FLOOD DISASTER MITIGATION AS REVEALED BY CAWANG-MANGGARAI RIVER IMPROVEMENT OF CILIWUNG RIVER

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ABSTRACT

Ciliwung River that flows from Bogor highland is one of the rivers traversing several lowlands in Jakarta. Having the lowland topographic condition, the area along Ciliwung River is potentially inundated. Flood disaster that occurred in early 2002 in Jakarta caused a wide inundation area (with approximately 25% area of Jakarta Province being flooded), serious damages in properties, and also loss of life.

This paper presents hydraulic routing analysis over Ciliwung River within the Cawang - Manggarai reach through several scenarios and further simulation using of HEC RAS 3.1 version Software. From the several scenarios and simulations, a conclusion among scenarios which results the lowest water surface elevation was withdrawn.

The final result of this simulation shows that Scenario 3 gives the lowest water surface elevation profile. Scenario 3 is subjected to river normalization, revetment works along the river, and also flood control structure improvement through the additional sluice gate on Manggarai Barrage. This scenario results 167 cm, 163 cm, 172 cm, 179 cm, 167 cm and 171 cm or 17,60%, 17,16%, 18,09%, 18,76%, 17,38% and 17,72% of maximum water level reduction respectively over cross section number S 20 to S 25, for several simulations with 100 year of design discharge.

Keywords: Simulation, river improvement, flood water surface elevation.

1 INTRODUCTION

Flood in Jakarta Province is a classic problem taking a part in most of urban people life. It is caused by unfavorable topographic condition of Jakarta where some of areas are floodplain. Jakarta is traversed by 13 rivers flowing from upland located in the south of Jakarta to the lowland area in the north. Ciliwung River is one of 13 rivers which always overflows to the vicinity. Kampung Melayu and Bukit Duri are identified as flood prone area due to overflow of Ciliwung River (Priyambodo, 2001). Morphology of Jakarta is dominated by low land area and traversed by some rivers flowing into Jakarta Bay. It causes Jakarta becomes potentially inundated. This problem becomes so complex since rainfall intensity tends to be high so that flood inundation in Jakarta is hard to alleviate. Characteristics of inundation (depth and duration) caused by rainfall are affected by drainage system (Legono et al., 2002) concerning that micro drainage system is the main water ways. Micro drainage system is commonly an open channel conveying water by gravitational force. Micro drainage system often does not work well since the inlet system is clogged due to rubbish or building ruins (Legono et al., 2002). The overland flow from micro drainage system is conveyed to macro drainage system (depends on its physiographic land), macro sub drainage, or surface accumulation system. Final terminal of this drainage system is commonly either natural river or artificial channel conveying water to the sea by gravity flow mechanism.

The issue and problem encountered by the surrounding area of Ciliwung River (see Figure 1) are:

a) This region is inhabited by less than 1 million people, and approximately 100.000 people live in slum area along riverbank.
b) The river overflows from its banks then inundates the surrounding residential area.

Some hydraulic routings were applied to analyze the height of Ciliwung River water level from Cawang to Manggarai sluice gate through various scenarios.

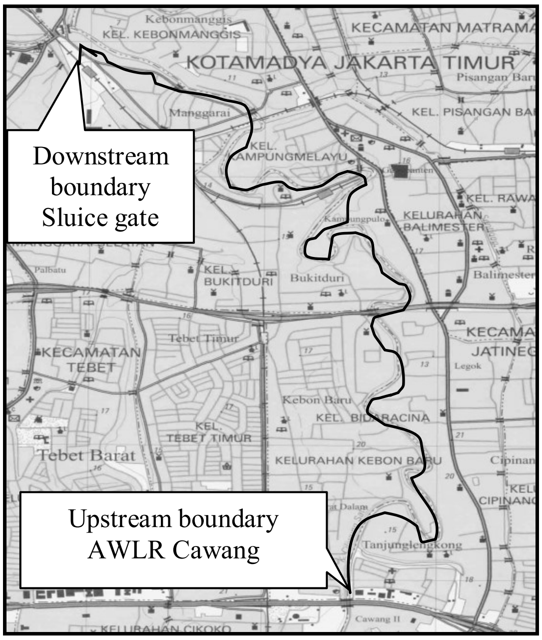

Figure 1. Ciliwung River (Bakosurtanal, 2001).

2 STREAMFLOW ROUTING OF CILIWUNG RIVER ON CAWANG-MANGGARAI REACH

2.1 HEC RAS Software Version 3.1

The research uses HEC RAS software Version 3.1. HEC RAS (Hydrologic Engineering Center's River Analysis System) is used for developing one dimensional flow simulation. Its graphic display gives simplicity to user. It also provides several kinds of hydraulic structure modeling. This numerical model applies basic equation as follows (HEC, 2002):

a) Continuity equation

$$\frac{\partial Q}{\partial x} + \frac{\partial A}{\partial t} = q_l \tag{1}$$

where Q is flow discharge (m^3/s), x is horizontal distance (m), A is wetted surface area (m^2), t is time (s), q_l is lateral flow discharge from right and left side of streamflow (m^3/s/m).

b) Momentum equation

$$\frac{\partial Q}{\partial t} + \frac{\partial}{\partial x}\left(\alpha \frac{Q^2}{A}\right) + g\,A\left[\frac{\partial y}{\partial x} + S_f\right] = 0$$
$$\frac{\partial Q}{\partial i} + 2\alpha \frac{Q}{A}\frac{\partial Q}{\partial x} - \alpha\left[\frac{Q}{A}\right]^2 \frac{\partial A}{\partial x} + g\,A\frac{\partial y}{\partial x} + g\,A\,S_f = 0 \tag{2}$$

where α is Coriolis coefficient, g is acceleration due to gravity (m/s^2), S_f is slope of energy, y is water elevation (m)

c) Flow through gate

$$Q = C\,W\,B\sqrt{2\,g\,H} \tag{3}$$

where H is energy head in the upstream over sill of spillway ($Z_U - Z_{sp}$), Z_u is energy head in the upstream (m), Z_{sp} is height of sill (m), C is discharge coefficient with typical value 0.5 – 0.7, W is gate width (m), B is gate opening (m).

2.2 River geometry

The required data consists of cross section, longitudinal section, and riverbed slope. Those are gained from Master Project of Regional Development in Ciliwung Cisadane River (PT. Satyakarsa Mudatama, 1997). Research sites are located at Manggarai sluice gate (S 0), Jl. KH. Abdullah Syafei (S67) Bridge, Bukit Duri Puteran and Kampung Melayu Kecil (S 20 - S 25).

2.3 Ciliwung River

The research uses flow hydrograph at a control point namely Manggarai gate (Agustina, 2002) with 2, 5, 10, 25, 50 and 100 year flood.

Tabel 1. Design discharge of Ciliwung River (Agustina, 2002)

Return Period (year)	Flow Discharge m^3/s)
2	272.33
5	328.69
10	364.38
25	413.02
50	449.10
100	484.92

3 RESEARCH METHODOLOGY

3.1 Model Scheme

Scheme of River (see Figure 2) is based on river geometry data comprising distance between adjacent points, elevation, reach length, Manning coefficient, contraction and expansion coefficient. Then, those parameters are inputted to software through geometry data editor.

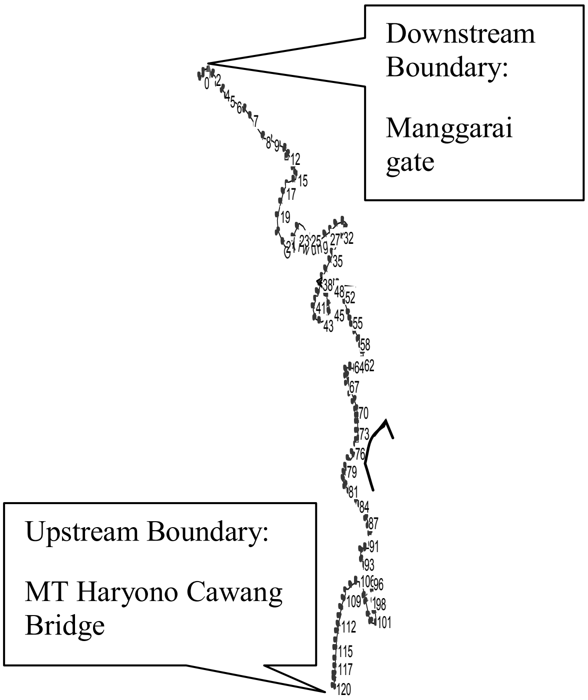

Figure 2. Scheme of Ciliwung River within Cawang-Manggarai Reach.

3.2 Boundary Condition and Initial Condition

Simulation uses flow hydrograph of Manggarai control point as upstream boundary condition (see Figure 3), gate opening as downstream boundary condition and base flow as initial condition. About 90% of design discharge is assumed to flow through upstream boundary condition and the rest flows as lateral inflow through micro drainage in the left and right side of the river. Gate opening data is obtained from field observation. Initial condition is assumed equal to base flow.

3.3 Simulation running Process

Simulation running is conducted by considering some conditions:

a) River normalization, either expanding in cross sections or in reaches (Satyakarsa Mudatama, PT., 1997), or channel diversion.
b) Improvement in flood control structure through additional gate (JICA-Nikken, 1997)

Simulation is varied in several conditions. There are existing condition, Scenario 1, Scenario 2, and Scenario 4 with 2, 5, 10, 25, 50, and 100 year flood. On running process, *plan* data will be automatically shown. *Plan* is a feature from such data set required for running. It comprises geometry and flow data.

4 ANALYSIS

Basically, simulation was carried out according to two conditions, i.e. existing condition, and subsequent condition (after being improved with normalization and additional flood control structures).

4.1 Existing condition

This condition assumes that there are no changes implemented to the actual condition. Manggarai sluice gate is fully opened. The result shows that by applying 100 year of return period, the bank is overtopped almost in a whole reach, especially at downstream.

4.2 Scenario 1

River normalization is assumed being implemented to cross section S 67 - S 90 with 0.035 of n Manning's value for riverbed and 0.02 for riverbanks. Cross section S 1 - S 66 are assumed to have the similar n Manning's value for riverbed and riverbanks. Manggarai sluice gate is widened and fully opened with 6 m of gate opening. The simulation of Scenario 1 results 55 cm, 54 cm, 48 cm, 52 cm, 48 cm, and 48 cm of water level reduction with 100 year of return period, from cross section S 20 up to S 25 on existing condition, successively. Water elevation on

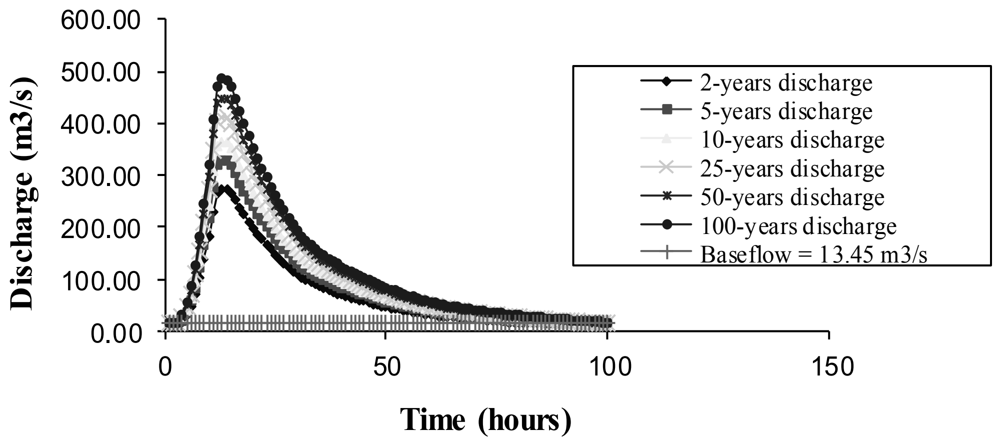

Figure 3. Flood hydrograph of Ciliwung River in Manggarai sluice gate (Agustina, 2002).

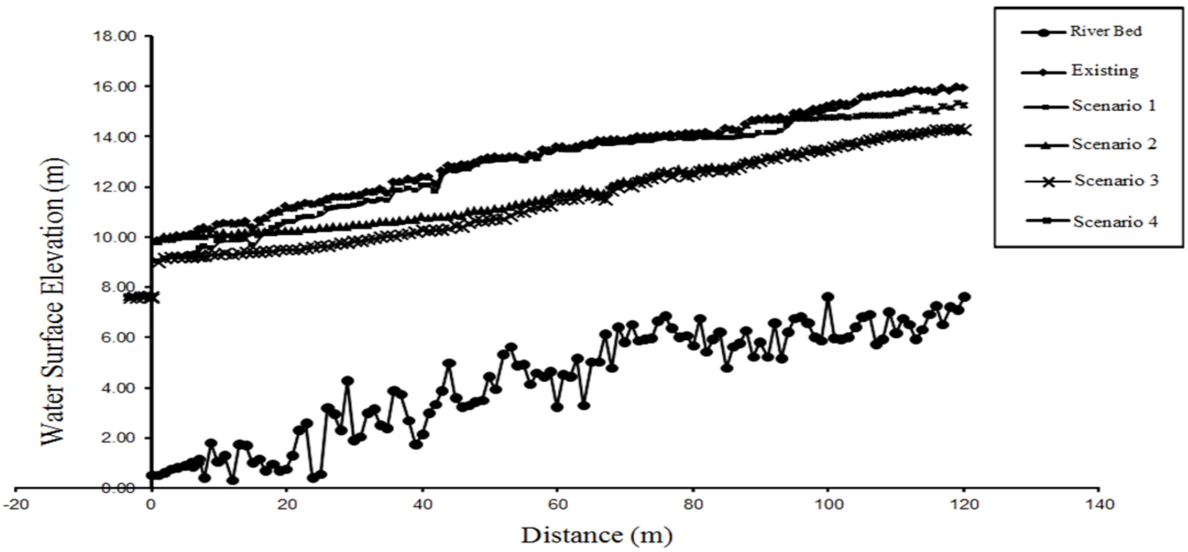

Figure 4. Water surface elevation of Ciliwung River flood.

Manggarai gate decreases about 81 cm compared to the existing condition, while water level beneath Jl. KH. Abdullah Syafei (Casablanca) Bridge decreases only 12 cm which apparently needs to be elevated about 2 m.

4.3 Scenario 2

River normalization is carried out along the river with 0.035 of n Manning's value for riverbed and 0.02 for riverbanks. Manggarai gate opening height is 6 m. The result shows that water elevation on S 20 – S 25 decrease about 92 cm, 89 cm, 98 cm, 106 cm, 97 cm, and 102 cm compared to existing condition with a return period of 100 year. Water surface elevation at Manggarai gate arises about 2 cm, while at Jl. KH. Abdullah Syafei (Casablanca) Bridge, it decreases 206 cm so that bridge deck is not necessary to elevate.

4.4 Scenario 3

Scenario 3 has the similar river cross section to Scenario 2. Manggarai gate is widened and fully opened with 6 m of the gate –opening. The results show the water surface level reduction from S 20 to S 25 with 100 year flood. The heights of decrement are 167 cm, 163 cm, 172 cm, 179 cm, 167 cm, and 171 cm, respectively compared to existing condition. Water surface level at Manggarai gate drops 82 cm, while water surface level beneath Jl. KH. Abdullah Syafei (Casablanca) Bridge decreases 227 cm.

4.5 Scenario 4

Scenario 4 has the similar river cross section to existing condition with one channel diversion. Manggarai gate is fully opened 6 m. For 100 year flood, water surface level on S 20 to S 25 decreases 1 cm referred to existing condition.

Scenario results are provided in Figure 4. The analysis results show that river management applying Scenario 3 gives the highest water level reduction among the other scenarios.

5 CONCLUSION AND RECOMMENDATION

The analysis of the results can be summarized below:

a) River normalization from station S 67 to S 90, and the existence of Manggarai sluice gate can reduce 54 cm, 48 cm, 52 cm, 48 cm, and 48 cm of water surface elevation on cross section S 20 - S 25 55 cm, successively compared to the existing condition with a return period of 100 year. Water surface elevation at Manggarai gate decreases 81 cm compared to existing condition, while water surface elevation beneath Jl. KH. Abdullah Syafei (Casablanca) decreases only 12 cm implying it needs to be elevated approximately 2 m.
b) River normalization implemented to whole reach from S 0 to S 120 with fixed Manggarai gate can lower 92 cm, 89 cm, 98 cm, 106 cm, 97 cm, and 102 cm of water surface elevation, respectively, on S 20 - S 25. Water level on Manggarai gate increases approximately 2 cm, while at Jl. KH. Abdullah Syafei (Casablanca) Bridge, it decreases 206 cm so that bridge deck does not need to be elevated.
c) Normalization of Ciliwung River that has been extended to whole reach, S 0 - S 120 and also the widened Manggarai gate can decrease 167 cm, 163 cm, 172 cm, 179 cm, 167 cm, and 171 cm of

river level, respectively, compared to the existing condition. Water surface elevation at Manggarai gate drops 82 cm and beneath Jl. KH. Abdullah Syafei Bridge, it decreases 227 in 100 year flood.

d) Channel diversion at the upstream induces water level reduction approximately 1 cm compared to the existing condition on cross section S 20 - S 25.
e) The largest impact towards river level reduction is caused by Scenario 3 with 100 year design flood.

Some recommendations can be given to improve the further research are listed below:

a) River normalization towards the downstream of Ciliwung River, specifically Cawang – Manggarai gate reach should be continued and equipped with additional gate (implementing the proposed improvement).
b) To prevent river narrowing, local government should prepare relocation center for inhabitant living along riverbank, particularly in the downstream area. It may be associated with river surveillance against human activity.
c) For further research, deep study towards lateral inflow from micro drainage system along river reach is necessary to conduct.

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