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T. Harianto
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PREFACE

It is widely believed that the effect of climate change have increased the awarness of people on the severe impact of water and air pollution, the rise of temperature, and the limitation of energy deposites. Besides that, global warming and climate change have played significant role in the change of infrastructure technology. Consequently, the development of infrastructure technology will be evaluated in order to create ecology-environmental friendly and optimized energy.

Sharing knowledge of infrastructure and civil engineering technology which well agree with environmental preservation are valuable to be implemented in the *1st International Conference on Civil Engineering and Infrastructure : "Future Challenges in Civil Engineering Infrastructure Technology"*. The conference is organized by Badan Musyawarah Perguruan Tinggi Teknik Sipil Indonesia (BPMTTSI).

This conference is a media for civil engineers, infrastructure practitioners, academicians, environmentalists and research, to discuss, explore and share recent development and research of infrastructure and civil engineering technology. In future, this conferece will contribute in improving human resources.

Sincerely,

Dr. Tri Harianto
Chairman

CONTENTS

STRUCTURAL ENGINEERING (ST)

URBAN PLANNING MANAGEMENT (UR)

ENVIRONMENTAL ENGINEERING (ER)

Proceedings of the 1st International Conference on
Civil Engineering and Infrastructure (ICCEI 2015)
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OPTIMIZATION OF PUMPING OPERATION SYSTEM IN MASSIVELY DEVELOPED INDUSTRIAL CITY OF CIKANDE

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ABSTRACT: This paper presents the optimization of pumping operation system in one of massively developed industrial city in Cikande, Tangerang with total area around 2,400 ha. Flood control in Cikande area uses the detention pond at the end of system with the capacity 1,395,610 m^3 and it is equipped with 5 pumps with the capacity 4.5 m^3/s. There are two parameters are being considered as the important factors for optimizing the pumping operation, water elevation at reservoir and pumping operation pattern. The water elevation at reservoir is defined that shall not exceed +7 m. The results show, after implementing the clustering and long storage system, the capability of the existing operation system to handle the flood increased from 5 years to 10 years of return periods; however the operation is not effective because of the pumping operation patterns are impulsive which causes the pumps break easily. Hence, by using the new optimized pumping operation system, it is successfully and effectively controls various floods i.e. 2, 5, and 10 years of return periods.

Keywords: Optimization, Pumping System, Clustering System; Long Storage; Massive Development

1. General Background

The conversion of rural area (land, forest, etc.) into urban area or industrial area will distract the hydrology characteristics such as the increasing of stream flow and volume of surface runoff, decreasing ground water table, and usually increase the erosion. (SCS, 1986; Calder, 1993; Chow, 1998). Sustainable Urban Drainage Systems (SUDS) is a new concept and approach to managing drainage system in order to control the impact of urbanization or industrialization. Concept of SUDS is allowing natural processes to break down pollutants, slowing and holding back the water that runs off from a site (Zheng, 2006).

There are several terms to describe the concept of SUDS, in Indonesia, based on the government regulations related to drainage system, the eco-friendly drainage system is used to describe the term for sustainability (Public Work Ministry, 2014). The eco-friendly drainage system is defined as an effort to manage the excess runoff using any kinds of methods such as, detention or retention pond, polder system, etc., with the purposes the water can be hold in the system before it will released to the water body.

In Indonesia, lots of areas are located below the sea level or the river water level. Hence, lots of the drainage systems in Indonesia were using the polder system. The polder system itself is a combination system between reservoir and pumping system. One industrial area in Banten province, Cikande (Figure 1.), with total area 2400 ha, the drainage system was design using polder system. Because of the land acquisition problem and the sloop is flat, in order to control the excess surface runoff, the drainage system in Cikande area is enhanced by clustering and long storage system.

The clustering system mean in every cluster or in every certain area there will be a certain area of detention pond (Figure 2.). From the previous study, for every 100 ha of industrial area it is required 5.65 ha area for detention pond with average depth 2 m in order to control flood of 10 years return periods (Wijaya, 2015). All the detention ponds in every clusters are connected with the secondary channel, where the channels are being utilize as a long storage. Although the sloop is flat, not every channel are effective to be utilized as long storage. Based on the previous study also, only main channel is effective to be utilizing as a long storage (Wijaya, 2015). To utilize the channel as a long storage, the sluice gate must be constructed at the end of the channel.

Figure 1. Location of study area

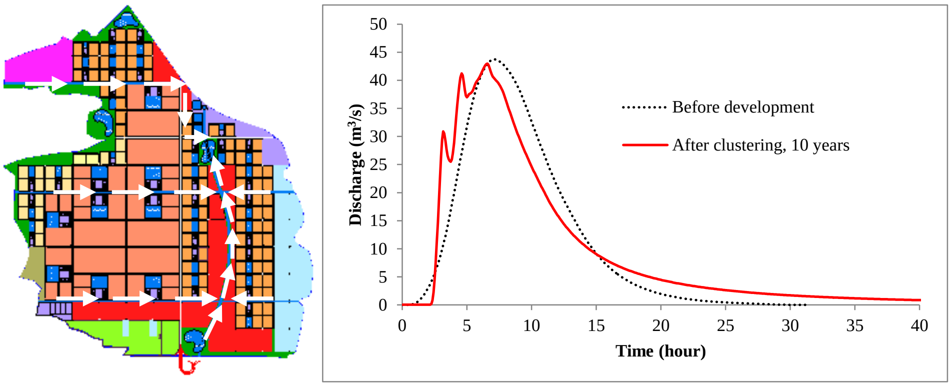


Figure 2 Implementation of clustering system and the result

The long storage system can handle the flood discharge up to 10 years return periods. Although it is effective to cope with the 10 years return period of flood, the long storage system is not effective to handle the flood for 25 years of return period. As it can be seen from figure below, to utilize the channel as a long storage, it is required 5 sluice gates to hold the water in the channel.

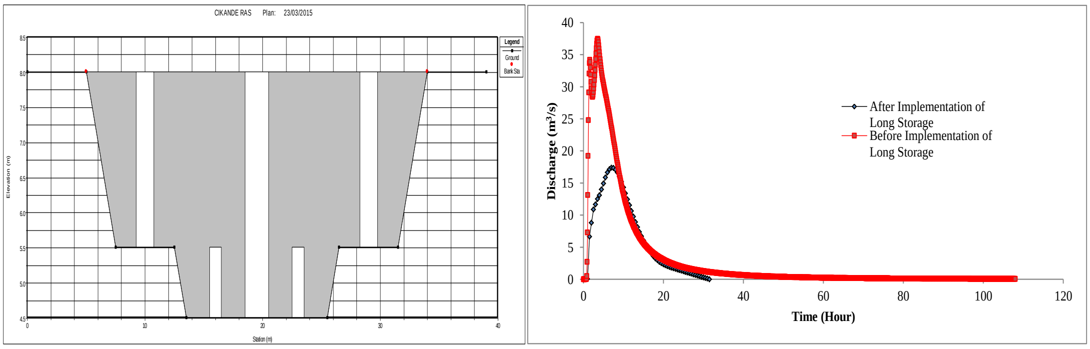


Figure 3 Long Storage design and result

From the previous researches shows that combination of clustering and long storage successfully controlling the flood up to 10 years of return periods. However, since the drainage system in Cikande area basically is a polder system, combination of clustering and long storage system definitely will change the pumping operation system, means the pumping operation system must be re-optimize based on the new system. Hence, this research will be focused on the optimization of the pumping system under combination of clustering and long storage system.

2. Methodology

In this research, the simulation of pumping operation is using the software HEC-RAS. Since the channels are connected with the reservoir and pumping operation system, this software is suitable to be use. There are two parameters have been considered in this research, first is time and the second is water elevation at the reservoir. As it can be seen from the figure below, which is how the research has been conducted.

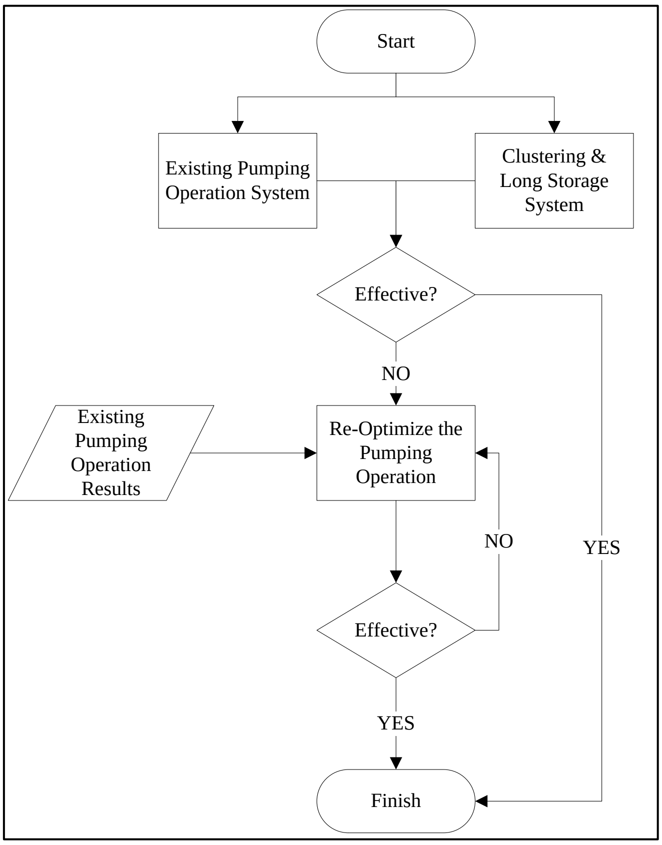


Figure 4 Flow diagram of the research

Basic equation in HEC-RAS is Saint-Venant equation. Saint-Venant equation consists of two equation, continuity equation and momentum equation (Methods, 2003).

$$\frac{\partial A}{\partial t} + \frac{\partial (vA)}{\partial x} = q \quad (1)$$

$$\frac{\partial v}{\partial t} + v\frac{\partial v}{\partial x} + g\frac{\partial y}{\partial x} - g(s_o - s_f) = 0 \quad (2)$$

The Saint-Venant equation can be solved using approach of finite difference. There two scheme to solve partial differential equations using finite difference, implicit scheme and explicit scheme. For HEC-RAS, the solution is using implicit scheme specifically implicit box scheme. Under this scheme, space derivatives and function values are evaluated at an interior point $(n+\theta)\Delta t$.

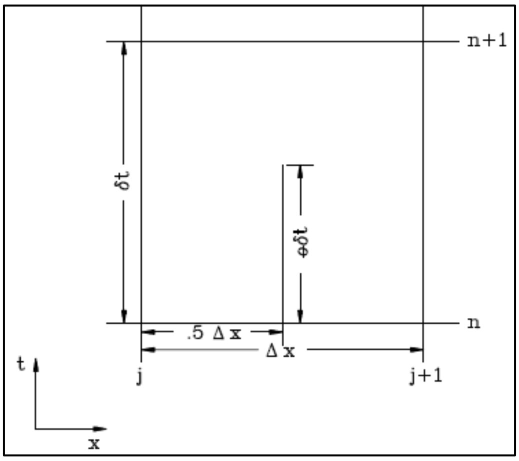


Figure 5 Implicit box scheme (Source: HEC-RAS Tech. Reference)

The general implicit finite difference forms are:

1. Time derivative

$$\frac{\partial f}{\partial t} \approx \frac{\Delta f}{\Delta t} = \frac{0.5(\Delta f_{j+1} + \Delta f_1)}{\Delta t} \quad (3)$$

2. Space derivative

$$\frac{\partial f}{\partial x} \approx \frac{\Delta f}{\Delta x} = \frac{(f_{j+1} - f_1) + \theta(\Delta f_{j+1} - \Delta f_1)}{\Delta x} \quad (4)$$

3. Function value

$$f \approx \bar{f} = 0.5(f_{j+1} - f_1) + 0.5\theta(\Delta f_{j+1} - \Delta f_1) \quad (5)$$

3. Results and Discussion

The Cikande area, based on the design, is equipped with 5 pumps with the efficiency as shown at the table below. Beside the pumps, the Cikande area also equipped with a reservoir with the characteristic shown at the figure below.

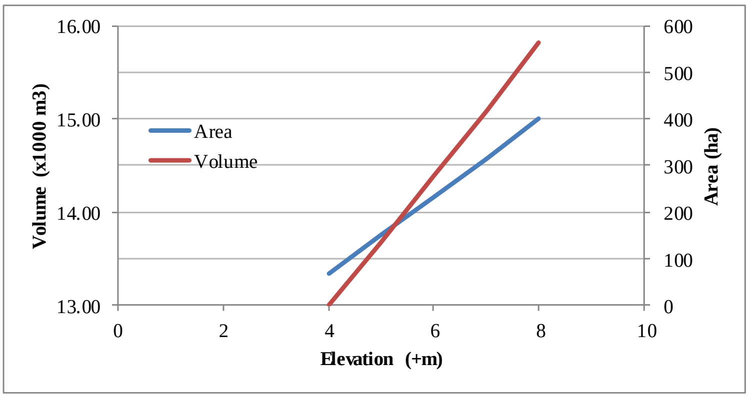


Figure 6 Elevation-area and elevation volume for the existing reservoir

Table 1. Efficiency pumps curve and pumping operation

Head (m)	Discharge (m^3/s)		Elev. ON (+m)	Elev.Off (+m)
0.00	4.50	Pump 1	5.50	5.00
0.50	4.05	Pump 2	5.50	5.00
1.00	3.60	Pump 3	5.50	5.00
1.50	3.15	Pump 4	6.00	5.50
2.00	2.70	Pump 5	6.50	6.00
2.50	2.25			
3.00	1.80			
3.50	1.35			
4.00	0.90			
5.00	0.00			

Therefore, to optimize the pumping operation then the pumping operation will be trying under several scenarios. In order to optimize the pump operation, some aspects should be considered. In this report, water elevation and time of operation are the aspects that will be considered. The purpose of the optimization is to optimize the utilization of the existing pumps. In other word, in the optimization process the number of pumps will not be added.

As it mentioned before, the parameters to optimization are water elevation in the reservoir and the duration time of pumping operation. The water elevation in the reservoir should not exceed the elevation +7 m. The reason because the maximum elevation of secondary channel section III is +7 m. It means if the water elevation at reservoir exceeding +7 m, the channel at that section will be flooded. Beside the maximum level of secondary channel section III, the other consideration is the safety. Hopefully, if the maximum level at reservoir is defined at +7 m there is still a free board 1 m.

The second parameter is duration time of pumping operation. This parameter are related to the cost effectively and safety. Longer duration time of operation, it means the cost for electricity will be higher. Longer duration also has a risk to break the pumps easily. Not only can broke and increase the electricity cost, longer duration also dangerous if another rains occur. Hence, in the optimization process the duration time should not longer than 12 hour. The last thing is all the simulation is under 10 years return period of rainfall.

The first optimization is using the existing operation. They are separated into 4 scenarios. The first scenario which already been done, the whole pumps will be operate with same operation as the existing operation. The second scenario the fifth pump will not be used and other pumps still using the same operation. The third scenario 3 pumps will be use and the fourth only use 2 pumps. In order to summarize the results, figure below shows that the scenario 1 and 2 gives the same result. It means that the fifth pump is not working because of the maximum elevation of the reservoir is + 6.48 m.

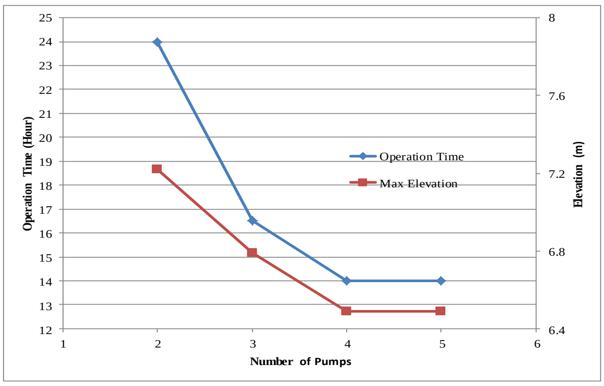


Figure 7 Maximum elevation and operation under several existing condition scenarios

From the figure above, scenario 3 and 4 gives the water elevation in the reservoir below +7 m even though the scenario 3 gives very critic result, +6.79 m. Although both of the scenarios give good result for the water elevation, however, the operation time for both scenarios were exceeding the limit, which more than 12 hours. The existing operation, in other words, is not gave the optimum operation for pumping system.

Based on the soil investigation, the ground water table at the reservoir is + 2.4 m. It means, effectively, the storage at the reservoir is reduced because of the ground water. This issue was not being considered in the previous design. Hence, for the further analysis, the ground water table will be taking into account. In order to find the most optimum operation, other scenarios should be conducted. The second analysis is consisting of three scenarios, where each scenario there will be another three scenarios. In the second analysis, all the scenarios will be conducted by turning on all the pumps at the same time and at the same water elevation, however, the number of pumps will be decreased in every scenario. All the scenarios are set so that the pumps will turn on at elevation higher than +5.5 m but not exceed elevation + 7 m and will turn off at elevation +5.5 m.

Table 2. New scenarios for optimization

Scenarios	Number of Pumps	Start at Elevation	Off at Elevation
I-A	5	6.0	5.5
I-B	5	6.5	5.5
I-C	5	7.0	5.5
II-A	4	6.0	5.5
II-B	4	6.5	5.5
II-C	4	7.0	5.5
III-A	3	6.0	5.5
III-B	3	6.5	5.5
III-C	3	7.0	5.5

The results for the all scenarios can be summarized at figure below. All the scenarios I give the best result for pumping operations. All the scenarios I give the time of operations under 12 hours and the water elevation under +7 m. From the result, scenario I-B would be the appropriate solution for the pumping operation. Not only below +7 m, scenario I-B still gives some space as a freeboard. However, the analysis is conducted based on the 10 years return period which mean the probability of the rainfall occurrences is less than compared to the rainfall of 2 and 5 years return period. The scenario I-B, perhaps, will be appropriate if the 10 years return period of rainfall occurred. In fact, rainfall which happens the most is 2 years or 5 years return period. As the result, from figure 6.7, the pumping system is not effective if the rainfall is 5 years return period. Hence, the pumping systems should be effective too if the 2 and 5 years return period of rainfall occurred.

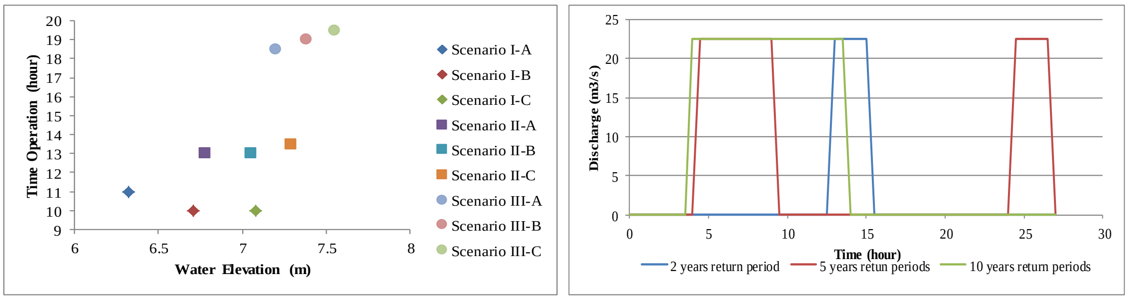
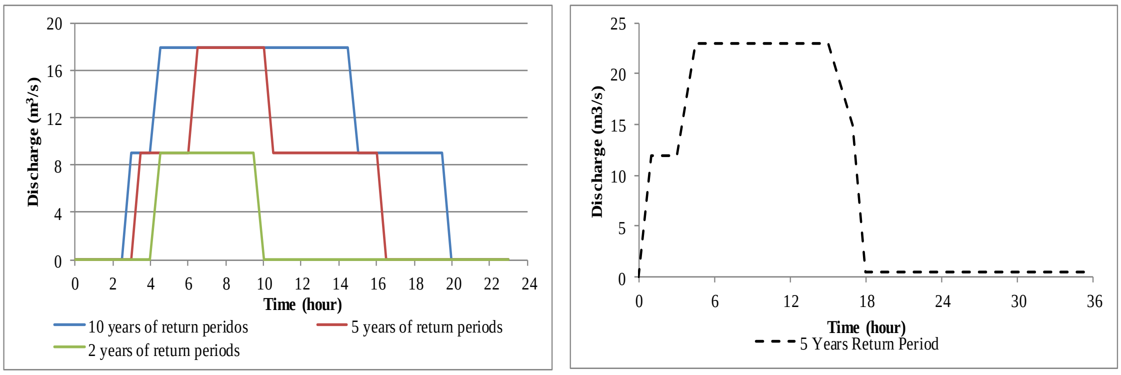


Figure 8 Optimization results under several scenarios and return periods

From figure 8 shows that for 5 years of return period, the pumping operation is not effective. Hence, the operation should make into several stages. As it can be seen from the table 5.5, two pumps will be operated at the water elevation + 6.0 m, followed by the second and third pumps will operated at + 6.5 m, and the last pumps will be operated are the fourth and fifth pumps at the elevation +7.0 m.

Table 3 Final pumping operation system

Pumps Number	Start at Elevation	Off at Elevation
1	+ 6.0 m	+ 5.5 m
2	+ 6.0 m	+ 5.5 m
3	+ 6.5 m	+ 6.0 m
4	+ 6.5 m	+ 6.0 m
5	+ 7.0 m	+ 6.5 m



(a) (b)

Figure 9 Comparison between final operation (a) and existing pumping operation system (Source: Millenium, 2014) (b)

From figure 9, the pumping system worked in several stages. For the 2 years return period analysis, it is shown the first two pumps are worked and for the 5 years return period and 10 years of return period, only 4 pumps are worked. It means the pump number five is not necessary. Comparing the final operation and existing operation, it shows that by introducing the clustering and long storage system it helps the pumping operation to handle the flood more efficienly. With the same number of pumps, the capability to handle the flood is increasing. At the begining, the pumping system only capable to handle up tp 5 years return periods of flood but then after the combination of clustering and long storage system the pumping system is capable to handle up to 10 years return periods of flood.

4. Conclusions

After several analyses which had already been conducted, there are some conclusions that can be drawn. Combination of two alternative solutions in order to reduce or to control the surface runoff as regards of industrilization also have a contribution related to the pumping operation system. In this study shows that with the combination of these two system it can elevate the pumping system capability to handle the flood even more. Althoguh the time operationThe new pumping operation is capable to handle up to 10 years return periods of flood while the old pumping operation only capable 5 years return periods. The time operation for the same return periods, 5 years return periods, decreases from 18 hours to just 14 hours. Although there is no analysis related to the economic study, it shows that new operation would be reducing the operation cost and work more efficient comapre to the existing pumping operation system.

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