologic Element	Drainage Area (KM2)	Peak Discharge (M3/S)	Time of Peak	Volume (MM)
Subbasin-1	149.9824	11.1	01Jan2006, 00:00	38.39
Reach-1	149.9824	11.1	07Jan2006, 00:00	38.39
Junction-1	149.9824	11.1	01Jan2006, 00:00	38.39
Subbasin-2	170.5490	12.4	01Jan2006, 00:00	37.70
Junction-2	320.5314	23.5	07Jan2006, 00:00	38.03
Reach-2	320.5314	23.5	01Jan2006, 00:00	37.89
Subbasin-3	189.7627	34.8	05Jan2006, 05:00	45.05
Junction-3	510.2941	58.4	05Jan2006, 05:00	40.56
Reach-3	510.2941	58.4	05Jan2006, 05:00	40.51
Subbasin-4	143.7124	29.3	05Jan2006, 05:00	51.75
Junction-4	654.0065	87.7	05Jan2006, 05:00	42.98
Reach-4	654.0065	87.7	05Jan2006, 05:00	42.98
Subbasin-5	137.6143	44.9	05Jan2006, 09:00	68.11
Junction-5	791.6208	130.7	05Jan2006, 06:00	47.35

Global summary results for hydrologic modelling

c) Calibration results for 2007

Graph below show the generated hydrographs resulted from the calibration process for 2007. Meanwhile, Summary 11 to 15 show the results for sub-basin 1 to 5.



Summary Results for Subbasin "Subbasin-1"

Project: Sg. Kurau Simulation Run: 2007
Subbasin: Subbasin-1

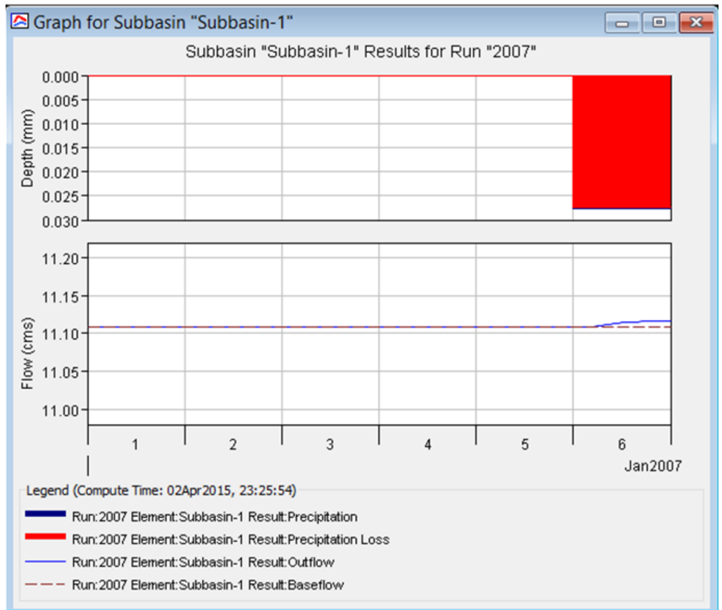
Start of Run: 01Jan2007, 00:00 Basin Model: 2007
End of Run: 07Jan2007, 00:00 Meteorologic Model: 2007
Compute Time: 02Apr2015, 23:25:54 Control Specifications: 2007

Volume Units: MM 1000 M3

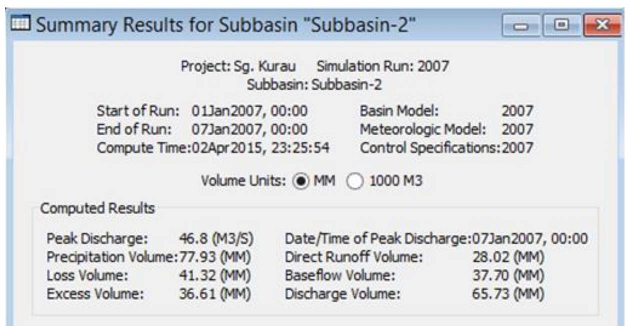
Computed Results

Peak Discharge: 11.1 (M3/S) Date/Time of Peak Discharge: 07Jan2007, 00:00
Precipitation Volume: 0.66 (MM) Direct Runoff Volume: 0.00 (MM)
Loss Volume: 0.66 (MM) Baseflow Volume: 38.39 (MM)
Excess Volume: 0.01 (MM) Discharge Volume: 38.40 (MM)

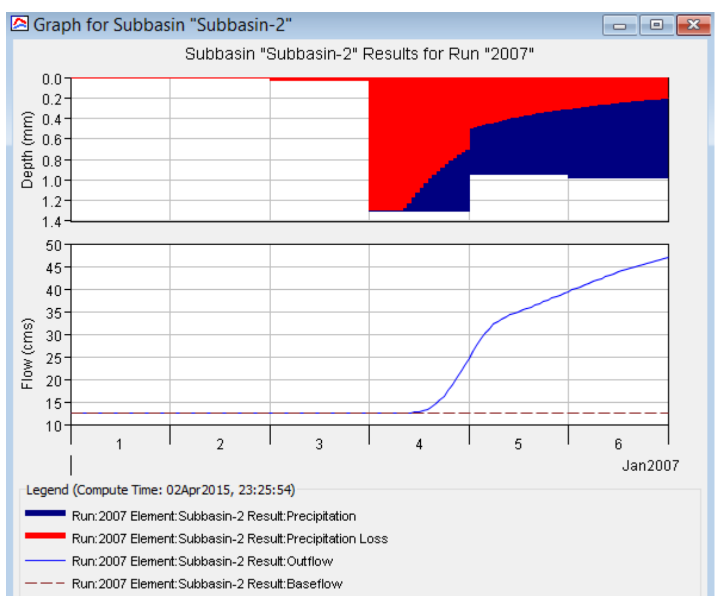
Summary 11



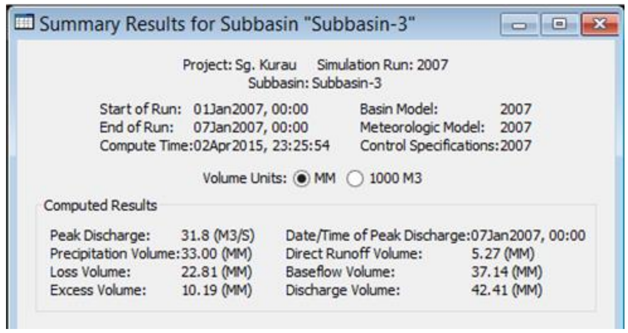
Sub-basin 1



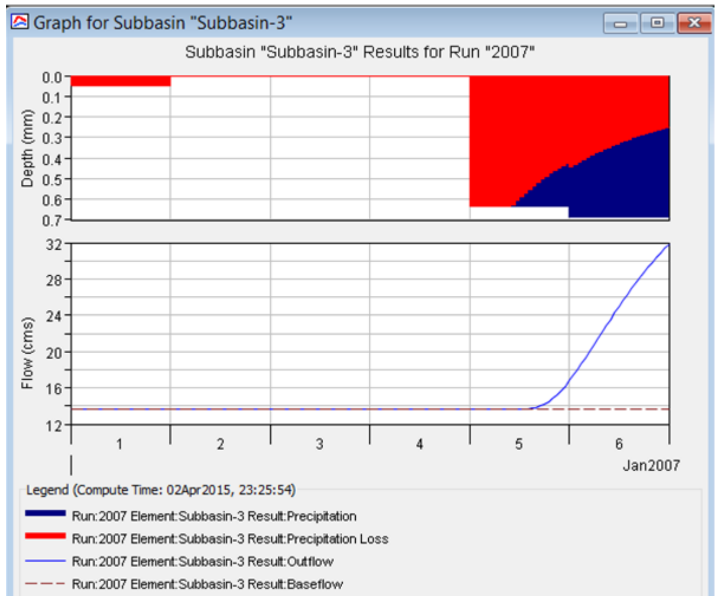
Summary 12



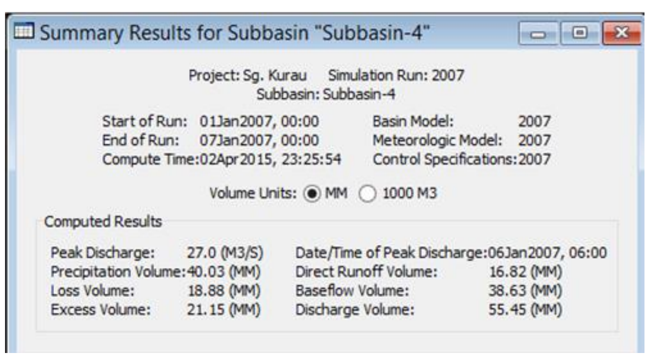
Sub-basin 2



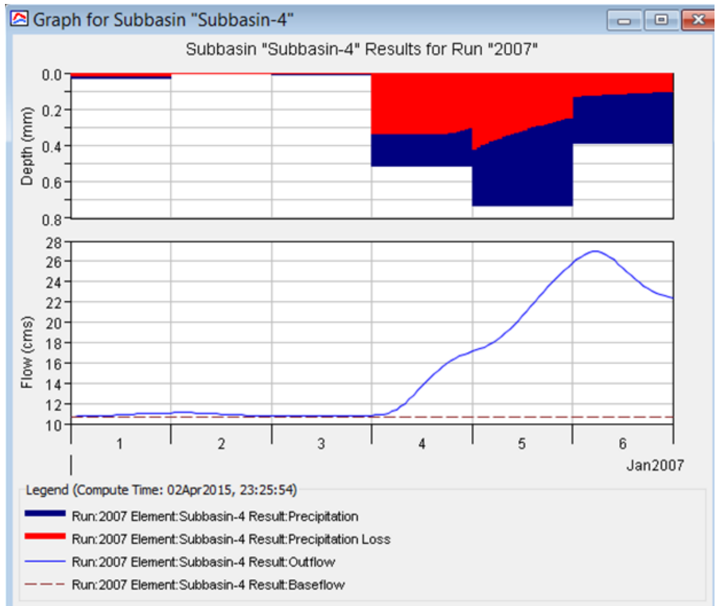
Summary 13



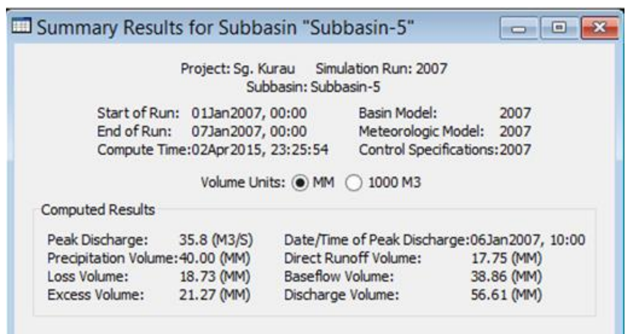
Sub-basin 3



Summary 14



Sub-basin 4



Summary Results for Subbasin "Subbasin-5"

Project: Sg. Kurau Simulation Run: 2007
Subbasin: Subbasin-5

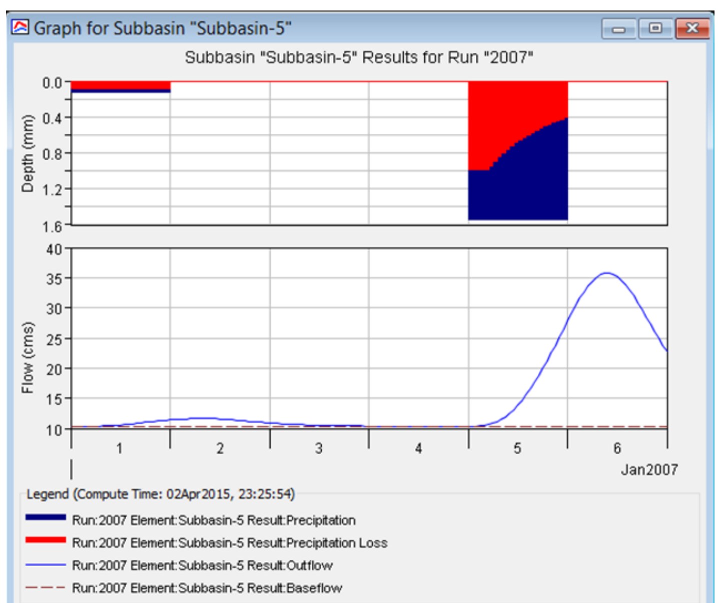
Start of Run: 01Jan2007, 00:00	Basin Model: 2007
End of Run: 07Jan2007, 00:00	Meteorologic Model: 2007
Compute Time: 02Apr2015, 23:25:54	Control Specifications: 2007

Volume Units: MM 1000 M3

Computed Results

Peak Discharge:	35.8 (M3/S)	Date/Time of Peak Discharge:	06Jan2007, 10:00
Precipitation Volume:	40.00 (MM)	Direct Runoff Volume:	17.75 (MM)
Loss Volume:	18.73 (MM)	Baseflow Volume:	38.86 (MM)
Excess Volume:	21.27 (MM)	Discharge Volume:	56.61 (MM)

Summary 15



Sub-basin 5

Global Summary Results for Run "2007"

Project: Sg. Kurau Simulation Run: 2007

Start of Run: 01Jan2007, 00:00 Basin Model: 2007
End of Run: 07Jan2007, 00:00 Meteorologic Model: 2007
Compute Time: 02Apr2015, 23:25:54 Control Specifications: 2007

Show Elements: All Elements Volume Units: (•) MM ( ) 1000 M3 Sorting: Hydrologic

Hydrologic Element	Drainage Area (KM2)	Peak Discharge (M3/S)	Time of Peak	Volume (MM)
Subbasin-1	149.9824	11.1	07Jan2007, 00:00	38.40
Reach-1	149.9824	11.1	07Jan2007, 00:00	38.40
Junction-1	149.9824	11.1	07Jan2007, 00:00	38.40
Subbasin-2	170.5490	46.8	07Jan2007, 00:00	65.73
Junction-2	320.5314	58.0	07Jan2007, 00:00	52.94
Reach-2	320.5314	57.7	06Jan2007, 23:00	52.61
Subbasin-3	189.7627	31.8	07Jan2007, 00:00	42.41
Junction-3	510.2941	89.1	06Jan2007, 23:00	48.82
Reach-3	510.2941	89.1	06Jan2007, 23:00	48.82
Subbasin-4	143.7124	27.0	06Jan2007, 06:00	55.45
Junction-4	654.0065	111.5	06Jan2007, 23:00	50.27
Reach-4	654.0065	111.5	06Jan2007, 23:00	50.13
Subbasin-5	137.6143	35.8	06Jan2007, 10:00	56.61
Junction-5	791.6208	140.4	06Jan2007, 13:00	51.25

Global summary results for hydrologic modelling

d) Calibration results for 2008

Graph below show the generated hydrographs resulted from the calibration process for 2008. Meanwhile, Summary 16 to 20 show the results for sub-basin 1 to 5.

Summary Results for Subbasin "Subbasin-1"

Project: Sg. Kurau Simulation Run: 2008
Subbasin: Subbasin-1

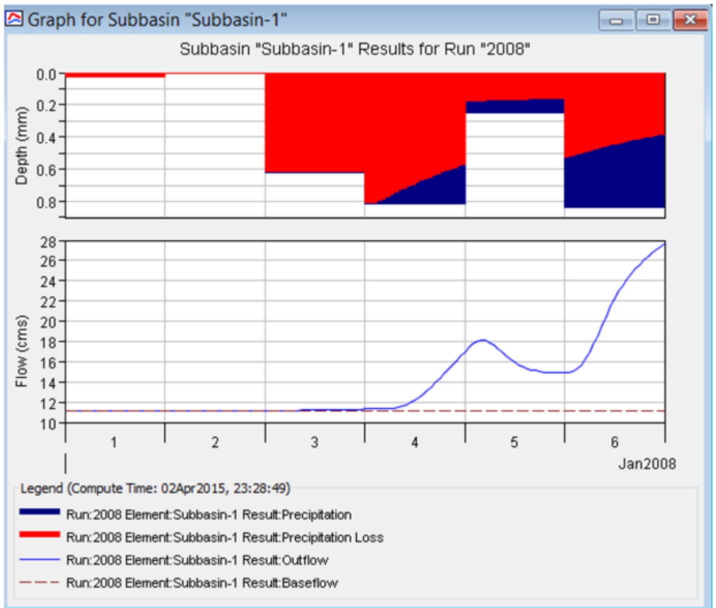
Start of Run: 01Jan2008, 00:00 Basin Model: 2008
End of Run: 07Jan2008, 00:00 Meteorologic Model: 2008
Compute Time: 02Apr2015, 23:28:49 Control Specifications: 2008

Volume Units: (•) MM ( ) 1000 M3

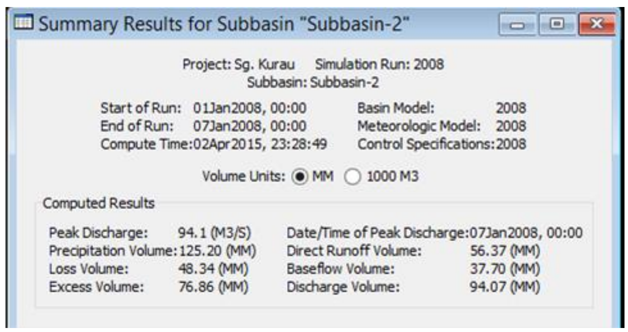
Computed Results

Peak Discharge: 27.7 (M3/S) Date/Time of Peak Discharge: 07Jan2008, 00:00
Precipitation Volume: 61.17 (MM) Direct Runoff Volume: 10.06 (MM)
Loss Volume: 46.64 (MM) Baseflow Volume: 38.39 (MM)
Excess Volume: 14.52 (MM) Discharge Volume: 48.45 (MM)

Summary 16



Sub-basin 1



Summary Results for Subbasin "Subbasin-2"

Project: Sg. Kurau Simulation Run: 2008
Subbasin: Subbasin-2

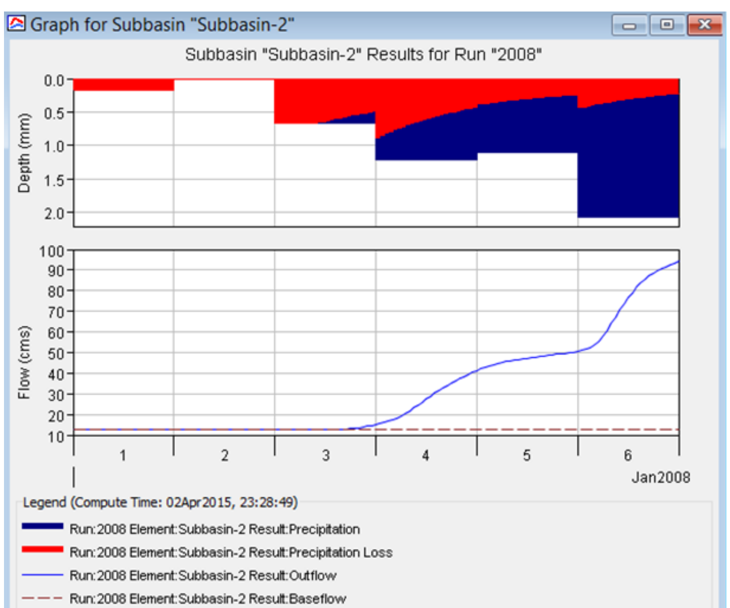
Start of Run:	01Jan2008, 00:00	Basin Model:	2008
End of Run:	07Jan2008, 00:00	Meteorologic Model:	2008
Compute Time:	02Apr2015, 23:28:49	Control Specifications:	2008

Volume Units: (•) MM ( ) 1000 M3

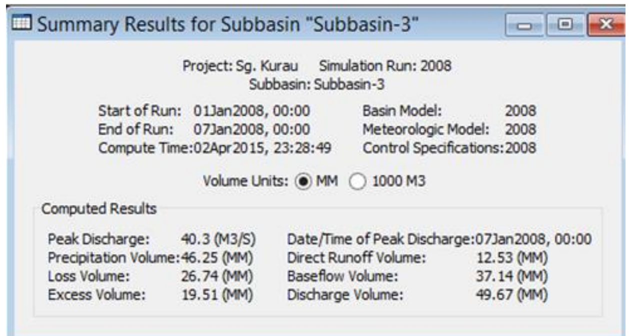
Computed Results

Peak Discharge:	94.1 (M3/S)	Date/Time of Peak Discharge:	07Jan2008, 00:00
Precipitation Volume:	125.20 (MM)	Direct Runoff Volume:	56.37 (MM)
Loss Volume:	48.34 (MM)	Baseflow Volume:	37.70 (MM)
Excess Volume:	76.86 (MM)	Discharge Volume:	94.07 (MM)

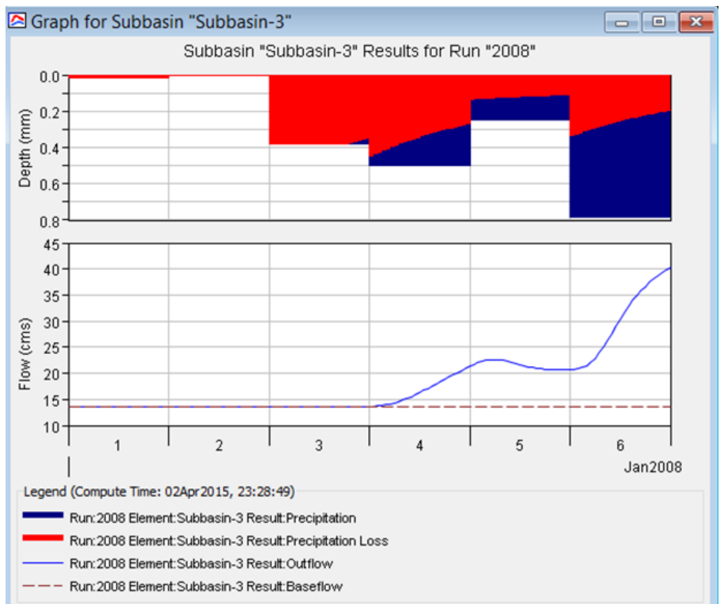
Summary 17



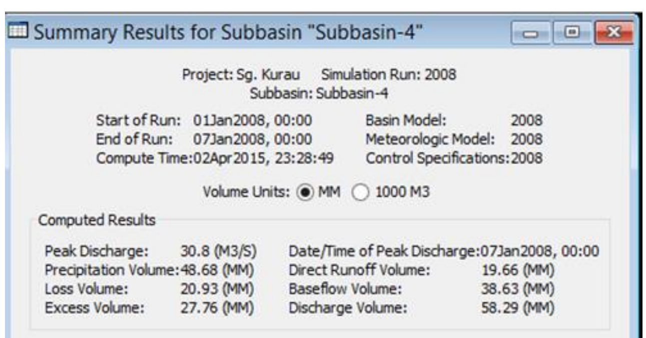
Sub-basin 2



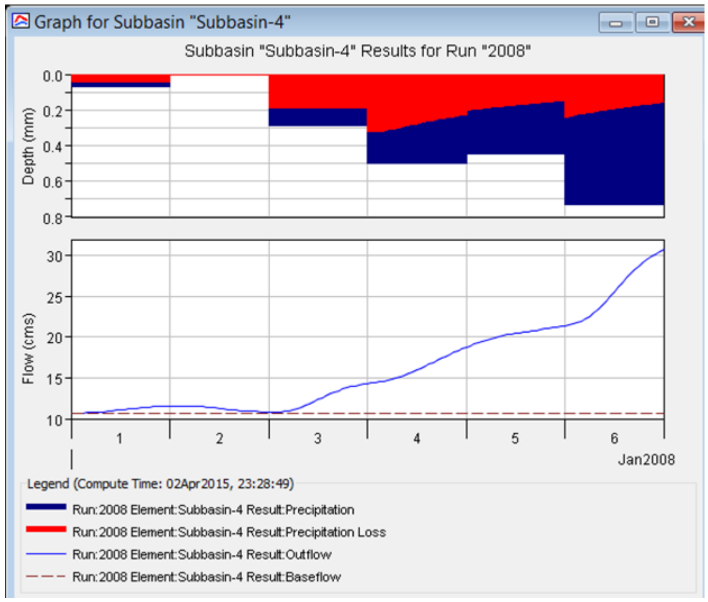
Summary 18



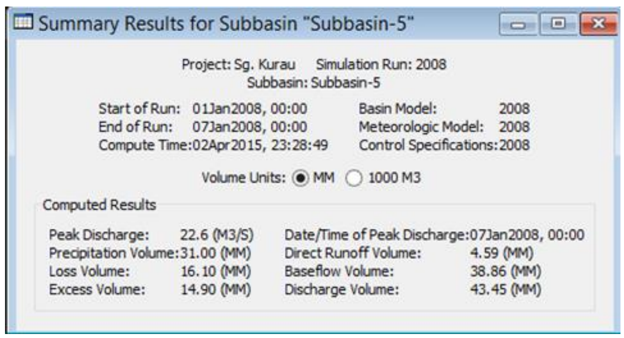
Sub-basin 3



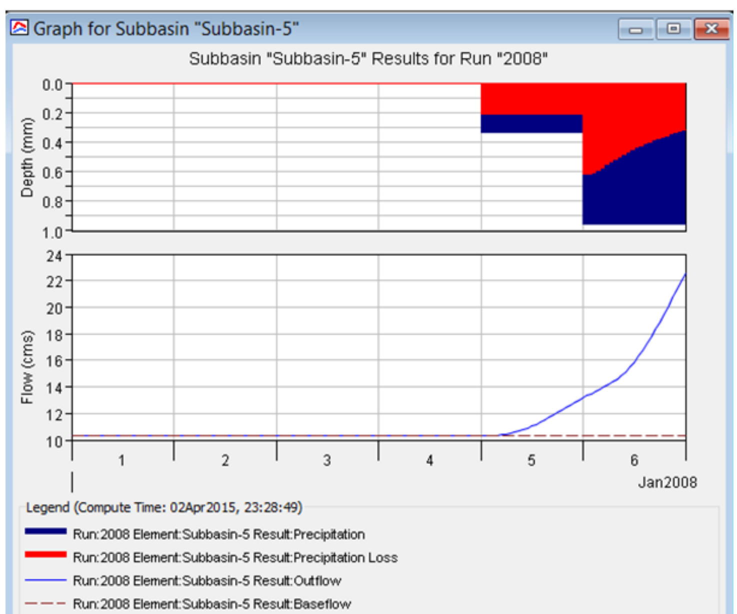
Summary 19



Sub-basin 4



Summary 20



Sub-basin 5

Global Summary Results for Run "2008"

Project: Sg. Kurau   Simulation Run: 2008

Start of Run: 01Jan2008, 00:00   Basin Model: 2008
End of Run: 07Jan2008, 00:00   Meteorologic Model: 2008
Compute Time: 02Apr2015, 23:28:49   Control Specifications: 2008

Show Elements: All Elements   Volume Units: (•) MM ( ) 1000 M3   Sorting: Hydrologic

Hydrologic Element	Drainage Area (KM2)	Peak Discharge (M3/S)	Time of Peak	Volume (MM)
Subbasin-1	149.9824	27.7	07Jan2008, 00:00	48.45
Reach-1	149.9824	27.6	07Jan2008, 00:00	48.30
Junction-1	149.9824	27.7	07Jan2008, 00:00	48.45
Subbasin-2	170.5490	94.1	07Jan2008, 00:00	94.07
Junction-2	320.5314	121.7	07Jan2008, 00:00	72.65
Reach-2	320.5314	121.7	07Jan2008, 00:00	72.65
Subbasin-3	189.7627	40.3	07Jan2008, 00:00	49.67
Junction-3	510.2941	162.0	07Jan2008, 00:00	64.10
Reach-3	510.2941	160.5	06Jan2008, 23:00	63.53
Subbasin-4	143.7124	30.8	07Jan2008, 00:00	58.29
Junction-4	654.0065	191.0	06Jan2008, 23:00	62.38
Reach-4	654.0065	191.0	06Jan2008, 23:00	62.38
Subbasin-5	137.6143	22.6	07Jan2008, 00:00	43.45
Junction-5	791.6208	213.0	06Jan2008, 23:00	59.09

Global summary results for hydrologic modelling

e) Calibration results for 2009

Graph below show the generated hydrographs resulted from the calibration process for 2009. Meanwhile, Summary 21 to 25 show the results for sub-basin 1 to 5.

Summary Results for Subbasin "Subbasin-1"

Project: Sg. Kurau   Simulation Run: 2009
Subbasin: Subbasin-1

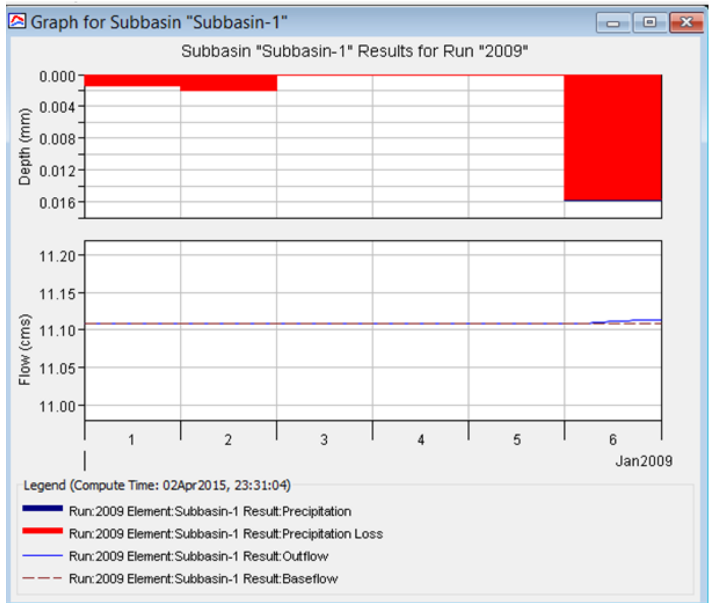
Start of Run: 01Jan2009, 00:00   Basin Model: 2009
End of Run: 07Jan2009, 00:00   Meteorologic Model: 2009
Compute Time: 02Apr2015, 23:31:04   Control Specifications: 2009

Volume Units: (•) MM ( ) 1000 M3

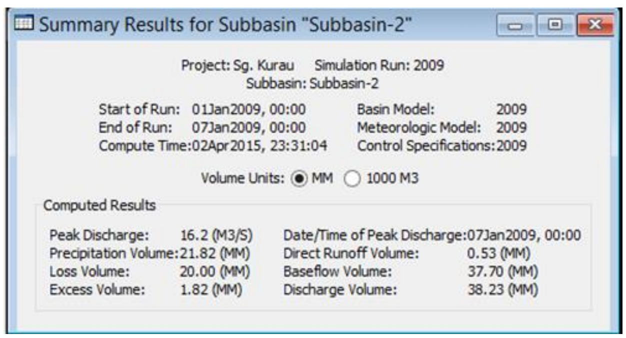
Computed Results

Peak Discharge:	11.1 (M3/S)	Date/Time of Peak Discharge:	07Jan2009, 00:00
Precipitation Volume:	0.46 (MM)	Direct Runoff Volume:	0.00 (MM)
Loss Volume:	0.46 (MM)	Baseflow Volume:	38.39 (MM)
Excess Volume:	0.00 (MM)	Discharge Volume:	38.40 (MM)

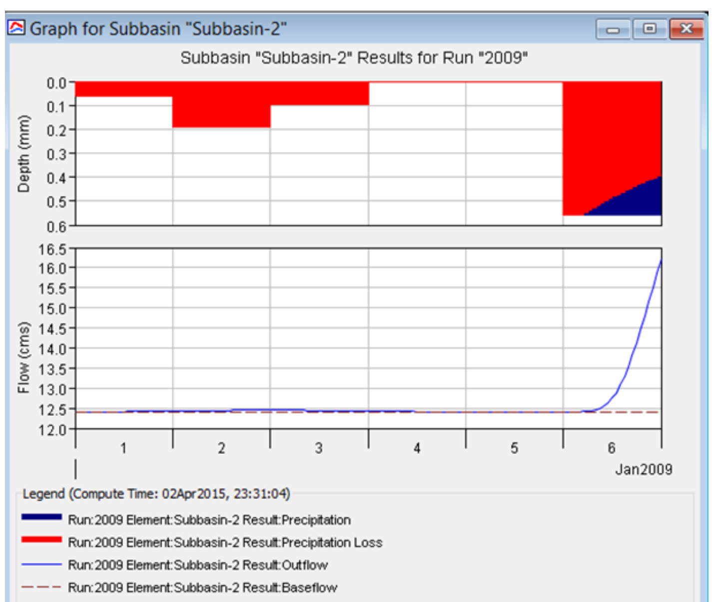
Summary 21



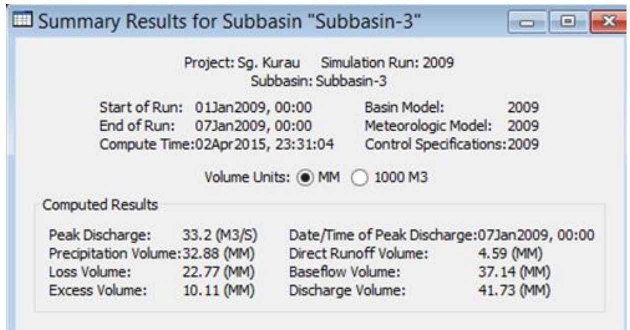
Sub-basin 1



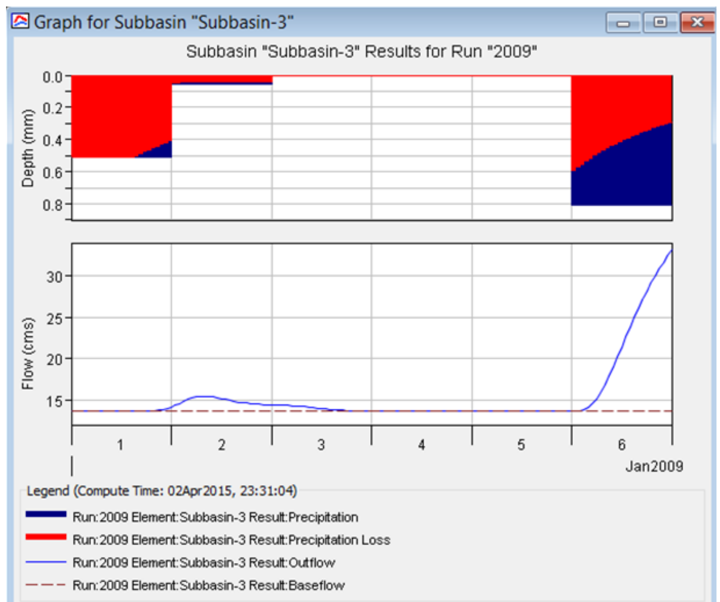
Summary 22



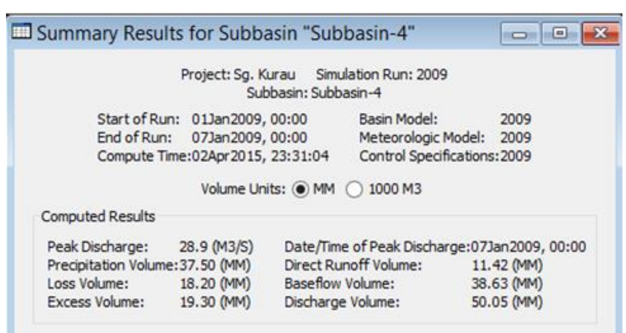
Sub-basin 2



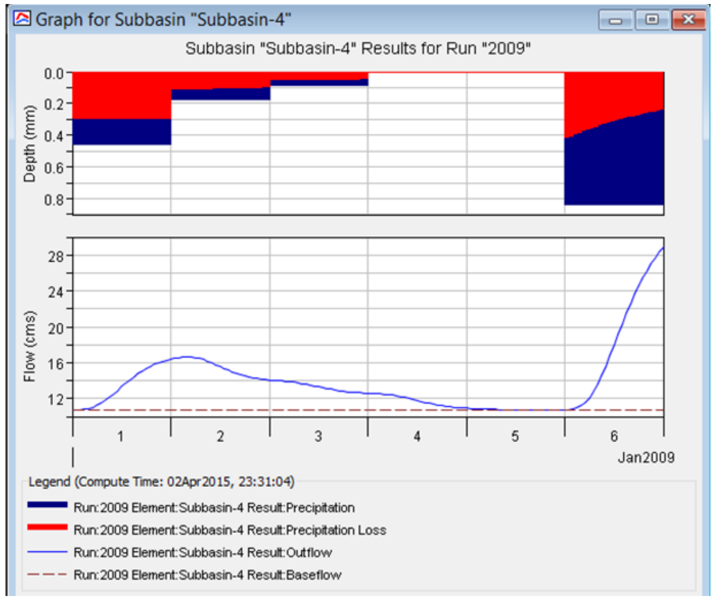
Summary 23



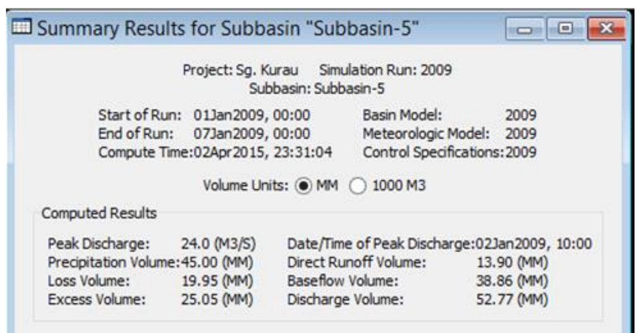
Sub-basin 3



Summary 24



Sub-basin 4


Summary Results for Subbasin "Subbasin-5"

Project: Sg. Kurau Simulation Run: 2009
Subbasin: Subbasin-5

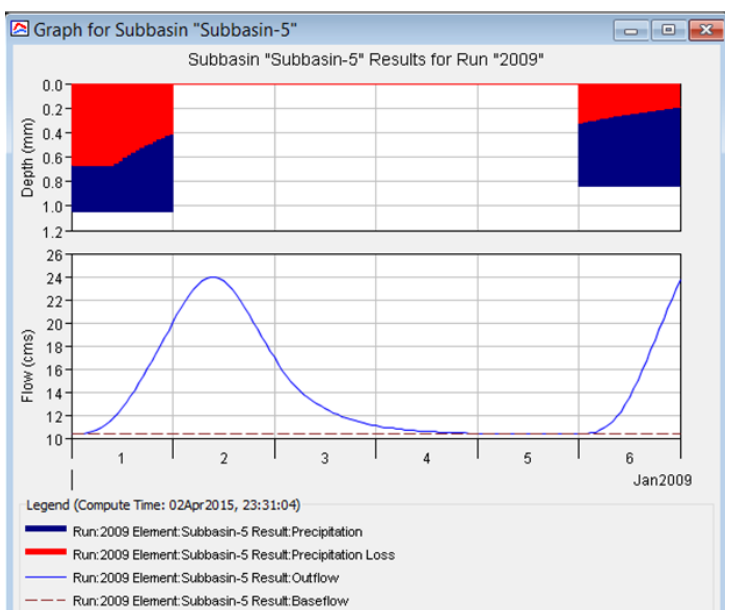
Start of Run: 01Jan2009, 00:00 Basin Model: 2009
End of Run: 07Jan2009, 00:00 Meteorologic Model: 2009
Compute Time:02Apr2015, 23:31:04 Control Specifications:2009

Volume Units: (•) MM ( ) 1000 M3

Computed Results

Peak Discharge:	24.0 (M3/S)	Date/Time of Peak Discharge:	02Jan2009, 10:00
Precipitation Volume:	45.00 (MM)	Direct Runoff Volume:	13.90 (MM)
Loss Volume:	19.95 (MM)	Baseflow Volume:	38.86 (MM)
Excess Volume:	25.05 (MM)	Discharge Volume:	52.77 (MM)

Summary 25



Sub-basin 5

Global Summary Results for Run "2009"

Project: Sg. Kurau Simulation Run: 2009

Start of Run: 01Jan2009, 00:00 Basin Model: 2009
End of Run: 07Jan2009, 00:00 Meteorologic Model: 2009
Compute Time:02Apr2015, 23:31:04 Control Specifications:2009

Show Elements: All Elements Volume Units: ◉ MM ○ 1000 M3 Sorting: Hydrologic

Hydrologic Element	Drainage Area (KM2)	Peak Discharge (M3/S)	Time of Peak	Volume (MM)
Subbasin-1	149.9824	11.1	07Jan2009, 00:00	38.40
Reach-1	149.9824	11.1	07Jan2009, 00:00	38.40
Junction-1	149.9824	11.1	07Jan2009, 00:00	38.40
Subbasin-2	170.5490	16.2	07Jan2009, 00:00	38.23
Junction-2	320.5314	27.3	07Jan2009, 00:00	38.31
Reach-2	320.5314	27.3	07Jan2009, 00:00	38.31
Subbasin-3	189.7627	33.2	07Jan2009, 00:00	41.73
Junction-3	510.2941	60.5	07Jan2009, 00:00	39.58
Reach-3	510.2941	60.5	07Jan2009, 00:00	39.58
Subbasin-4	143.7124	28.9	07Jan2009, 00:00	50.05
Junction-4	654.0065	89.4	07Jan2009, 00:00	41.88
Reach-4	654.0065	89.4	07Jan2009, 00:00	41.88
Subbasin-5	137.6143	24.0	02Jan2009, 10:00	52.77
Junction-5	791.6208	113.1	07Jan2009, 00:00	43.77

Global summary results for hydrologic modelling

f) Calibration results for 2010

Graph below show the generated hydrographs resulted from the calibration process for 2010. Meanwhile, Summary 26 to 30 show the results for sub-basin 1 to 5.

Summary Results for Subbasin "Subbasin-1"

Project: Sg. Kurau Simulation Run: 2010
Subbasin: Subbasin-1

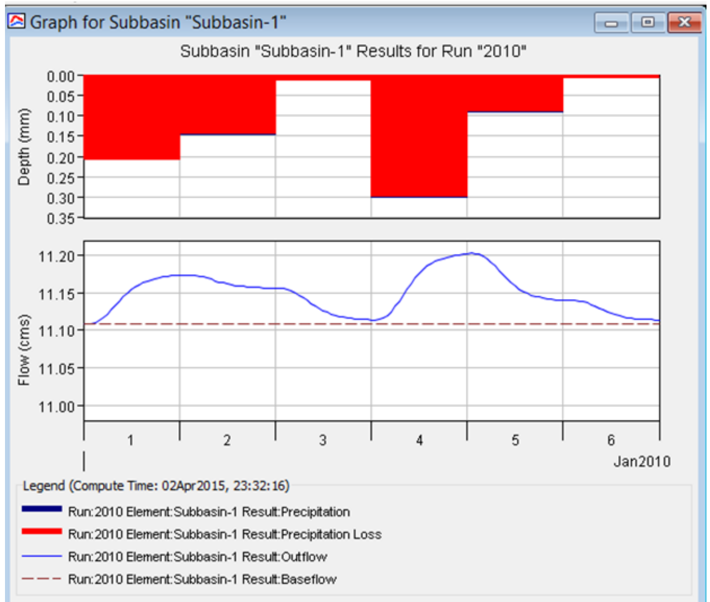
Start of Run: 01Jan2010, 00:00 Basin Model: 2010
End of Run: 07Jan2010, 00:00 Meteorologic Model: 2010
Compute Time:02Apr2015, 23:32:16 Control Specifications:2010

Volume Units: ◉ MM ○ 1000 M3

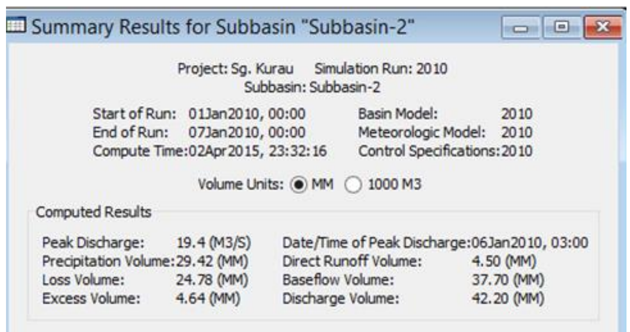
Computed Results

Peak Discharge: 11.2 (M3/S) Date/Time of Peak Discharge:05Jan2010, 01:00
Precipitation Volume:18.31 (MM) Direct Runoff Volume: 0.14 (MM)
Loss Volume: 18.17 (MM) Baseflow Volume: 38.39 (MM)
Excess Volume: 0.15 (MM) Discharge Volume: 38.54 (MM)

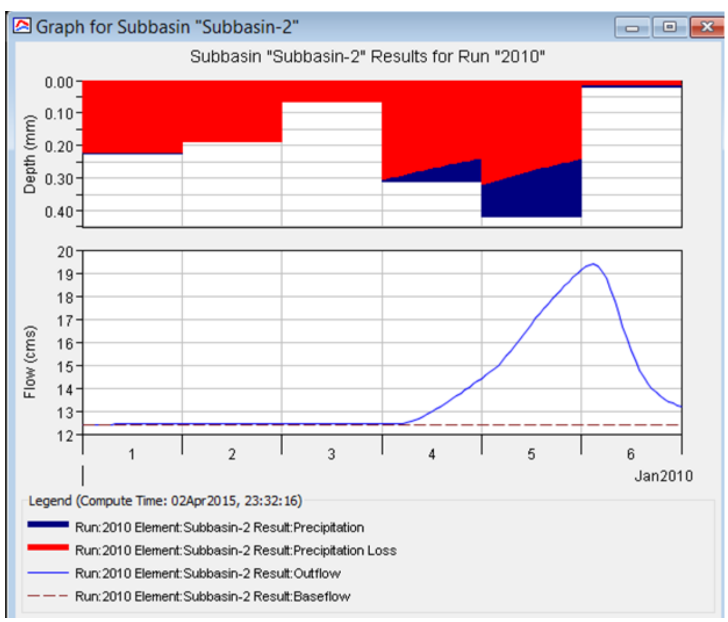
Summary 26



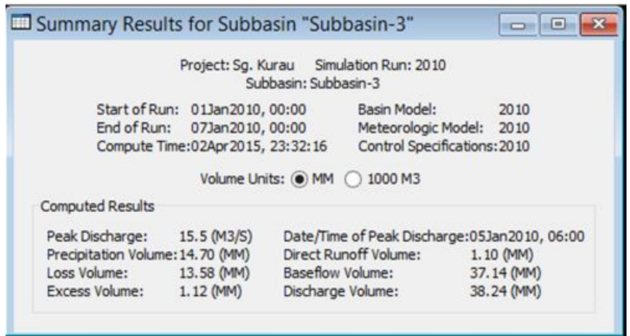
Sub-basin 1



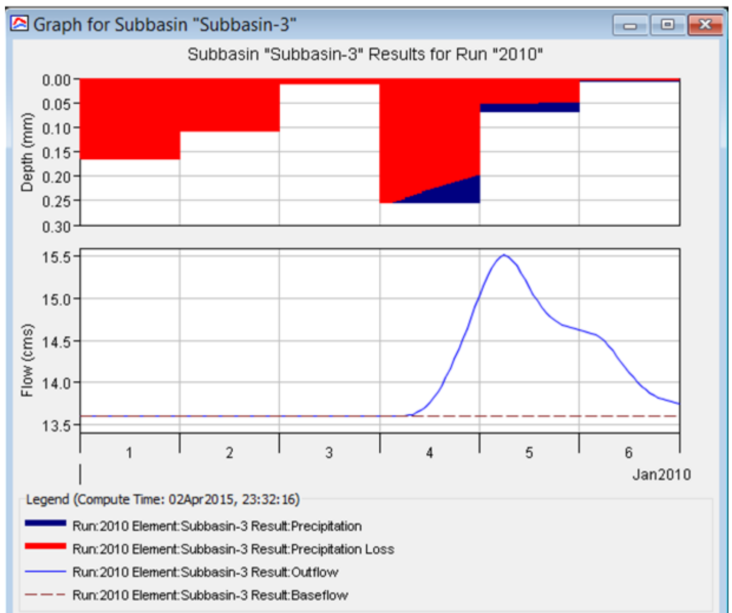
Summary 27



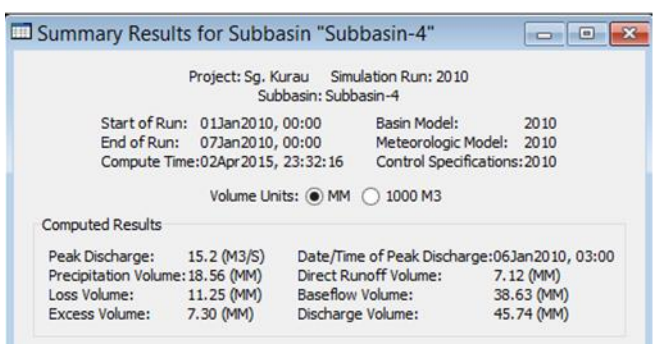
Sub-basin 2



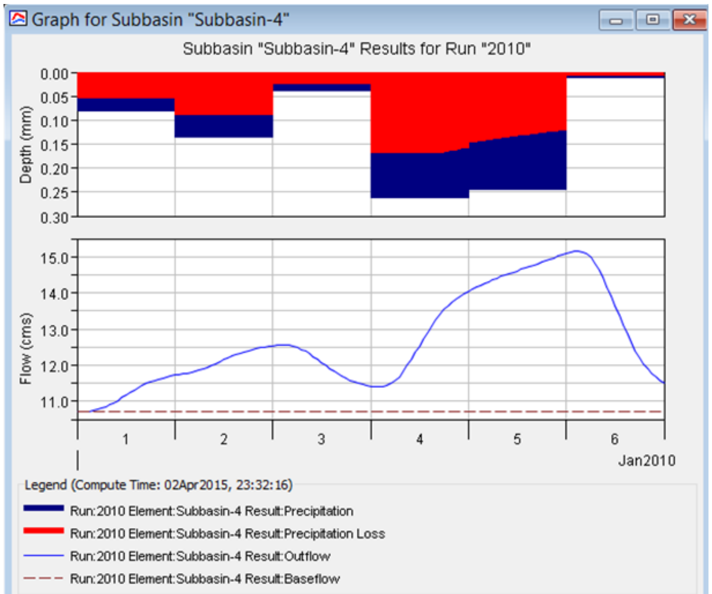
Summary 28



Sub-basin 3



Summary 29



Sub-basin 4

Summary Results for Subbasin "Subbasin-5"

Project: Sg. Kurau Simulation Run: 2010
Subbasin: Subbasin-5

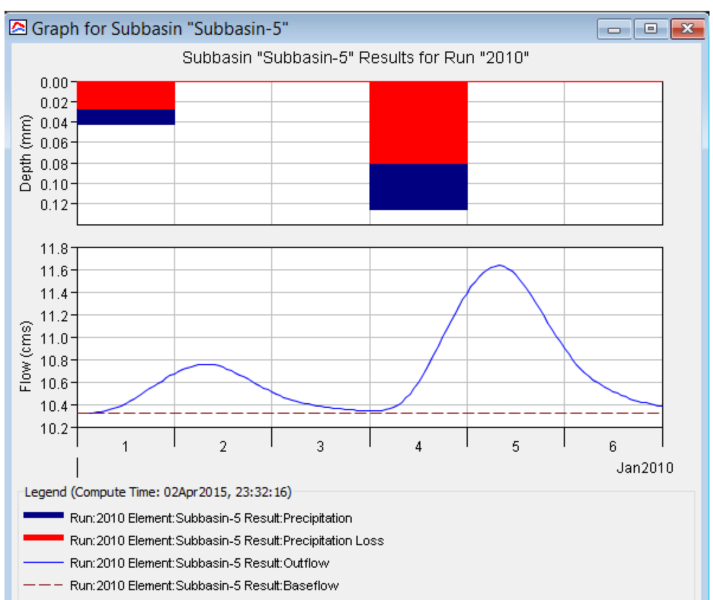
Start of Run: 01Jan2010, 00:00 Basin Model: 2010
End of Run: 07Jan2010, 00:00 Meteorologic Model: 2010
Compute Time: 02Apr2015, 23:32:16 Control Specifications: 2010

Volume Units: (•) MM ( ) 1000 M3

Computed Results

Peak Discharge: 11.6 (M3/S) Date/Time of Peak Discharge: 05Jan2010, 08:00
Precipitation Volume: 4.00 (MM) Direct Runoff Volume: 1.42 (MM)
Loss Volume: 2.56 (MM) Baseflow Volume: 38.86 (MM)
Excess Volume: 1.44 (MM) Discharge Volume: 40.29 (MM)

Summary 30



Sub-basin 5

Global Summary Results for Run "2010"

Project: Sg. Kurau Simulation Run: 2010

Start of Run: 01Jan2010, 00:00 Basin Model: 2010
End of Run: 07Jan2010, 00:00 Meteorologic Model: 2010
Compute Time: 02Apr2015, 23:32:16 Control Specifications: 2010

Show Elements: All Elements Volume Units: (•) MM ( ) 1000 M3 Sorting: Hydrologic

Hydrologic Element	Drainage Area (KM2)	Peak Discharge (M3/S)	Time of Peak	Volume (MM)
Subbasin-1	149.9824	11.2	05Jan2010, 01:00	38.54
Reach-1	149.9824	11.2	05Jan2010, 01:00	38.54
Junction-1	149.9824	11.2	05Jan2010, 01:00	38.54
Subbasin-2	170.5490	19.4	06Jan2010, 03:00	42.20
Junction-2	320.5314	30.5	06Jan2010, 03:00	40.49
Reach-2	320.5314	30.5	06Jan2010, 03:00	40.49
Subbasin-3	189.7627	15.5	05Jan2010, 06:00	38.24
Junction-3	510.2941	45.1	06Jan2010, 02:00	39.65
Reach-3	510.2941	45.1	06Jan2010, 02:00	39.65
Subbasin-4	143.7124	15.2	06Jan2010, 03:00	45.74
Junction-4	654.0065	60.3	06Jan2010, 02:00	40.99
Reach-4	654.0065	60.3	06Jan2010, 02:00	40.99
Subbasin-5	137.6143	11.6	05Jan2010, 08:00	40.29
Junction-5	791.6208	71.1	06Jan2010, 02:00	40.87

Global summary results for hydrologic modelling