TECHNICAL EVALUATION OF THE ADDITIONAL RETENSION BASIN FOR SOLVING THE INNUDATION PROBLEM IN DEMANG LEBAR DAUN AREA, PALEMBANG CITY

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ABSTRACT

Palembang, the capital city of South Sumatra Province is a metropolitan city which has growth dynamically. It can be seen by the development of infrastructure, trade and service sector, and population. Administratively, Palembang is devided into 16 districts and 107 sub-district with 401 km^2 area and almost 14 million inhabitants.

Topographically, Palembang is a lowland area with flat topography. It has 19 catchment areas. About 30% of Palembang area is lowland. Lowland areas function as temporary storage areas of the water both from the rainfall run off as well as the high water level of the Musi River. Unfortunately, because of the fast growing of Palembang city, some of the lowlands have been converted into settlement, trade and industrial areas.

Due to the lost of temporary storage function of the area which has caused the inundation in several spots in Palembang. The local government tried to reset the function of water retention by creating several areas to be used as retention areas. One of the potential areas to be used as a retention basin is besides Jalan Demang Lebar Daun, Pakjo Sub District, Ilir Barat I District.

This study was conducted in order to evaluate the effect of the additional retention in reducing or solving the inundation problem of this area. Several scenarios were developed and a one dimensional hydrodynamic DUFLOW model was used in order to evaluate the hydraulic performance of the water management system in this area.

The operation of the water management system should be considered properly where in this case at the beginning of rainy season, the water level in the retention basins should be low enough (+1.6 m+MSL) in order to store the run off as much as possible. As a recommendation, besides this additional retention basin, a pumping station is proposed with the capacity of 0.1 m^3/s.

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INTRODUCTION

Palembang, the capital city of South Sumatra Province is a metropolitan city which has growth dynamically. It can be seen by the development of infrastructure, trade and service sector, and population. Administratively, Palembang is divided into 16 districts and 107 sub-districts with 401 km^2 areas and almost 1.4 million inhabitants.

Topographically, Palembang is a lowland area with flat topography. It has 19 catchments areas. About 30% of Palembang area is lowland. Lowland areas function as temporary storage areas of the water both from the rainfall run off as well as the high water level of the Musi River. Unfortunately, because of the fast growing of Palembang city, some of the lowlands have been converted into settlement, trade and industrial areas.

Due to the lost of temporary storage function of the area which has caused the inundation in several spots in Palembang, the local government has tried to reset the function of water retention by creating several areas to be used as retention areas. One of the potential areas to be used as a retention basin is besides NISSAN mobil in Jalan Demang Lebar Daun, Lorok Pakjo Sub District, Ilir Barat I District.

From the land use map of Demang Lebar Daun area in Figure 1, it can be seen that most of the area has been used as a densely residential area which means that the run off coeficient is very high. The Indonesian Republic Regulation number 26 year 2007 about spatial planning states that 30% of each river catchment has to be forestry area. In flood and inudation cotnrol point of view, the regulation means that more water retains underground and retain in the trees to reduce the runoff in every river catchment. However, the fact is that the green area in every catchment is still need to be improved.

The permeability of land in Palembang city is very small only 0.019 m/second (Public Works Office of Bina Marga & Water Resource Management, 2009). Therefore, in present, Palembang city tries to maximize the function of the green area, not only expect it as the infiltrion area but also as the retension basin which function to keep the water before it goes to the river. The making of retension pool is more efective than the green area in order to overcoming the flood and inudation problem.

The non-utilized small parcel of land belongs to Palembang city which is located besides NISSAN mobil in Jalan Demang Lebar Daun, physically and topographically is suitable to be used as the retension pool to overcome the flood and inudation problem in the area. This study is conducted to evaluate several scenarios which can be used in overcoming the inudation in Demang Lebar Daun Area using GIS (Geographical Information System) and mathematical model DUFLOW (Dutch Flow).

PROBLEM DEFINITION

The lost of the infitration area and retension basin in the urban area has caused flood and inudation problem in Palembang. One of the area is Demang Lebar Daun Area which is the main access to several important places in Palembang. The site is a depressive area which is topographically low in comparison with the surrounding area. The condition makes the area prone to the inudation problem. This situation can be seen in Figure 1 and Figure 2.

Figure 1. Inundation condition in Demang Lebar Daun when it starts to decrease

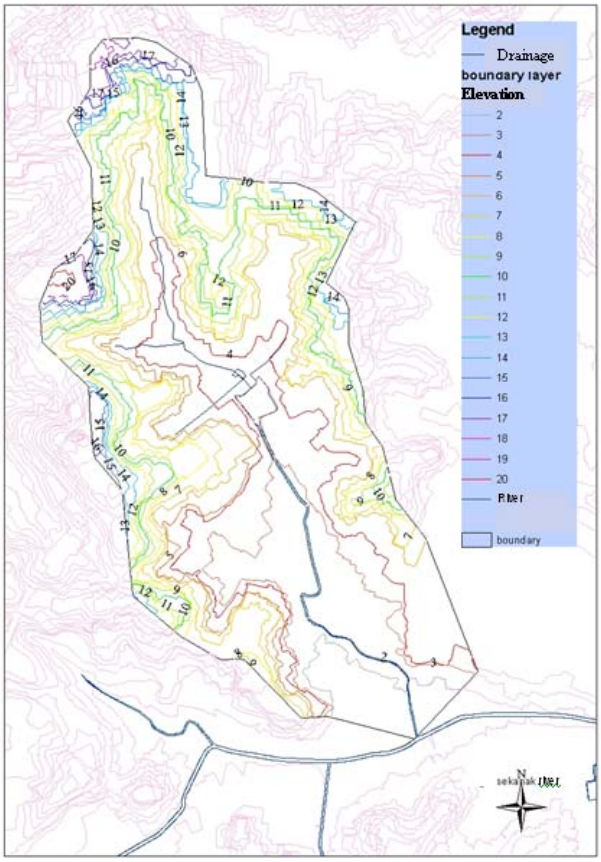

Figure 2. Topographical condition of Demang Lebar Daun and its vicinity

The total area of the existing retention basin besides Siti Khodijah Hospital is 1.1 ha. It means that only 1.3% from the total service area of 85 ha. As can be seen in Figure 2, this percentage is very small compare the total service area. Besides the existing retention basin, there are still some lowlands which naturally function as the temporary water storage area. Unfortunately, because of the rapid urbanization in Palembang city, the lowlands which are free and used as temporary storage are becoming smaller.

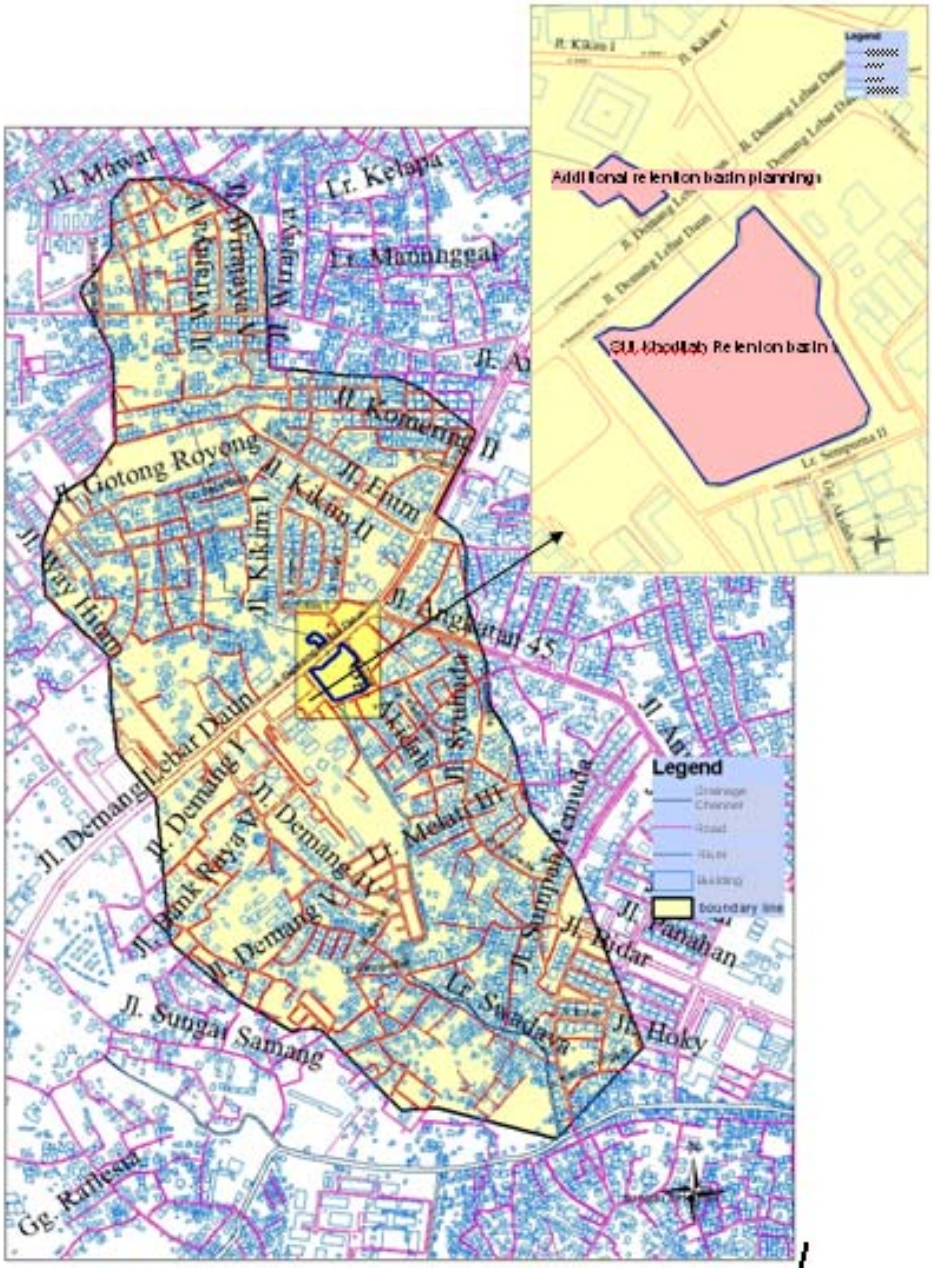

Figure 3. Location map of Demang Lebar Daun and its vicinity

The area around Sekanak sub-river, in the downstream of existing retention basin, was the lowlands which has function to keep the water temporarily.

Even though the area has topographically lower than the highest water level of the river in the wet season, in fact the settlement area was not inundated by the highest water level from the river. The situation happens because the municipality has raised the embankment of the river and sub-river in the area. The area also is not inundated for the heavy rainfall due to the remaining lowlands which storage the water from the rainfall before it goes to the river. Unfortunately, the land use in the area has changed gradually to be settlement area by reclamation. Then, it is considered very important that the municipality and the society have to be concern about the remaining lowlands function as the natural temporary storage areas.

OBJECTIVE OF THE STUDY

The study is focused on reducing the inundation in Demang Lebar Daun area which is the main access to several important places in Palembang. To solve the inudation problem in the area, the land besides NISSAN Mobil that belongs to Palembang Municipality phisically and topographically is considered to be suitable for being utilized as a retension basin. This study is conducted to evaluate the hydraulic performance of this retention basin by several scenario using mathematical model DUFLOW (Dutch Flow) and digital elevation model GIS (Geographical Information System)

METHODOLOGY OF THE STUDY

The area of the study is the catchment area of the retention basin in Siti Khodijah and Sekanak Sub-river. Boundary conditions in the downstream is the water level in Sekanak River which is measured at the estuary of the Sekanak sub river (see Figure 11) and as upstream boundary condition is design run off from the upper area.

Topographical data from BAPPEDA of Palembang city was used and evaluated by using GIS (Geographical Information System) to obtain the digital elevation model of the study area.

To get the proper solution in solving the inundation problem in the study area, several scenarios have been evaluated in the study. Hydrological and hydro meteorological data were calculated, and the results were used as the input data in mathematical model DUFLOW. Then the water levels from the mathematical model result were used to create digital inundation map by using GIS.

Several scenarios evaluated in this study are:

- Scenario for existing condition
- Scenario with drainage channel widening
- Scenario with additional retention basin
- Scenario with additional retention basin and pump

DATA ANALYSIS

Hydrological Data Analysis

Hydrological data analysis consists of design rainfall analysis and rainfall intensity analysis. The support data used is from BMG Kenten station, Talang Betutu station and Plaju Station from year 1980 to 2004. The rainfall intensity is obtained from the calculation of maximum monthly rainfall data using Gumbel Distribution Method.

Table 1 Rainfall intensity for several return periods using Gumbel method

Return Period (year)	Rainfall Intensity (mm)
2	112
5	147
10	171
25	201
50	223
100	245

Rainfall and evaporation of the area can be seen in Figure 4

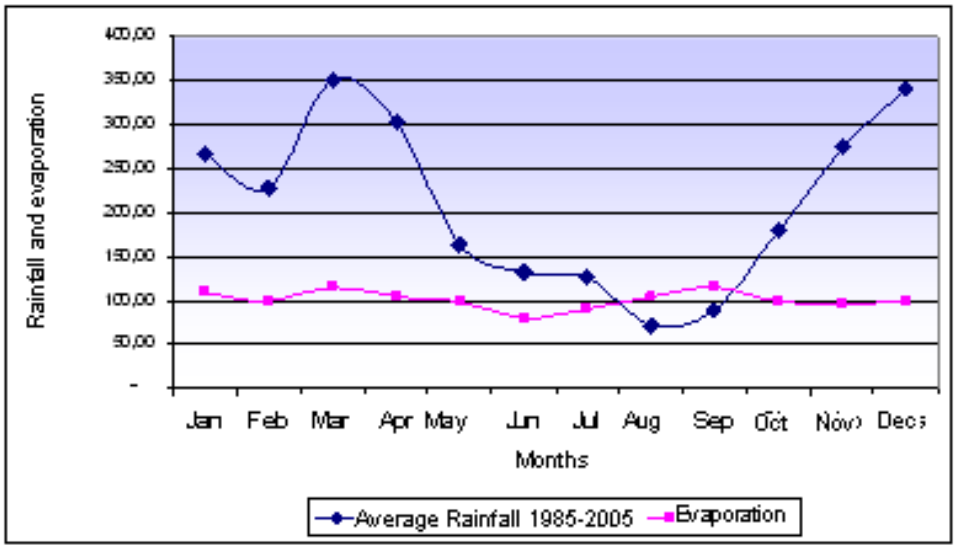

Figure 4. Rainfall and evaporation

Topographical Data

Topographical data used was the result from the previous study by Bappeda of Palembang City in 2004 then evaluate using GIS to create digital elevation model which is shown in Figure 5.

Primary Data: Hydrometeorology

Water Level

Water level data in Sekanak River fluctuates due to the tidal influence from the Musi River. The highest water level in Sekanak River is +3.2 m+MSL.

Drainage channel, sub-river, river and retention basin dimension

Several cross sections were measured and were used in the model preparation (schematization).

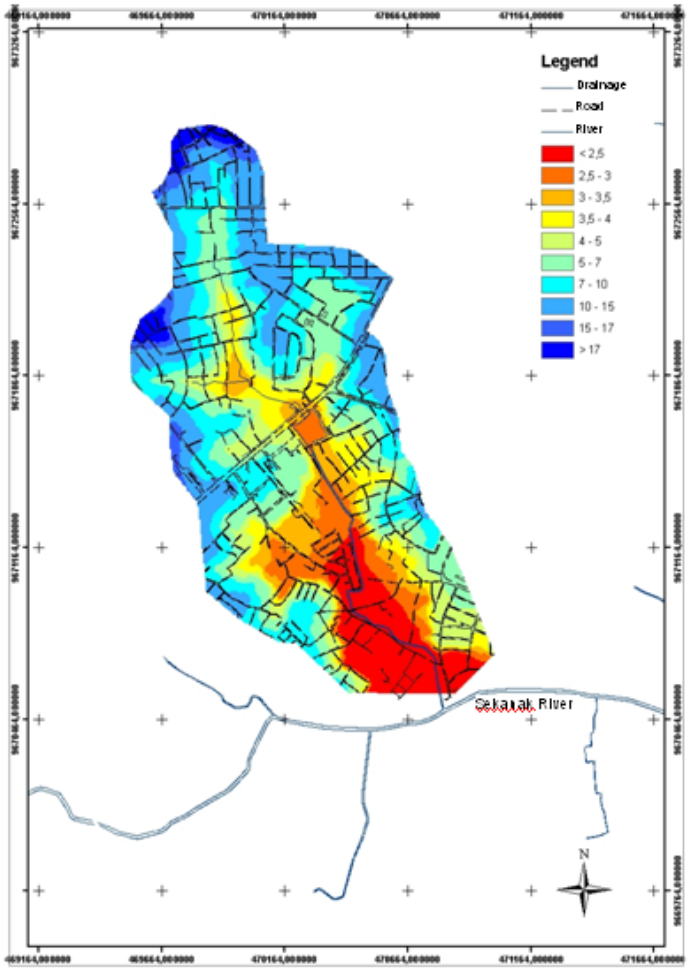

Figure 5. Digital elevation model of Demang Lebar Daun and its vicinity

RESULTS AND DISCUSSION

Figure 6 and Figure 7 are the digital elevation models and land use map of Demang Lebar Daun area and vicinity which are obtained by converting the vector forms of topographical data. Figures 6 shows that the level in the area varies from lower than +2.50 m+MSL up to higher than +17.00 m+MSL.

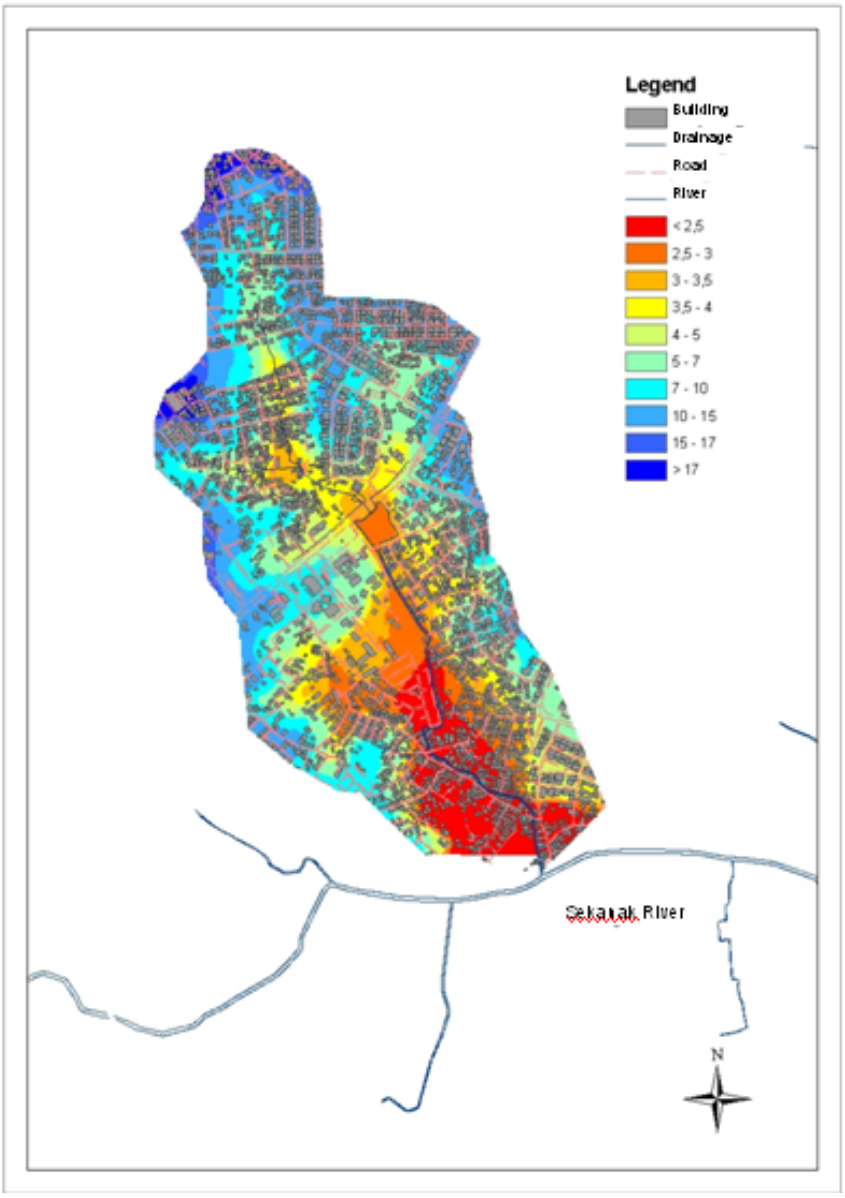

Figure 6. Land use map of Demang Lebar Daun and its vicinity

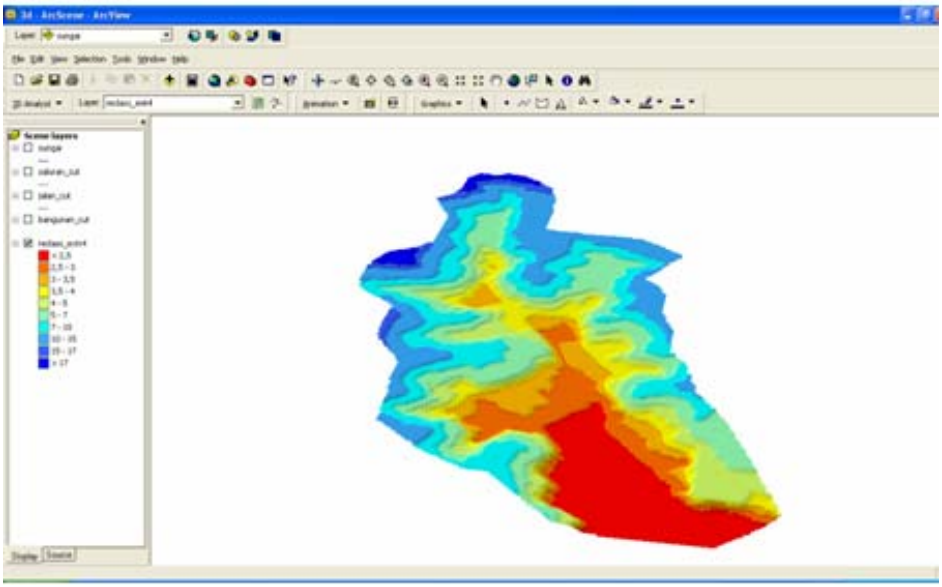

Figure 7. Three dimensional of Demang Lebar Daun and its vicinity land use map

From the land use and digital elevation model in Figure 6 and 7, it is clear that most of the areas are used for settlement.

For this study, mathematical model DUFLOW were used and 4 scenarios has been developed and modelled. For each scenario, initial condition has been set and the water level in the retention basin is +1.60 m+MSL in order to utilize the dynamic storage of the system as the design.

Scenario 1: Existing condition of the drainage system

Model schematization can be seen in Figure 8

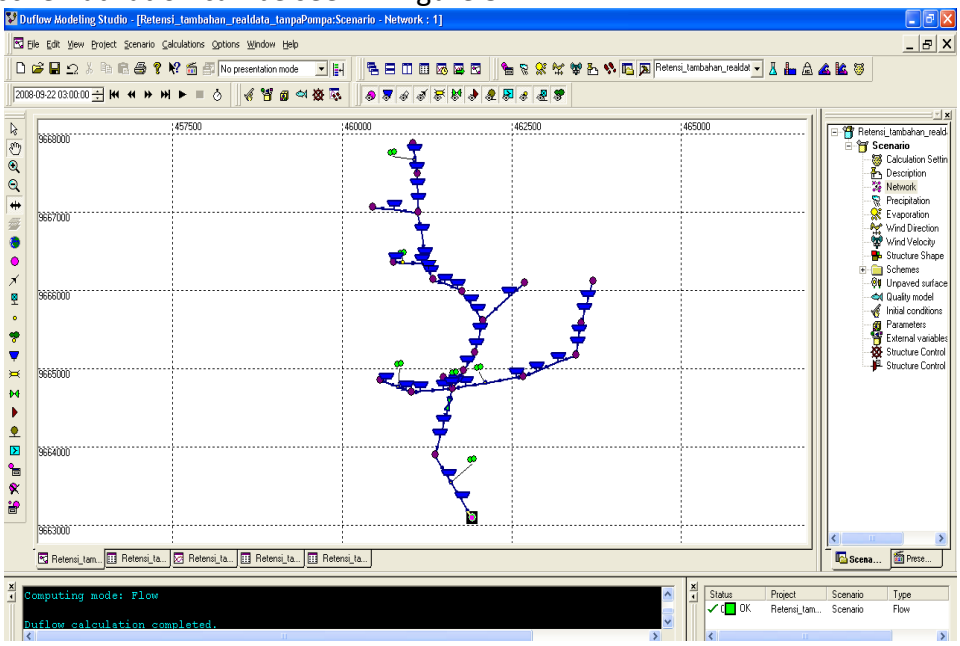

Figure 8.Drainage system model schematization of Demang Lebar Daun and its vicinity

The result of the model is shown in Figure 9:

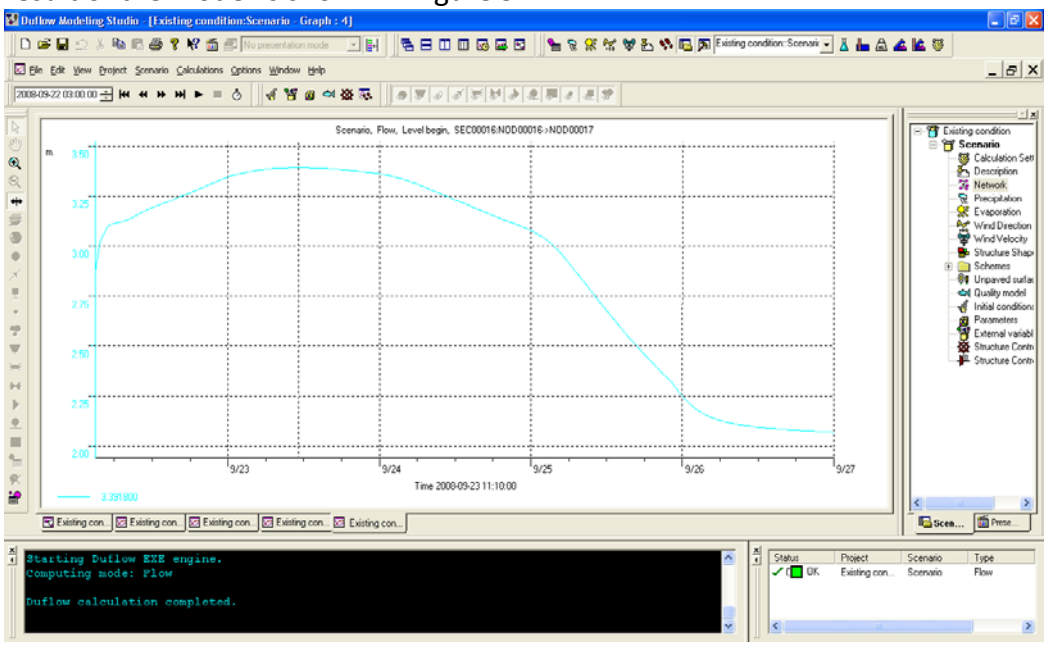

Figure 9. Water level in drainage system at the upstream of retention basin

Figure 9 shows the water level in Sekanak River, whereas the highest water level is +3.2 m+MSL in 16 March 2010. The data was obtained from the observation in the location using peil schaal board which can be seen in Figure 10. Rainfall data used as input in this model is 201 mm/day for the return period of 25 years referred to Table 1.

Figure 10. Staff gauge in Sekanak river

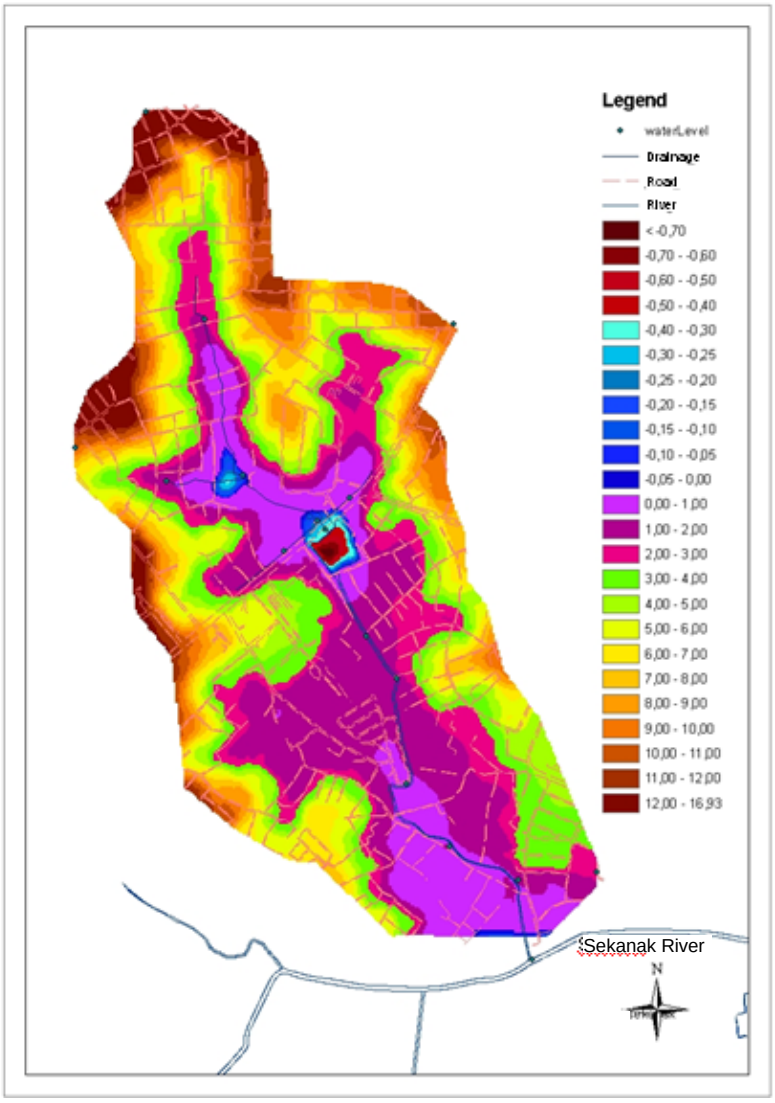

Figure 11. Digital l elevation model of the inundation condition for existing condition in Demang Lebar Daun

Using GIS, the inundation map in Figure 11 is obtained by overlaying between the topographical map and the water level map using The map shows that the inundation depth in the location up to 30 cm and about 0.63 ha in the settlement area in the upstream of the retention basin and about 0.4 ha in Demang Lebar Daun street and its vicinity. Therefore, the total inundated area will be about 1.4 ha.

Meanwhile, the downstream of the retention basin is not taken into account since the embankment of the river has been raised. It means that the high water level due to the tidal influence from the Musi river can not enter the related area.

Scenario 2: Drainage system with drainage channel widening

To overcome the inundation problem in Demang Lebar Daun area, scenario 2 is set up where the drainage channel has been changed from 2m to 5m for 558m length.

From the mathematical model DUFLOW, it is obtained that the effect of the drainage channel widening is not really significant. The reduction of the water level is only 1 cm for the design rainfall design of 25 years return period (see Figure 12)

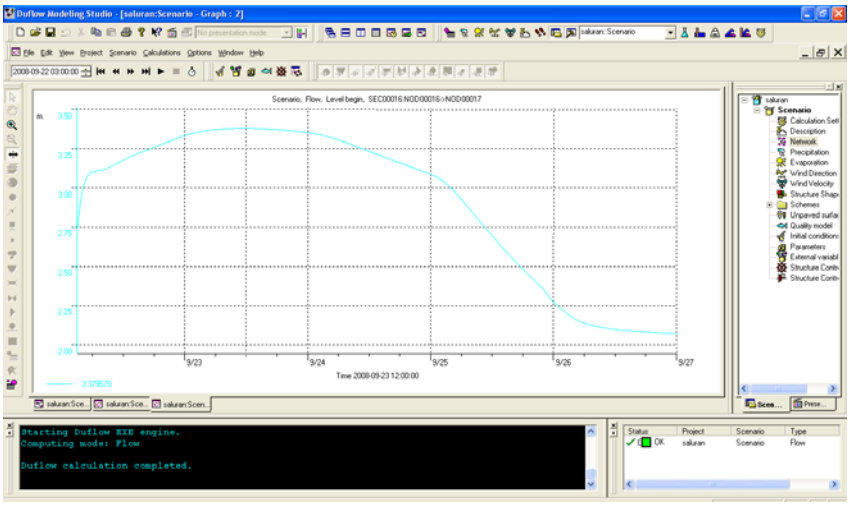

Figure 12. Water level at the upstream of the retention basin, Scenario 2 widening the drainage channels

Again, the water level from the model is used as the input to GIS to get the inundation area as can be seen in Figure 13.

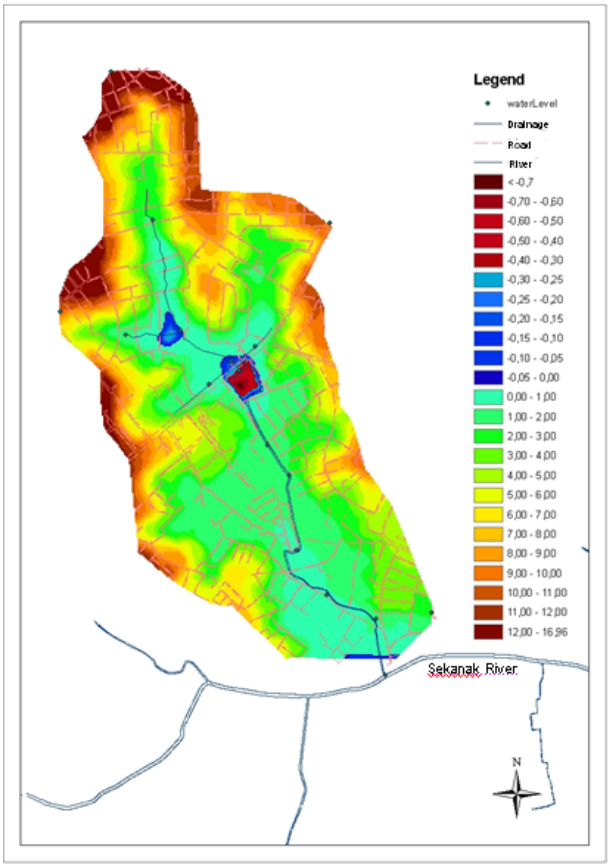

Figure 13. Digital elevation model of the scenario with drainage channel widening

In the digital elevation model of Figure 13, the inundation area at the upstream of the retention basin becomes 0.75 ha and about 0.55 ha on Demang Lebar Daun street. By widening of the drainage channel up to 5 m only reducing the inundation area about 14 % from the existing condition.

The technical obstacle will also be found if the widening of the drainage channel is conducted in the area, it will not so easy practically because the area around the channel has already been occupied and used as a very dense settlement area which shows in Figure 14.

Figure 14. Photo's of drainage channel conditions at the upstream of retention basin

Scenario 3. Drainage system with additional retention basin

Scenario 3 is where the drainage system with the proposed additional retention basin in the system. The retention basin is located in the lowest part of the area before the street of Demang Lebar Daun and the existing retention basin. The land of the additional retention basin besides NISSAN mobil belongs to Palembang Municipality, which means that the Municipality does not have to spend any compensation cost to obtain the land.

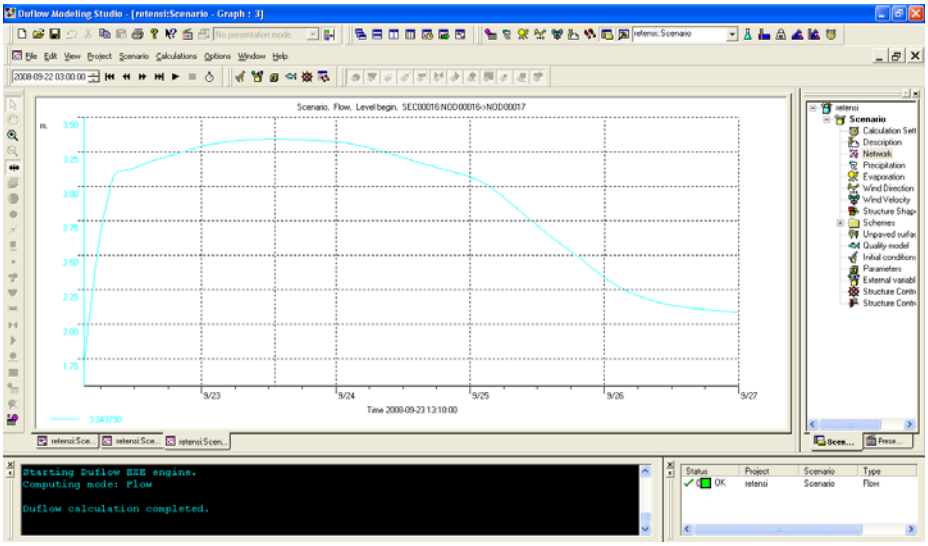

Figure 15. Water level upstream of the existing retention basin with additional retention basin

By constructing the additional retention basin about 0.18 ha, the reduction of the water level is only 5 cm than the existing condition (see Figure 15). The additional retention area is in fact is only 0.3% from the service area.

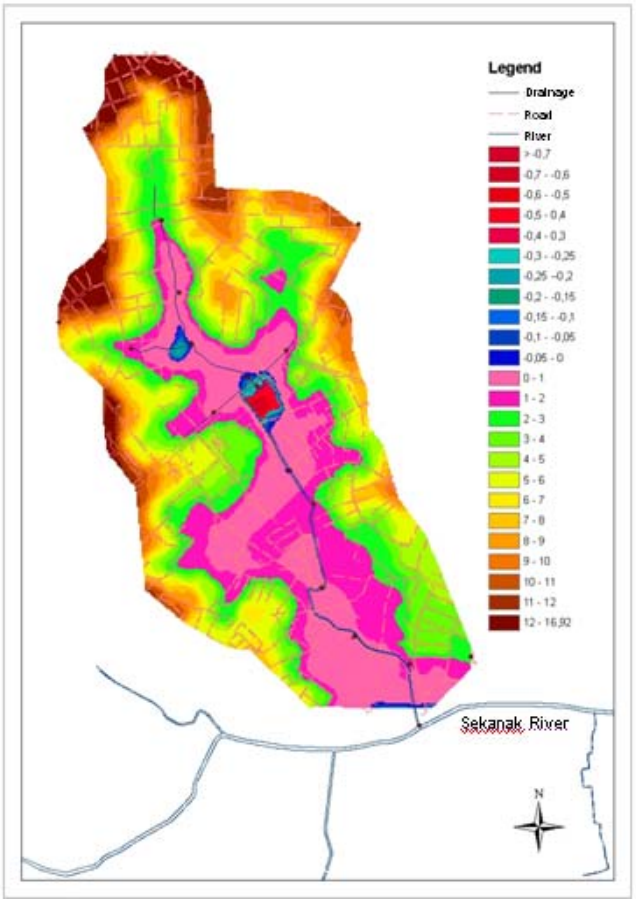

Figure 16. Inundation map for the Scenario 3 with additional retention basin

Figure 16 shows that with additional retention basin besides NISSAN mobil, the inundation area in Demang Lebar Daun decrease into 0.6 ha in the upstream of the additional retention basin and 0.4 ha in Demang Lebar Daun street. It means that the inundation area reduces about 29% from the existing inundation total area which is 1.4 ha.

Scenario 4: Drainage system with additional retention basin and pump

Based on the Scenario 1, Scenario 2, and Scenario 3 and also by considering the development condition in Palembang nowadays, besides having more retention basin, it is proposed to evaluate the use of pump in order to solve the inundation problem in Demang Lebar Daun area.

To support the idea, the Scenario 4 has been studied by installing pump with capacity the capacity 0.1 m3/second. The pump will operate as:

- the water level in the retention basin reachs +2.75 m+MSL;
- The pump will stop the operation if the waterl level in the retention basin reachs +2.00 m+MSL.

The result of the model simulation is presented in Figure 17

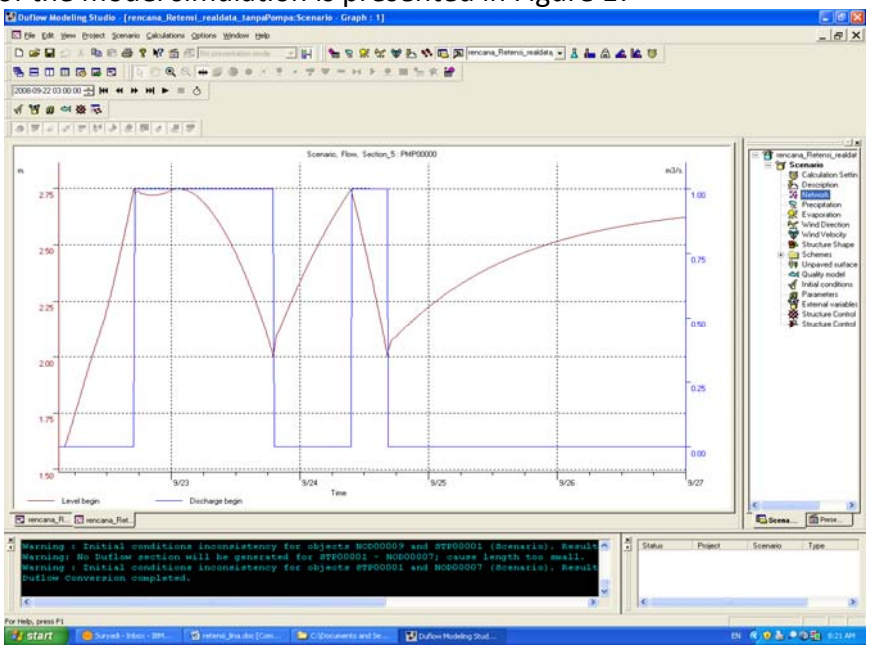

Figure 17. Water level using pump with capacity 0.1 m3/s

It can be seen in Figure 17 that the water level varies between +2.75 m+MSL dan +2.00 m+MSL according to the pumping operation. The maximum water level is not more than +2.75 m+MSL which means the pump capacity is sufficient for solving the flood problem. Moreover, the pump operation for the design rainfall is only for one day. For the second day after the design rainfall, the pump still work for several hours. It means that the hydrodynamic condition in the system and the residual of the run off which arrives from the upstream of the service area may cause the water level in the retention basin still reaching +2.75 m+MSL during the second day.

CONCLUSIONS AND RECOMENDATIONS

Conclusions

- The alternative of widening the drainage channel from 2 m into 5 m will only reduce the inundation area about 14% in the upstream of the retention basin and Demang Lebar Daun street.
- The optional of additional retention basin about 0.18 ha which is located besides NISSAN mobil can reduce the inundation area about 29% in the upstream of the retention basin and in Demang Lebar Daun street.
- By considering the development condition of the area, besides the additional retention basin the use of pump with the capacity of 0.1 m^3/s will sufficient to solve the flood problem.
- In operating the drainage system, especially in the rainy season, the water level should be managed in such manner to maximize the use of the retention basin.

Recommendation

- The additional retention basin combined with the pump is very significant to solve the inundation problem in Demang Lebar Daun area.
- The operational and maintenance of drainage system in the catchments of Sekanak river considered necessary to overcome the inundation problem in Demang Lebar Daun area.
- Related to the flood control programme for in Palembang city, it is important to evaluate for all the drainage system and river catchments in Palembang an integrated and systemic way.

REFERENCES

BAPPEDA Kota Palembang, 2006, Rencana Desain Tata Ruang Kota Palembang, Palembang, Indonesia.

BAPPEDA Kota Palembang, 2004, Master Plan Sistem Drainase Kota Palembang, Palembang, Indonesia.

Jos van Alphen, Eelco van Beek, Marco Taal, Editor, 2005, Floods, from Defence to Management, , Taylor&Francis Group plc, London, UK.

Land and Water Management Tidal Lowlands, 2005b, Technical Guidelines on Tidal Lowland Development. Volume II, Water Management, Report of the Joint Indonesia – Netherlands Working Group, Jakarta, Indonesia.

Monirul.. M. Qader Mirza, Ajaya Dixit, Ainun Nishat, Editor, Kluwer Academic Publishers, 2003, Flood problem and Management in South Asia, Dordrecht, the Netherlands.

Pemerintah Kota Palembang, 2006, Palembang dalam Angka, Palembang, Indonesia.

Stowa, 2005. Duflow Modeling Studio : User's Guide. Version 3.6 UNESCO-IHE, Delft, the Netherlands.