Analysis of The Influence of Reservoirs in Effort Jragung River Flood Reduction

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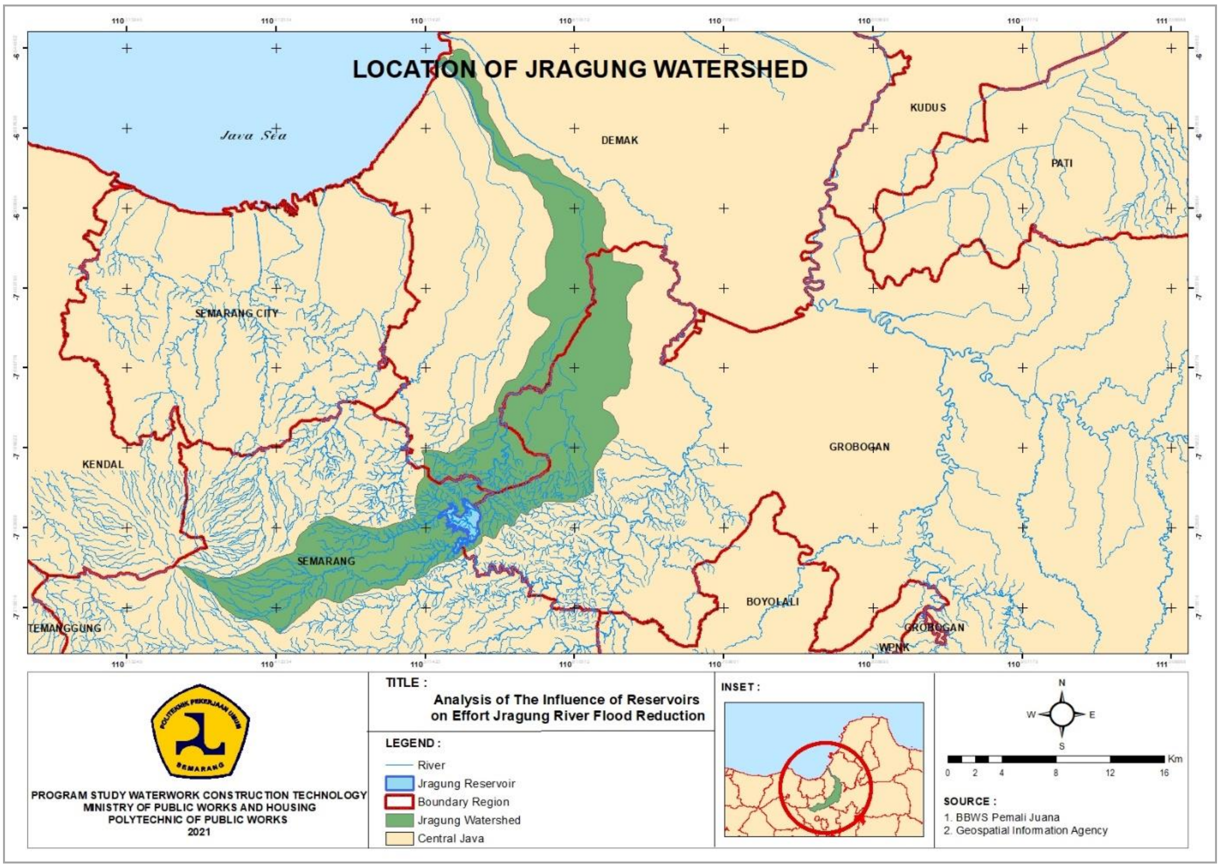
Abstract. The Jragung watershed is located in the districts of Demak and Grobogan, the districts where this research was conducted. The purpose of this study was to analyze the reduction of flood discharge through the design of the upstream catchment area in the form of reservoirs and tanks. The hydrological method used for the calculation of rainfall-runoff is using the HEC-HMS software, and for hydraulics analysis using the 2-Dimensional HEC-RAS to produce a map of the flood area. Based on the hydraulics analysis, it was found that the existing flood discharge (before there was a reservoir) was 500,9 m^3/s in the Wonokerto River as a downstream watershed. After adding the storage area in the upstream part of the watershed, the flood discharge can be reduced to 422.9 m^3/s, or the flood discharge can be reduced to 78.0 m^3/s. Analysis of flood inundation mapping using HEC-RAS in existing conditions resulted in flood inundation covering an area of 3,738.00 ha, and after adding the reservoir it decreased to 3,026.21 ha, thus the inundation area could be reduced by 711.79 hectares or about 19.04%.

1. Introduction

Floods are the cause of loss of property as well as victims, floods can also damage facilities and infrastructure and endanger humans. Based on recent developments in Demak and Grobogan, the amount of runoff and sediment in the Jragung River System is increasing, while the capacity of the riverbed is limited. The increase in water and sediment is an indicator that the land outcrop in front of the Jragung Watershed is getting wider, so that it has an impact on reducing infiltration water and soil erosion. The flow of the Jragung watershed is relatively straight and winding because some watersheds have been normalized to facilitate river flow to the sea. Hydrologically, by looking at the shape of the Jragung watershed, it has relatively moderate flood discharge, but with a longer duration because the shape of the Jragung watershed is in the form of bird feathers and the slope of the riverbed is relatively gentle. The section of the Jragung watershed starting from the Gemboyo River to the Wonokerto River to the downstream (Java Sea estuary) is a morphological land unit, because the topography is flat and is a residential area with the majority for business, such as rice fields and plantations. Further downstream, the Jragung watershed has a wider river valley (between 50-100 m) with a depth of 4-8 meters. The location of the Jragung Watershed is shown in Figure 1.



Source: Analysis, 2021

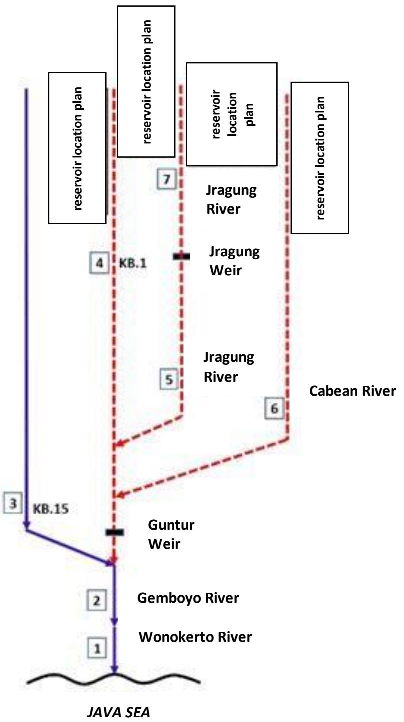
Figure 1. Location of Jragung Watershed

2. Literature Review

2.1. Flood Management

Flood control is a part of water resource management that is specific to rainfall and flood control through flood control dams, or improving carrier systems (rivers, drainage) and preventing potential damage by managing land use and flooded areas (flood plains).

The Jragung River flood control concept was previously integrated with the Tuntang River flood control. The downstream system is the lack of drainage and the same capacity in the Guntur Dam, causing flooding in the upstream of the Dam for a long time (based on information from residents, inundation is more than 2 months). Design diagram for The Jragung Watershed System is shown in Figure 2.



Source: Analysis, 2021

Figure 2. Design Diagram for The Jragung Watershed System

2.2. Basin

Basin is a small reservoir that serves to collect water during excess water in the rainy season and is used when there is a shortage of water in the dry season for many purposes, such as drinking water, irrigation, tourism, flood control etc. Retention planning criteria are to follow Kasiro and Wanny-Rusli:

1. Maximum reservoir height = 10.00 m for fill type, and 6.00 m for gravity or composite type; where the height of the reservoir body is measured from the surface of the deepest foundation excavation to the top of the reservoir body.
2. Maximum reservoir capacity is 100.000 m^3
3. Maximum rainfed area is 100 ha = 1 km^2
4. Dam on this border is a small retention basin.

2.3. Criteria for Selection of Retention Basin

Based on the selection of the location of the reservoir as a water reservoir when there is excess water in the rainy season, it is based on 2 (two) aspects, such as technical aspects and non-technical aspects with certain parameters in each aspect. The parameters are described in Table 1 below.

Table 1. Reservoir Location Selection Parameters

No	Reservoir Location Selection Parameters							
	Technical Aspects				Non-Technical Aspects			
	Topography	Geology	Hidrology	Reservoir Effectiveness	Accessibility	Social and Enviromental	Cost	Benefit
1	Vegetation of the pond floodplain	Type of subgrade foundation	Plan flood discharge	Operation time	Quarry distance from the reservoir site	Number of residents to be relocated	Land acquisition costs	Coverage of irrigation area
2	Volume of stockpile		Effective storage volume	Water costs /m3	Access road to the reservoir site	Land status on site and inundation	Reservoir construction costs	Benefits of raw water
3	The area to release		Sediment volume			The local community's response	Operation and maintenance costs	
4	Abutment slope		Area of DTA reservoir			Moved infrastructure		

Source: Anjasmoro, Suharyanto and Sangkawati. 2016

2.4. Flood Discharge Planning

Hydrological analysis of this research activity is to estimate flood discharge from rainfall data and estimate reliable discharge. Flood discharge with a return period of 1000 years, 10,000 years and PMF which were estimated by statistical methods based on observable daily rainfall data. Flood discharge was analyzed using HEC HMS version 4.1 software specifically for the SCS hydrograph unit technique. Topographic maps, soil type maps and land use maps are needed to analyze flood discharge. Flood flow analysis is needed to analyze the maximum elevation of reservoir water in PMF flood discharge conditions. Thus, it is possible to predict the position of the dam peak elevation and the dimensions of the overflow that are safe from PMF flooding. Flood routing analysis will leverage or assist with HEC HMS software version 4.1. This model or software can analyze the magnitude of the flood discharge and simulate flood tracking in the reservoir. using HEC-RAS as a flood risk management tool, the main purpose of these maps is to determine the level of accuracy of flood and flood area management.

3. Research Methods

3.1. Data Collection

The data needed in this study uses secondary data. The secondary data needed in this study are as shown in Table 2.

Table 2. Secondary Data Required

No.	Data Type	Data Source
1.	Water discharge in the Jragung watershed	- Department Of Public Works, Water Resources And Spatial Planning, Central Java Province - Department of Public Works, Water Resources, Jragung Tuntang
2.	Rainfall	- Department Of Public Works, Water Resources And Spatial Planning, Central Java Province - Department Of Public Works, Water Resources, Jragung Tuntang - Department Of Pemali Juana Watershed, Ministry Of Public Work And Housing
3.	Watershed Map	- Department of Pemali Juana Watershed, Ministry Of Public Work And Housing
4.	Tidal	- Department of Pemali Juana Watershed, Ministry Of Public Work And Housing
5.	River section (cross section, long section, layout)	- Department of Pemali Juana Watershed, Ministry Of Public Work And Housing
6.	Jragung Weir AWLR Data	- Department of Pemali Juana Watershed, Ministry Of Public Work And Housing
7.	Jratunseluna River Basin Planning and Management Pattern	- Department of Pemali Juana Watershed, Ministry Of Public Work And Housing

3.2. Analysis Method

Before carrying out a hydrological analysis, it is necessary to determine the rain station, rain data and catchment area. In the hydrological analysis, the steps to determine the Flood Discharge Plan will be discussed. The steps for determining the flood discharge are calculating the regional average rainfall, the planned rainfall, conducting an alignment test to determine the method that meets the distribution test, calculating the rainfall intensity and the planned flood discharge.

3.2.1. *Calculation of Regional Average Rainfall*

The analysis of rainfall data was performed using the Thiessen polygon method. The Thiessen polygon method is used when the area of influence and the average rainfall per station are different, the rain recording data uses the Tanjung Mas rain station. This method uses the area represented by the rainfall station as an important factor in calculating the average rainfall.

3.2.2. *Rainfall Plan*

- Frequency Distribution
  1) Normal Method,
  2) Log Normal Method,
  3) Log Pearson III Method,
  4) Gumbel Method,
  5) Rain Data Alignment Test Method.
- Alignment Test:
  1) Compatibility test with Chi Square Distribution Test
  2) Smirnov - Kolmogorov Test
- Rainfall intensity

3.2.3. *Analysis Flood Discharge*

In general, the procedure for using the HEC-HMS software is as follows.

a. Creating Component Models
   1) Basin model
   2) Meteorology model
   3) Control specification
b. Creating Time Series Data, such as:
   1) Rainfall time series data,
   2) Discharge time series data.
c. Creating Paired Data (if necessary), such as:
   1) Unit hydrograph,
   2) Correlation with elevation-volume.
d. After the component model has been created, the next process is filling out the components of each model.
   1) Creating a Basin Model,
   2) Select and fill in the Basin Model
   3) Fill out the meteorological model,
   4) Filling control specifications,
   5) Filling time series data,
   6) Fill in the paired data,
   7) Checking data,
   8) Simulation,
   9) Calibration (if discharge data available)

3.2.4. *Flood Inundation Mapping*

Steps to model 2D flow:

a. Terrain data setup from Ras Mapper.
   This arrangement aims to create images and projections by inputting terrain data on the Ras Mapper, and the result is an image that is in accordance with the research location.
b. 2-dimensional flow area setting.

The purpose of this preparation is to create a mesh by digitizing around the river to form a closed polygon. In order to determine the size of the mesh generated by the computed points periodically with all the breaklines, if an error occurs, it is possible to delete the error points with the delete points. The result of this process is a mesh with the number of cells depending on the size of the grid.

c. Boundary Condition Preparation.
This setup is intended to generate upstream and downstream boundaries in the simulation using the SA/2D range BC line generated from this process, namely upstream and downstream.
Flow scenario selection the purpose of this selection is to determine the scenario used for the simulation. Two flow scenarios are used in the HEC-RAS software, namely steady flow and unsteady flow.
Running process, The purpose of this process is to run a simulation, while the resulting model is a pool that will occur. In this case, the simulation on the running data process is an unsteady simulation that is used for 24 hours.

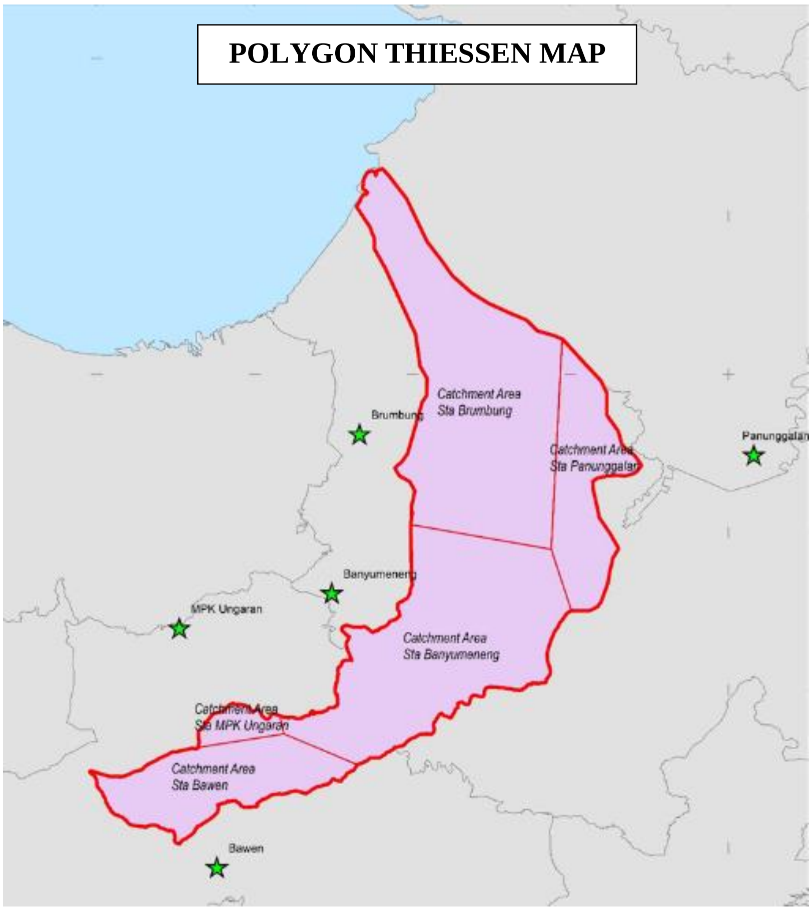
4. Analysis

4.1. Hydrological Analysis

Hydrological analysis are required for planning the improvement of the Jragung River. Hydrological analysis is used to obtain the expected flood discharge.

4.2. Rainfall Distribution

The effect of the rain station on each section according to the Thiessen method is shown in Figure 3, and rainfall data on the Jragung watershed is shown in Table 3.



Source: Analysis, 2021

Figure 3. The effect of rain according to the Thiessen method

Tabel 3 Rainfall of Jragung Watershed

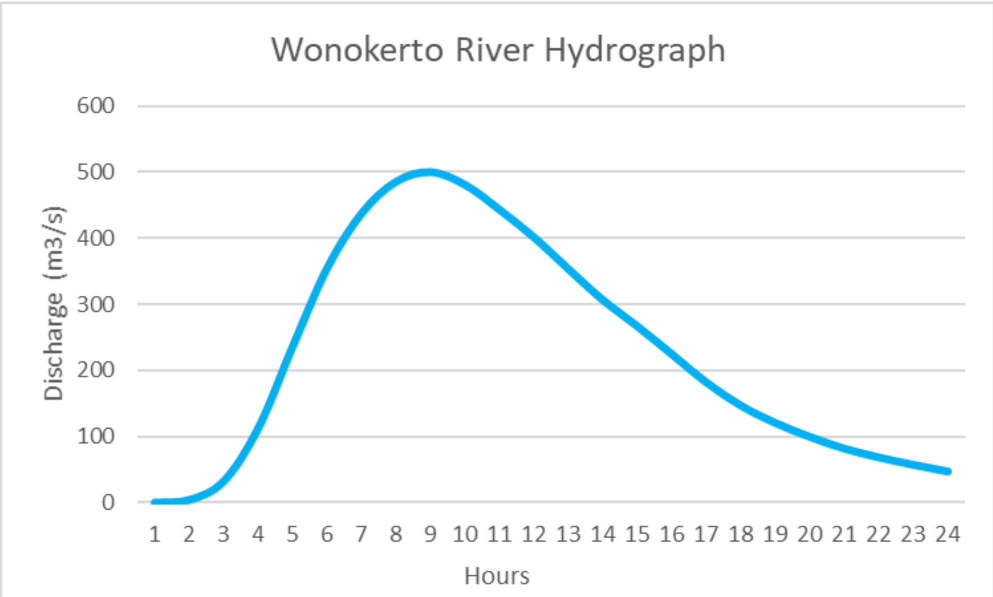
Year	Rain Area Jragung Watershed (mm)
2005	43,78
2006	80,51
2007	55,29
2008	66,47
2009	71,73
2010	75,71
2011	48,66
2012	40,01
2013	56,34
2014	107,49
2015	81,30
2016	62,79

Source: Analysis, 2021

4.3. Planned Flood Discharge Analysis

4.3.1. *Planned Flood Model Existing Condition*

In running the HEC-HMS model in the existing condition, it is carried out in the Jragung watershed without a reservoir (existing condition). Observations of the results of the running model were taken in the Wonokerto River downstream of the Jragung watershed. In Figure 4 it can be seen that the peak discharge of Wonokerto River is 500.9 m^3/s.

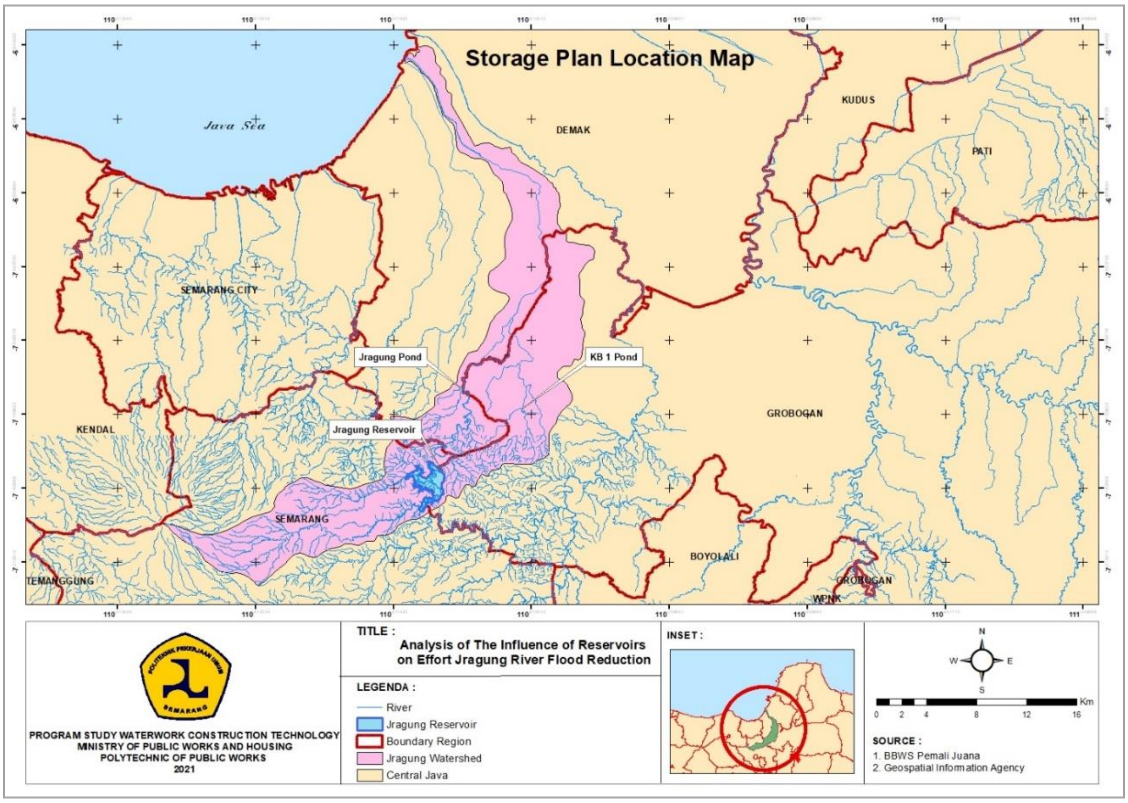


Source: Analysis, 2021

Figure 4. Existing Condition of Wonokerto River Flood Hydrograph

4.3.2. *Planned Flood Model with Reservoir*

According to the plan, the addition of reservoirs includes the Jragung dam, KB 1 and Jragung reservoirs. Storage plan location map is shown in Figure 7.

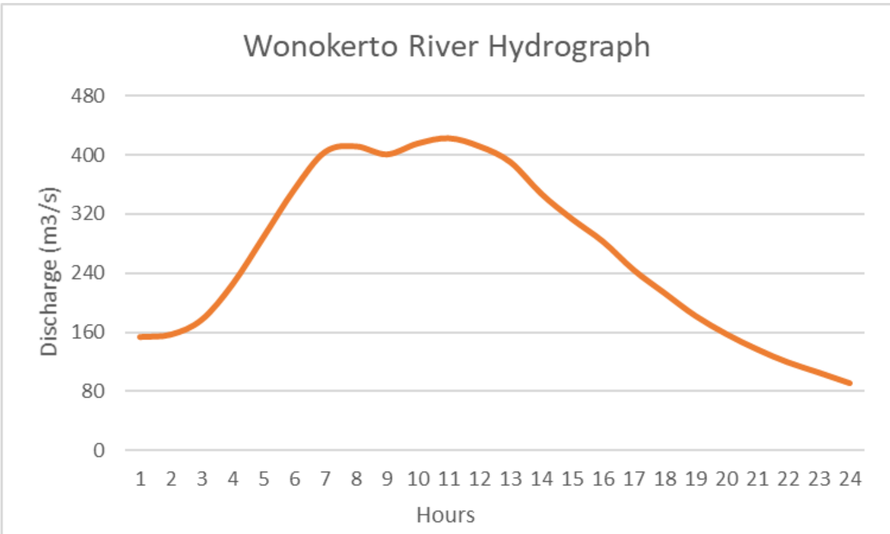


Source: Analysis, 2021

Figure 5. Storage Plan Location Map

The following is the storage capacity of reservoirs and dams in the Jragung River system. The storage capacity of the Jragung dam is 142.8 million m^3, the retention of the Jragung reservoir is 0.47 million m^3, and the retention of the KB 1 reservoir is 0.31 million m^3.

In running the HEC-HMS model in the state after adding the number of reservoirs. Observations of the results from the model were taken in the Wonokerto River downstream of the Jragung watershed. In Figure 6, it can be seen that the peak discharge of the Wonokerto River decreased to 422.9 m^3/s.



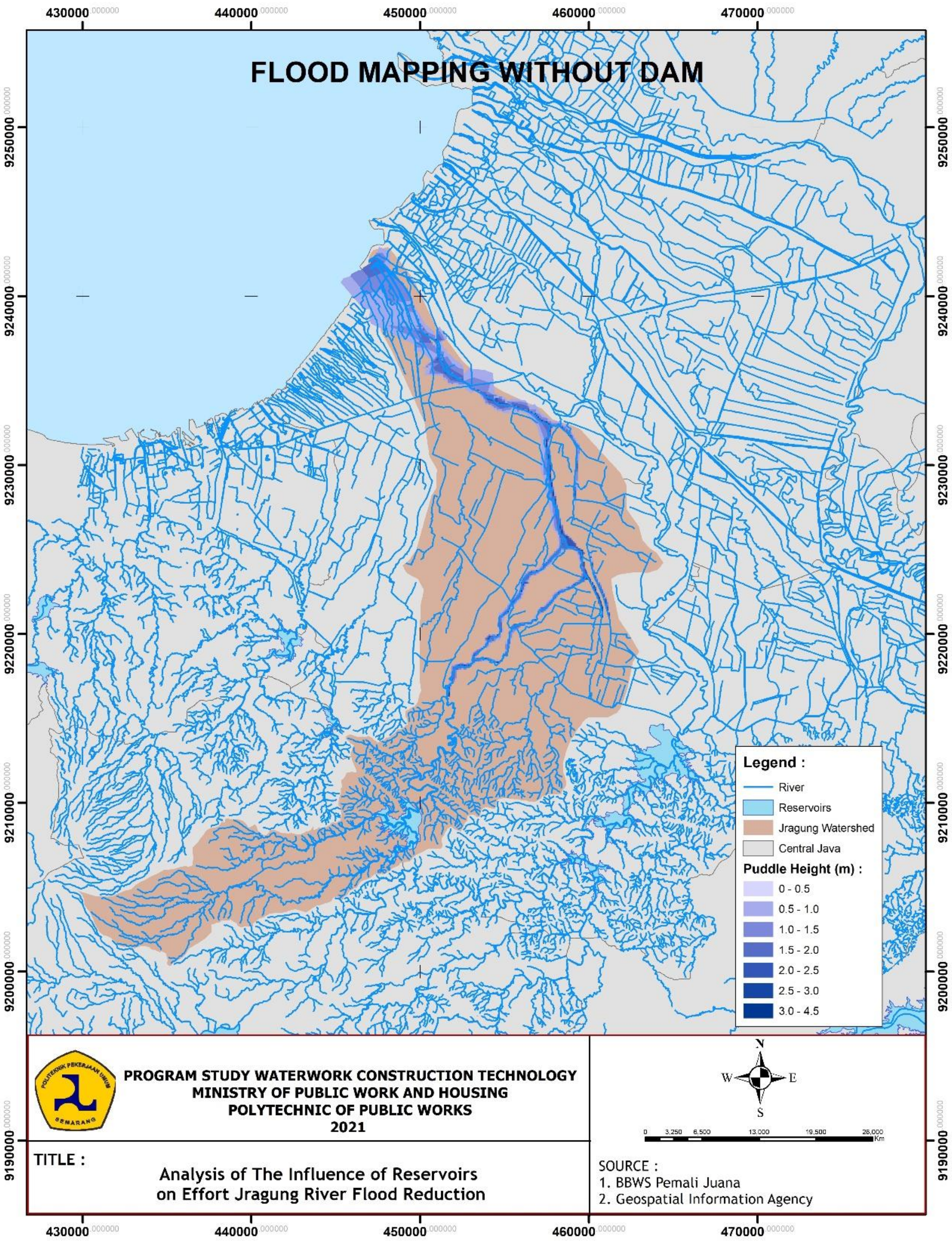
Source: Anayisis, 2021

Figure 6. Wonokerto River Flood Hydrograph with a Reservoir

4.4. Flood Inundation Analysis

4.4.1. *Existing Condition*

Based on the results of flood inundation analysis using HECRAS 5.03 the area of flood inundation with conditions without reservoirs is 3,738 hectares with the majority of inundation areas located downstream of the watershed or on the Wonokerto River. Map of flood inundation existing condition is shown in Figure 7.

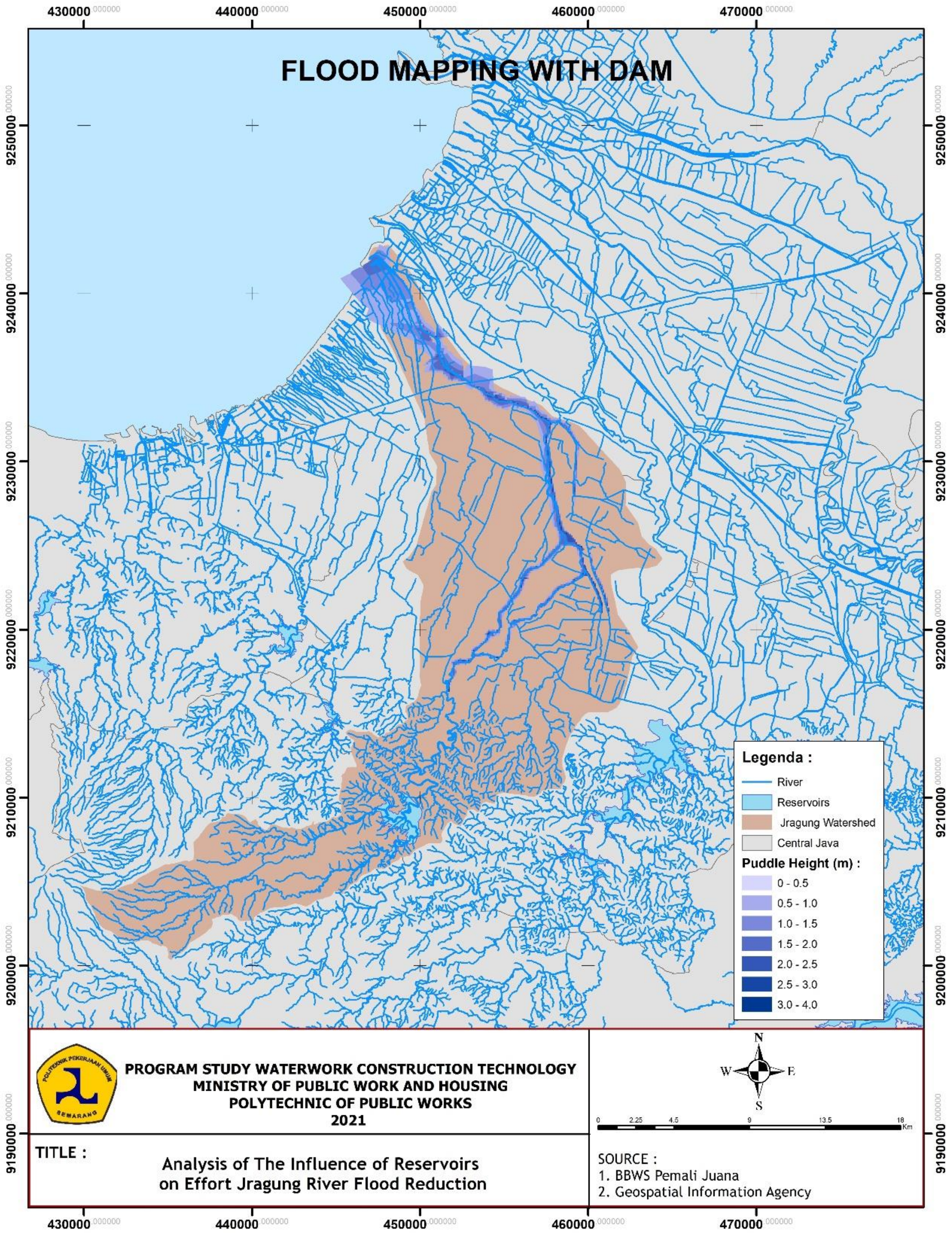


Source: Analysis, 2021

Figure 7. Map of Flood Inundation Existing Condition

4.4.2. *Condition With Reservoir*

Based on the flood inundation analysis using HECRAS 5.03 with the presence of a reservoir, it was able to reduce the flood inundation area from 3,738.00 hectares to 3,026.21 hectares. Thus, the inundation area can be reduced by 711.79 hectares or about 19.04%. Map of flood inundation existing condition is shown in Figure 8.



Source: Analysis, 2021

Figure 8. Map of Flood Inundation With Reservoirs

5. Conclusion

- Flood discharge analysis using HEC-HMS under existing conditions revealed flood discharge of 500.9 m^3/sec in the Wonokerto River as a downstream catchment. After adding a reservoir in the upstream catchment, the flood discharge can be reduced to 422.9 m^3/s, which corresponds to a flood reduction of 78.0 m^3/s.
- Analysis of flood inundation mapping using HEC-RAS in existing conditions resulted in flood inundation covering an area of 3,738.00 ha, and after adding the reservoir it decreased to 3,026.21 ha, thus the inundation area could be reduced by 711.79 ha or about 19.04%.

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