Hydrological Study The Upstream Part of Siak Watershed (Case Study: Tapung Kanan River & Tapung Kiri River)

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Abstract. Hydrological analysis is very important in the scientific development of water resources. In the planning and maintenance of civil structures water, the design flood discharge needs to be assessed. Tapung Kanan River and Tapung Kiri River are the upper reaches of the Siak Watershed. The distribution of rainfall around the river fits the gumbel distribution and meets the criteria in the chi square test and the Kolmogorov test. Hyetograph design rain uses the distribution of rain patterns in the Water Research Center with a duration of 3 hours. Based on the reliability of the synthetic unit hydrograph (SUH) ITB-1, the two rivers showed good performance with an average volume accuracy of 98.09% and an average volume/ DRO control ratio of 1,0006. Tapung Kanan River Flood discharge for a period of 10 years obtained 6380.83 m³/ sec with a runoff volume of 22,664,541.84 m³ while Tapung Kiri River Flood discharge for a period of 10 years obtained 6207.29 m³/ sec with a runoff volume of 22,189,284.58 m³.

1. Introduction
The river is a natural channel of water and material flow from upstream to downstream then lower places and finally empties into the sea. In terms of hydrology, the main function of river to collect rainfall and flow it to the sea. The area where river has water is a catchment area, which is usually called the River Flow Area (DPS). Therefore, DPS can be said as a unit in the area where rainwater becomes a river flow [1].

The problem of water catchment areas is generally more emphasized in the review of hydrological components, their effects on one another and their connections to other components. Watershed (DAS) is an area that is restricted to the back of the mountain where the raindrops falling on the area will be accommodated by the ridge of the mountain and flow through small river to main river. Watershed can be regarded as an ecosystem. In an ecosystem there is a connection between a biotic environment, an abiotic environment, and an interfacing cultural environment of various component functions to form a regular entity. The watershed ecosystem consists of three parts, upstream watershed, central watershed and downstream watershed [2].

Siak Watershed is one of watershed in Riau province. This watershed consists of four sub watershed namely Sub Watershed Tapung Kanan, Sub Watershed Tapung Kiri, Sub Watershed Mandau and Sub Watershed Siak Hilir. To control the high river flow downstream and also water building palnning, then it needs to be analyzed upstream hydrological problems. In addition, the last 10 years Riau province has increased forest fires and land, included Siak Watershed. So it needs to be researched hydrological problems in the siak watershed, especially the upstream area (Tapung Kanan River and Tapung Kiri River).

The Data needed is rainfall data at the nearest station, so it will be analyzed shape and pattern of rainfall then determine hyetograph of 10 period to increase capacity of river according criteria flood
control guidelines. Hyetograph is needed to get hydrograph flow so that the rain distribution of hours is needed. Because nothing of automatic rain station data at study location, then the research was used distribution of rain pattern of Puslitbang Air (Wanny Adidarma dkk) and then sensitivity test with the duration of rain 3 hours, 6 hours, and 8 hours.

Watershed characteristic data are also needed in this research because nothing measurement data (observation hydrographs) So synthetic unit hydrograph in used to analyze river discharge including peak flow and peak time. The relationship between hydrographs with the physical condition of watershed can indicate watershed’s response to rainfall input. The watershed response in hydrological concept is called flood hydrograph.

This research about high of river flood hydrograph due to hydrological response (rainfall). So that this research provides a great information in water resource management, water building infrastructure planning and utilization of facilities and infrastructure and as one consideration to the stakeholders in water resource management, so as not to cause excessive damage to the environment and surrounding communities.

2. Method

2.1. Research Location
Siak watershed consists of four Sub-watershed namely Sub watershed Tapung Kanan, Sub watershed Tapung Kiri, Sub watershed Mandau and Sub watershed Siak Hilir. The location of research is conducted on the upstream watershed namely Tapung Kanan sub watershed, and Tapung Kiri sub watershed. For the next, Siak watershed presented in the Figure 1 below:

![Figure 1. Siak Watershed Map (Source: BPPT)](image)

2.2. Research data
This research is divided into three major parts namely data collection and surveys, data analysis (data calculation) and analysis. Data required in this research in the form of secondary data obtained from Balai Wilayah Sungai Sumatera III, Riau Province.

2.3. Analysis and calculation
Secondary data collection first step in research, then analysis and calculations are divided into 2 step. First, rainfall analysis in the form frequency analysis so that good distribution to represent data. Then the distribution is tested square and Kolmogorov. Then analysis of the rain intensity and hyetograph (rain design). The hyetograph (rain design) is needed to get flow hydrograph, so it needs to distribution of rain pattern. because nothing automatic rain station data at site research, then this research was used...
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Second, analysis calculates peak discharge, peak time and volume control of hydrographs with synthetic unit hydrographs of ITB-1 method. The basic concept of the calculation of synthetic unit hydrographs by ITB method was first published by Dantje K. Natakusumah in the National Seminar on Water Resources Engineering in Bandung, 2009. Further through Capacity Improvement Research Program ITB 2010, the method is further developed by D.K. Natakusumah (ITB), W. Hatmoko (Puslitbang Air, Ministry of Public Works) and Dhemi Harlan (ITB). Although this method was developed last compared to other SUH methods, but this method is general so the other methods can be considered as special case.

Calculation of method synthetic unit hydrograph ITB is not developed based on analysis of basic form of SUH field observation, but based on observation on the principle of work, structure, function and how to operate various calculation methods and calculation results of a commonly used synthetic unit hydrograph, all of which states were developed from the results of field observations. The aim to develop a new synthetic unit hydrograph calculation method that can do the same without duplicating other already existing methods.

![Figure 2. Flowchart](image-url)
3. Result and Discussion
Generally, The Synthetic Unit Hydrograph ITB-1 have quite unique parameters. From observation of the working principle and method of operation of other synthetic unit hydrograph methods, this method develops a new method of calculation of common synthetic unit hydrograph and according to principle of time conservation with discharge formula generally and easy to remember. While other methods have the same principle, but each method is derived differently. So that, although the principle is same, there is no general formula of discharge that applies to all and something was missing, when this common formula is important for education, teaching and practical.

Based on the modelling of SUH ITB-1 with watershed characteristic data, volume of Tapung Kanan river and Tapung Kiri river was obtained. In table. 1 indicates that there is a difference between measurement volume and modeling volume. The Tapung Kanan River has measurement volume of 2,431,198 m$^3$, while modelling volume of SUH ITB-1 2,344,384 m$^3$. The accuracy of the model to this volume is 96.30%. The Tapung Kiri River has measurement volume of 2344229 m$^3$, while modelling volume of SUH ITB-1 2,341,404 m$^3$. The accuracy of the model to this volume is 99.88%.

| Watershed | River         | Volume Control | SUH ITB-1 Volume (m$^3$) | Accuracy (%) |
|-----------|---------------|----------------|--------------------------|--------------|
| Siak      | Tapung Kanan  | 2,431,198      | 2,344,384                | 96.30        |
|           | Tapung Kiri   | 2,344,229      | 2,341,404                | 99.88        |

The result of applying unit hydrograph concept, Then value of volume control ratio (Tapung Kanan River and Tapung Kiri River) is close to 1 or maximum error 5% (Table. 2). This can prove that reliability of SUH ITB-1 can be modeled on upstream siak watershed (Tapung Kanan River and Tapung Kiri River). The peak discharge resulted from this modeling on both rivers can be seen in the Table. 3, Figure 4 and Figure 5.

| Watershed | River         | Error Maximal | Volume SUH ITB-1 Ratio | Status       |
|-----------|---------------|---------------|-------------------------|--------------|
| Siak      | Tapung Kanan  | 5%            | 1.000066                | Oke          |
|           | Tapung Kiri   | 5%            | 1.000088                | Oke          |

| Watershed | River         | Q_peak (m$^3$/sec) |
|-----------|---------------|--------------------|
| Siak      | Tapung Kanan  | 39.950             |
|           | Tapung Kiri   | 38.867             |

Figure 3. SUH ITB-1 Watershed Tapung Kanan River
The results of rainfall analysis are input in super position of hydrograph at period of 10 years, so that discharge flooding Peak River Tapung Kanan 6,380.83 m³/sec with a volume runoff 22,664,541.84 m³, while River Tapung Kiri 6,207.29 m³/sec with a volume of runoff 22,189,284.58 m³. The value of hyetograph (rain of design) source from the pattern of rain 3 hours, namely 108.8 mm/hour, 38.4 mm/hour and 12.8 mm/hr. The graph of peak discharge of Tapung Kanan River and Tapung Kiri River can be seen in the following figure.

4. Conclusion
The conclusions of study are:
   a. Synthetic unit hydrograph ITB-1 method for Tapung Kanan river and Tapung Kiri river has good reliability
   b. The 10 year discharge period (superposition hydrograph) shows that Tapung Kanan river is higher discharge than tapung kiri river.
   c. Sustainable watershed management should be done to reduce large discharge runoff.
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