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Analysis of water distribution system at Alang-Alang Lebar

To cite this article: D I Kusumastuti *et al* 2021 *IOP Conf. Ser.: Earth Environ. Sci.* **930** 012019

Analysis of water distribution system at Alang-Alang Lebar

D I Kusumastuti[1], A Gustira[2], E P Wahono[1]

[1]Civil Engineering Department, Faculty of Engineering, Lampung University, Bandar Lampung,
[2]Civil Engineering Master of Science Program, Faculty of Engineering, Lampung University, Bandar Lampung, Indonesia.

*Corresponding author: kusumast@gmail.com

Abstract. Municipal Waterworks Tirta Musi manages and supplies clean water to Palembang city. The distribution network system of Municipal Waterworks Tirta Musi is expected to distribute water sufficiently to all customers in the 18 districts this Municipal Waterworks serves. However, it was found that in Alang-alang Lebar service unit water was not delivered sufficiently. Moreover, Alang-alang Lebar service unit plans to improve the service so that the system will serve increasing customers until the next 20 years. This study aims to analyze the water distribution system to find the cause of insufficient water in Alang-Alang Lebar; predicting the number of customers in the next 20 years, and propose some improvements in the distribution system. A computer program EPANET was used to conduct the simulations on pipe networks. Data required for hydraulic analysis using EPANET was obtained from Municipal Waterworks Tirta Musi. The result shows that head pressure was the main problem in Alang-Alang Lebar. Adding discharge of pump reservoir, enlarging pipe diameters in some parts will improve the distribution performance. The proposed design of the distribution system will be able to deliver water for the next 20 years with an increasing number of the customer.

Keywords: clean water, EPANET, water distribution system

1. Introduction

Municipal Waterworks Tirta Musi is a government company that manages and supplies clean water to Palembang city [1]. It is located in the capital of South Sumatera province, Indonesia, with more than 1.6 million people [2]. The municipal waterworks utilize Musi River, one of the largest rivers in Indonesia. There are 18 districts supplied by Municipal waterworks Tirta Musi including Alang-alang Lebar, Bukit Kecil, Gandus, Ilir Barat I, Ilir Barat II, Ilir Timur I, Ilir Timur II, Ilir Timur III, Jakabaring, Kalidoni, Kemuning, Kertapati, Plaju, Sako, Seberang Ulu I, Seberang Ulu II, Sematang Borang and Sukarami (Figure 1) [3,4]. The network system of Municipal Waterworks Tirta Musi is expected to distribute water sufficiently to all customers in all districts. In order to fulfill the need for clean water, municipal waterworks Tirta Musi continuously improves the service by improving water quality, adding production capacity, and fixing the distribution network system.

Most of the districts are well supplied by municipal Waterworks Tirta Musi, except Alang-alang Lebar and Sukarami districts. To improve the service of Municipal Waterworks Tirta Musi, the service is divided into several service units based on the area. Alang-alang Lebar unit serves the whole area of Alang-alang Lebar district and some areas of Sukarami district. All areas served by Alang-alang Lebar unit include Alang-alang Lebar, Karya Baru, Talang Kelapa, Sukarami, Kebun Bunga, Sukodadi, Talang Betutu and Talang Jambe villages.

Insufficient supply in those two districts due to the location's distance from the waterworks and large service area. Additionally, there is a significant increase in population in this area due to a residential area. However, the discharge release by municipal waterworks Tirta Musi is still insufficient. The problem that water cannot reach some locations within the distribution pipe networks of Municipal Waterworks also happened in some places in Indonesia [5,6,7,8,9]. In addition to the quantity, distributed water quality also needs to be fulfilled the requirements [10,11,12].

Alang- Alang Lebar service unit is willing to improve the service so that the people in their service area get adequate clean water. With the increasing need for clean water for customers, it is necessary to evaluate and calculate clean water needs in the Alang-Alang Lebar Service Unit at present and in the future. So that the people will get clean water distributed from the Municipal Waterworks sufficiently even at peak hours. Therefore, this study aims to evaluate the existing distribution system in the Alang-Alang Lebar Service Unit's water distribution area, analyze water needs and distributed discharges to meet customer needs in the next 20 years, and analyze hydraulic distribution system and water availability.

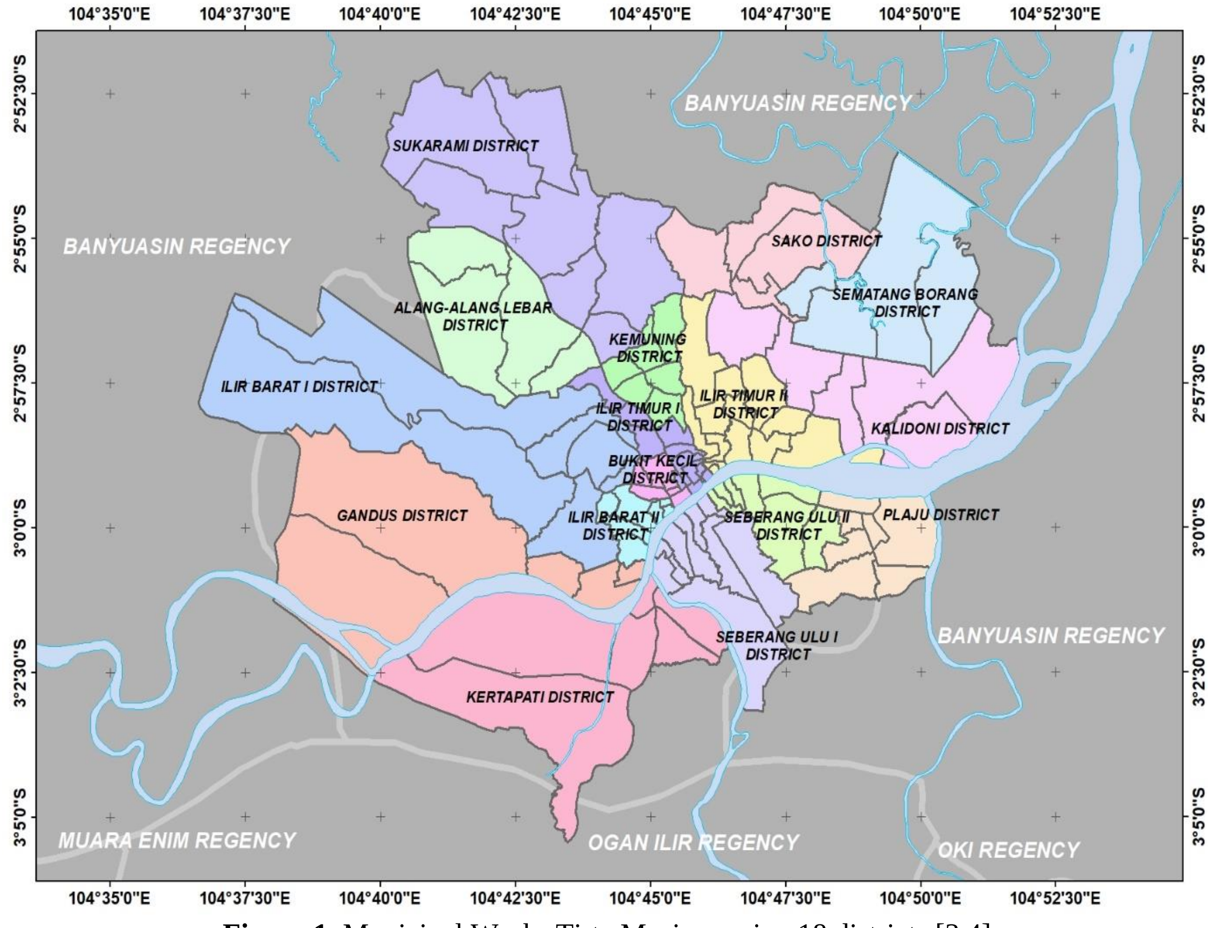


Figure 1. Municipal Works Tirta Musi covering 18 districts [3,4]

2. Materials and Methods

The steps performed in the analysis of water distribution systems in Alang-alang Lebar service unit are as follows:

1. To recapitulate on the number of active customers and water usage in the last five years.

2. To project the addition of active customers for the next 20 years based on recapitulation done in the last five years. According to the regulation of the Minister of Public Works No. 18 / PRT / M / 2007 [13] on the implementation of the development of drinking water systems, some methods can be used to estimate the population in the next 20 years. The methods include arithmetic, geometric and exponential methods [14,15]. Estimation resulting from the three methods will be tested to get the correlation coefficient values approaching one and the smallest standard deviation value.
3. After analyzing the discharge of water demand in the next 20 years, it can be calculated the distributed discharge, the discharge of the pump reservoir, the scheme of distribution system from the reservoir until the end of the distribution service.
4. Flow in the pipe network is related to flow discharge and pressure at each node. There are two equations to be solved, including the continuity equation in each node/junction and Darcy-Weisbach and Hazen-Williams equations to solve the nonlinearity relationship between discharge and energy loss in each pipe [16,17]. The equations can be solved using iteration methods as the pipe networks consist of loops. The computer program which can be used for such computation is EPANET [18,19]. Data required for the simulation using EPANET 2.0 includes network map, node/junction of distribution components, elevation, the length of distribution pipes, diameter of pipes, type of pipes, pipe age, pump specification, load at every node, and fluctuation factor of water usage.
5. This study conducts two simulations. The first is a simulation program at the existing condition using the current distribution system. The second simulation runs the distribution system for the next 20 years. After successfully entering the required data, the program will automatically analyze the system giving some outputs, i.e., hydraulic head, pressure, velocity, and headloss unit.

3. Results and Discussion

Along with the city's development, the public demands of the facilities provided by the government will increase, including the need for adequate water both now and in the future. Of the three methods mentioned before, it was found that the exponential regression method is the most suitable method for projections of the future customer in the area of Alang-alang Lebar Services Unit as the correlation coefficient value is closest to 1 (one) and the standard deviation is the smallest. Therefore, the addition of customers and projected water requirements for the next 20 years was calculated using the exponential regression method.

Table 1. Customer and Discharge Projections for Water Supplies

No.	Urban Village	Present		Next 20 years		
		Active Customers (SR)	Required water discharge (l/s)	Active Customers (SR)	Required water discharge (l/s)	Adding 8% losing Water (l/s)
1	Karya Baru	4,348	39.24	15,353	138.57	150.62
2	Talang Kelapa	6,378	54.86	22,522	193.73	210.58
3	Alang-Alang Lebar	1,647	14:23	5,816	50.25	54.62
4	Sukarami	3,167	28.63	11,183	101.10	109.89
5	Kebun Bunga	4,525	36.44	15,978	128.68	139.87
6	Talang Betutu	2,324	16.85	8,206	59.49	64.66
7	Sukodadi	2,791	20:33	9,855	71.79	78.03
8	Talang Jambe	1,555	10:26	5,491	36.23	39.39
	Total	**26,735**	**220.85**	**94,405**	**779.85**	**847.66**

Table 1 shows active customers and water needed at present and the next 20 years. The projection of active customers and required discharges for the next 20 years and corresponding villages is shown in Figure 2. Clean water needs for customers at Alang-Alang Lebar Service Unit in the next 20 years is 779.850 liters/sec or 24.256.388 m^3/year. Adding factor 8% for losses during distribution, the total required water discharge at the Service Unit of Alang Lebar in the 20 years is 847.66 liters/sec or 26.365.639 m^3/year.

Simulation for the existing condition and following 20 years including two boosters in Alang-alang Lebar Service unit, i.e., boosters Alang-alang Lebar and Punti Kayu. Table 2 presents discharges of pump reservoirs for the existing condition are 200 l/s and 150 l/s at Alang-alang Lebar and Punti Kayu, respectively. In comparison, discharges of pump reservoirs for the next 20 years are 950 l/s and 300 l/s at Alang-alang Lebar and Punti Kayu, respectively. Pump capabilities are kept the same for simulations 1 and 2 with 30 m and 50 m for Alang-alang Lebar and Punti Kayu, respectively. Table 3 presents pipe diameter and type at the existing condition and the next 20 years. It can be seen that in some parts, the pipe needs to be enlarged or changed the type.

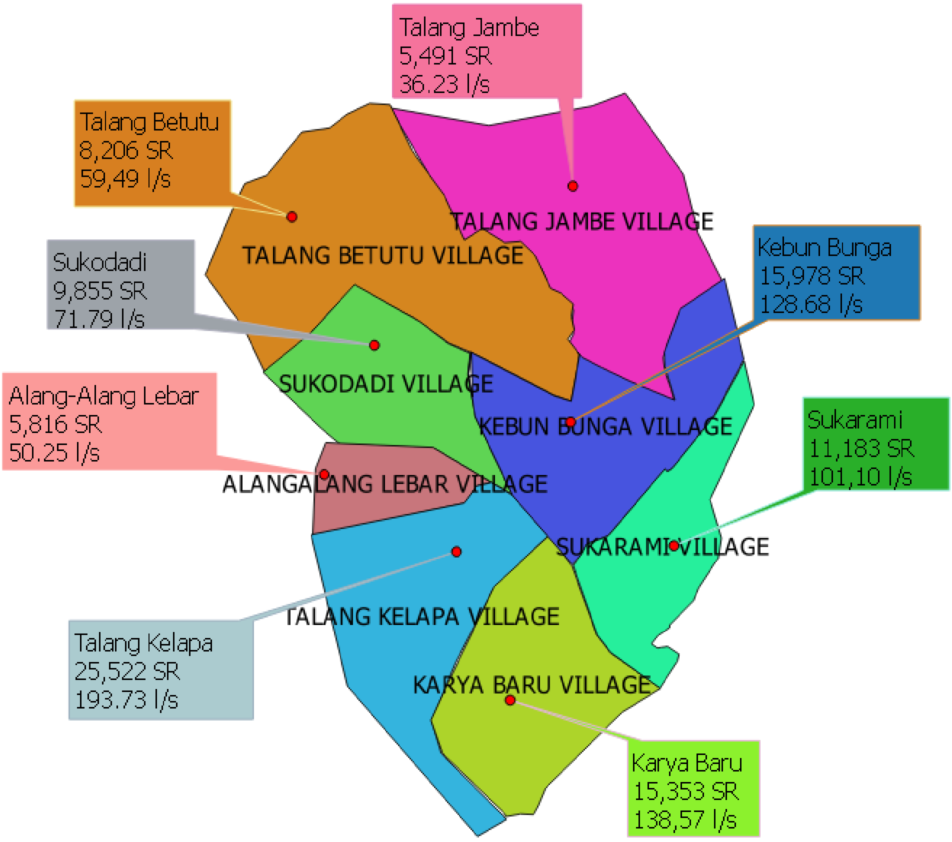


Figure 2. Projected number of active customers and distribution discharge at each village in Alang-Alang Lebar service unit

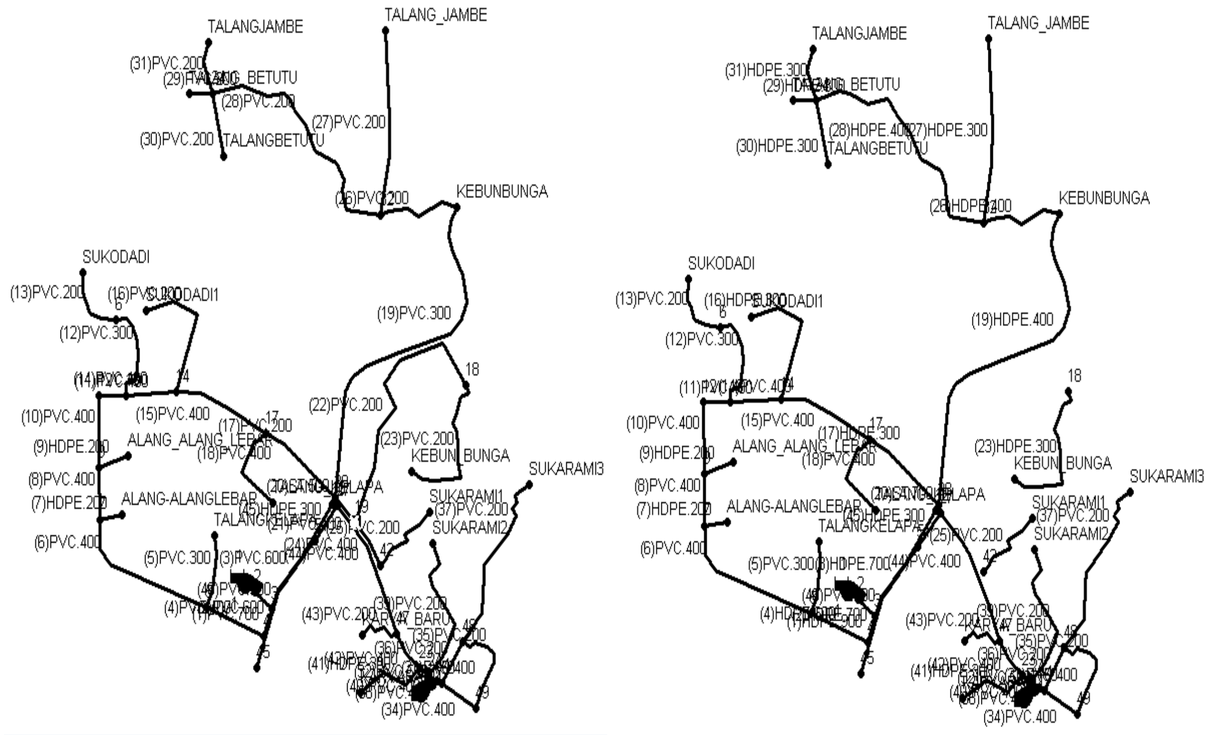
Tabel 2. Discharge and Capability of Pump Reservoir at Existing Condition and Next 20 years at Booster Alang-alang Lebar and Punti Kayu

Booster	Simulation	Period	Discharge of Pump Reservoir (Lps)	Pump Capability (m)
Alang-alang Lebar	1	Present	200	30
	2	Next 20 years	950	30
Punti Kayu	1	Present	150	50
	2	Next 20 years	300	50

Table 3 Pipe Diameters and Type at Existing Condition and Next 20 years

Existing Pipe		Pipe ID	Design Pipes Next 20 years	
Diameter	Type		Diameter	Type
700	PVC	1	900	HDPE
600	PVC	2	700	HDPE
600	PVC	3	700	HDPE
400	PVC	4	600	HDPE
300	PVC	5	300	PVC
400	PVC	6	400	PVC
200	HDPE	7	200	HDPE
400	PVC	8	400	PVC
200	HDPE	9	200	HDPE
400	PVC	10	400	PVC
400	PVC	11	400	PVC
300	PVC	12	300	PVC
200	PVC	13	200	PVC
400	PVC	14	400	PVC
400	PVC	15	400	PVC
200	PVC	16	300	HDPE
200	PVC	17	300	HDPE
400	PVC	18	400	PVC
300	PVC	19	400	HDPE
500	ST	20	700	ST
400	PVC	21	400	PVC
200	PVC	22	300	HDPE
200	PVC	23	300	HDPE
400	PVC	24	400	PVC
200	PVC	25	200	PVC
200	PVC	26	400	HDPE
200	PVC	27	300	HDPE
200	PVC	28	400	HDPE
200	PVC	29	300	HDPE
200	PVC	30	300	HDPE
200	PVC	31	300	HDPE
500	PVC	32	500	PVC
400	PVC	33	400	PVC
400	PVC	34	400	PVC
200	PVC	35	200	PVC
200	PVC	36	200	PVC
200	PVC	37	200	PVC
400	PVC	38	400	PVC
200	PVC	39	200	PVC
400	PVC	40	400	PVC
300	HDPE	41	300	HDPE
400	PVC	42	400	PVC
200	PVC	43	200	PVC
400	PVC	44	400	PVC
300	HDPE	45	300	HDPE
300	PVC	46	300	PVC

Map of distribution pipe network at Alang-alang Lebar service unit is presented in Figure 3a for existing condition and Figure 3b for the next 20 years. Some of the differences of the distribution pipe networks are that pipe diameters are larger at some pipe nodes, as was presented in Table 3.



(a) (b)

Figure 3. Map of distribution pipe network at Alang-alang Lebar Service Unit for existing condition **(a)** and the next 20 years **(b)**

Simulation 1 uses some parameters presenting the current condition. Four parameters are observed from running EPANET software: pressure, flow velocity, discharge, and head loss. It is presented in Figure 4 that the pressure at the end of the service pipe in Talang Betutu village is - 1.69 m at 06.00 am. The Minister of Public Works Regulation No. 18 / PRT / M / 2007 mentioned that the minimum flow velocity is 0.30 m/s, pipe no. 30 shows the flow velocity of 0.23 m/s at 06.00 am (Figure 5). Accordingly, simulation one obtained the direction and discharge at each distribution pipe, and pipe no.29 shows that the discharge is 11.70 l/s at 6 am (Figure 6). The pressure loss in each distribution pipe is shown in Figure 7, and it was shown that pipe no.29 shows that the pressure loss (unit head loss) is 1.01 m/km at 6 am.

Simulation 2, designed for the next 20 years, is presented in Figures 8, 9, 10, and 11. As presented in Figure 8, the pressures at the end of each pipe are none of them being negative. Moreover, even in Talang Betutu village, the pressure at the pipe end is 1.67 m. Furthermore, Figure 9 shows the flow velocity of 0.39 m/s at 06.00 am. The simulation obtained the direction and flowed at each distribution pipe, and Figure 10 shows the flow in pipe no. 29 is 44.94 l/s at 06.00 am. Figure 11 shows pressure loss in the distribution pipe network, while pipe no. 29 shows the pressure loss/unit head loss of 1.46 m/km at 06.00 am.

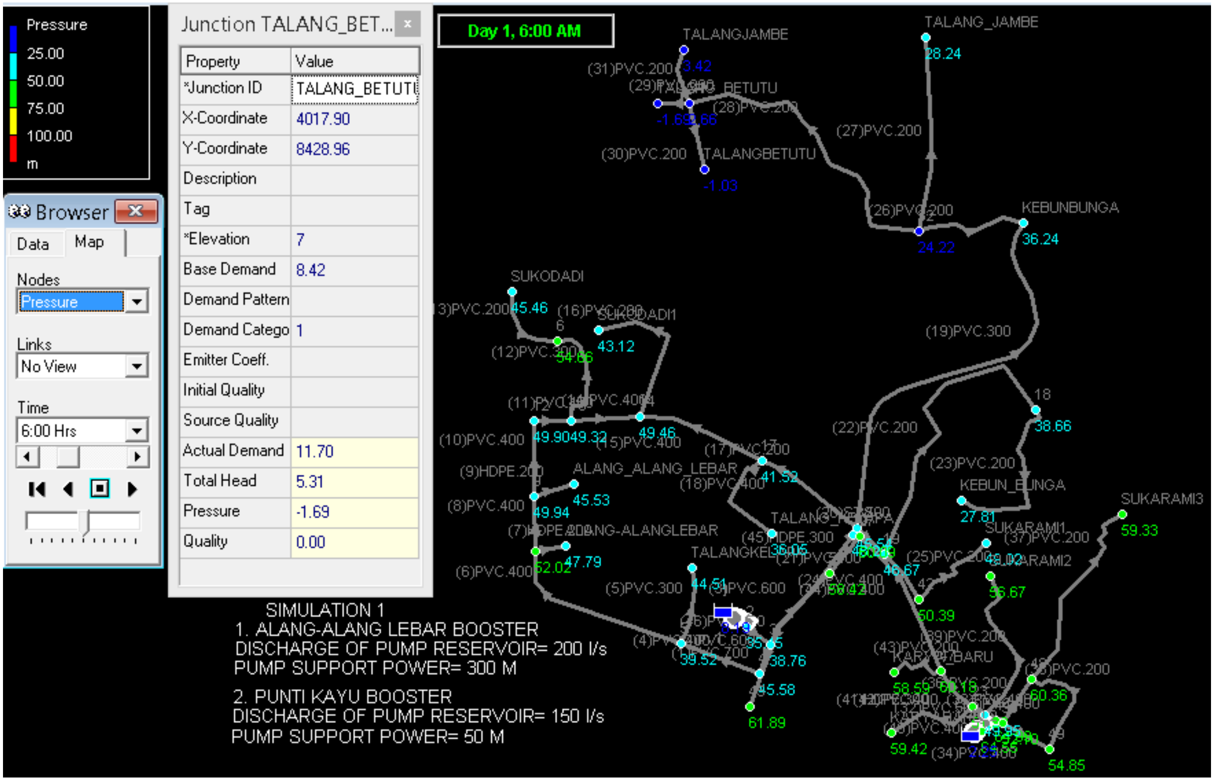


Figure 4. Pressures at the end of pipes on Simulation 1 at 06:00 am.

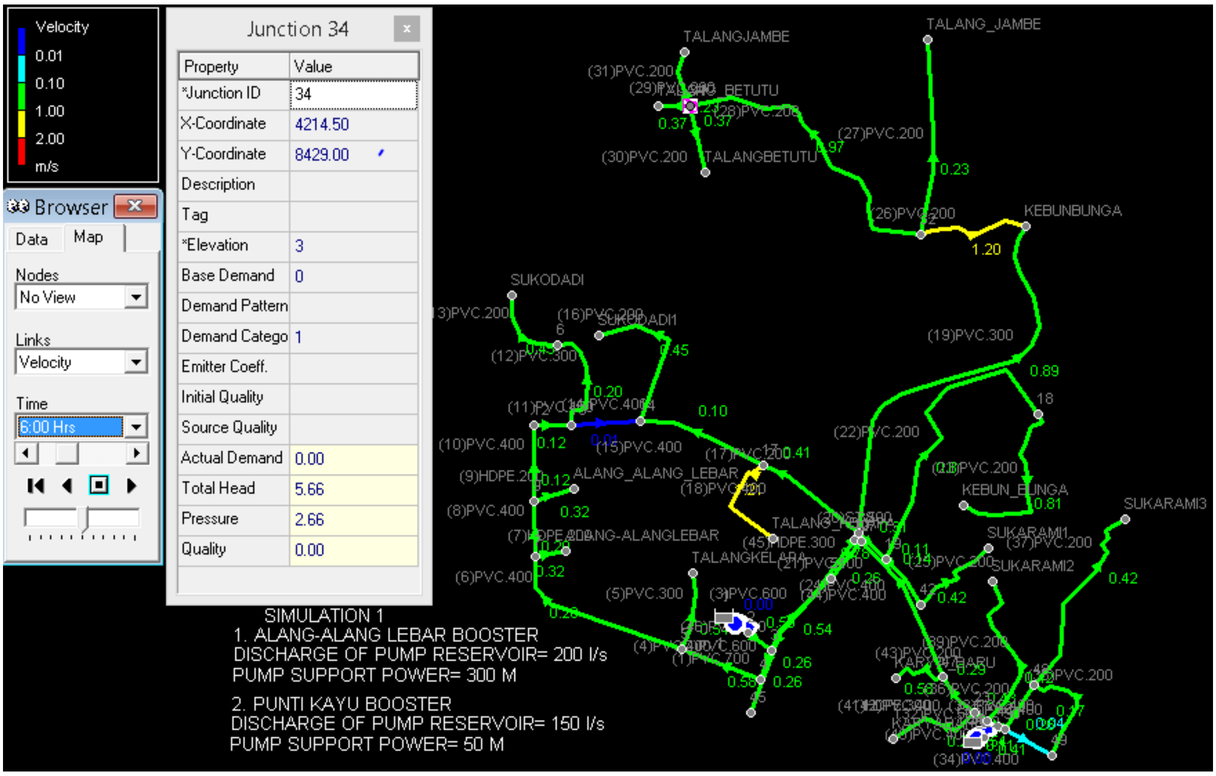


Figure 5. Flow velocity in pipes on Simulation 1 at 06:00 am

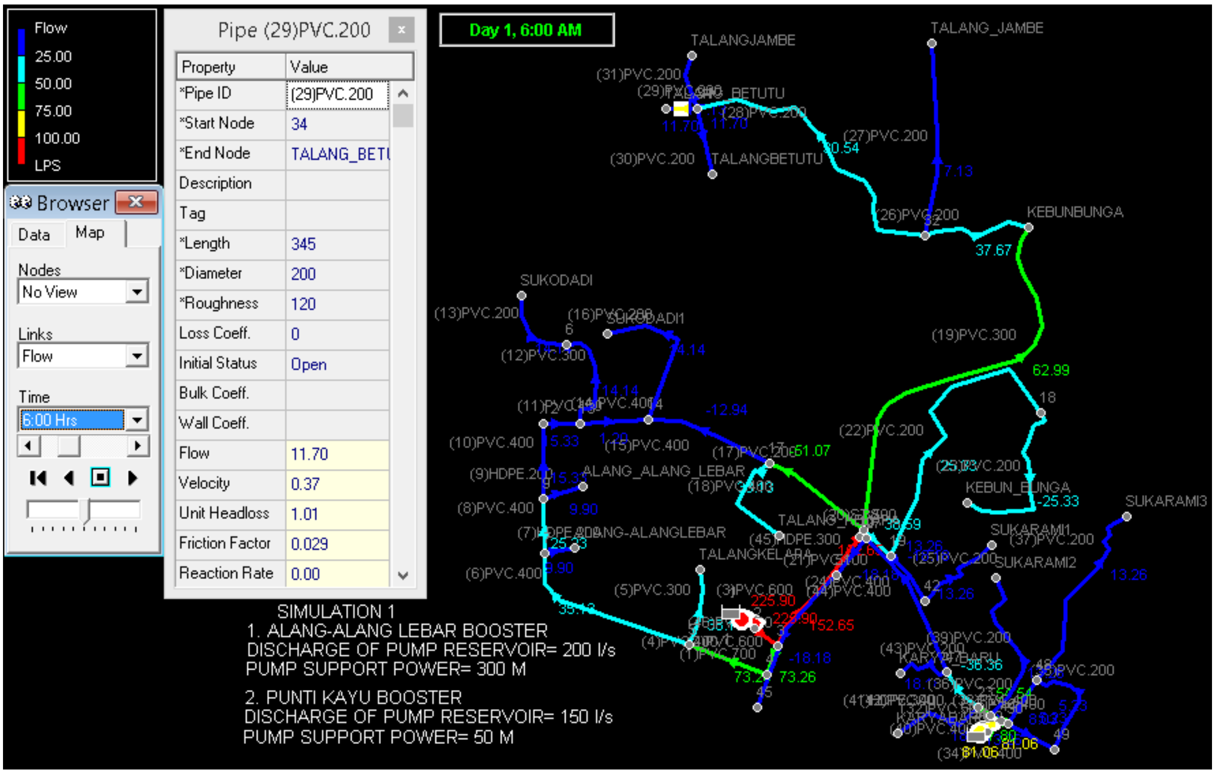


Figure 6. Flow In Pipes and Flow Direction on Simulation 1 at 06:00 am

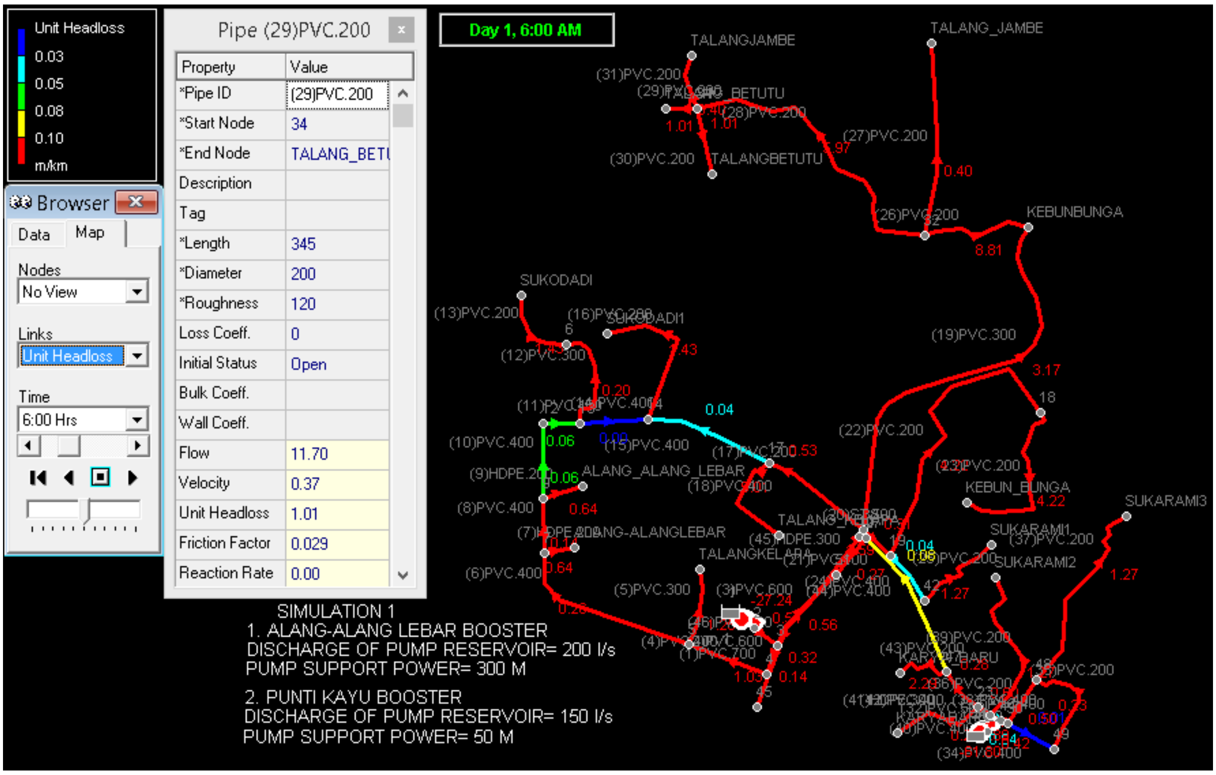


Figure 7. Loss of Pressure Pipe Distribution on Simulation 1 at 06:00 am

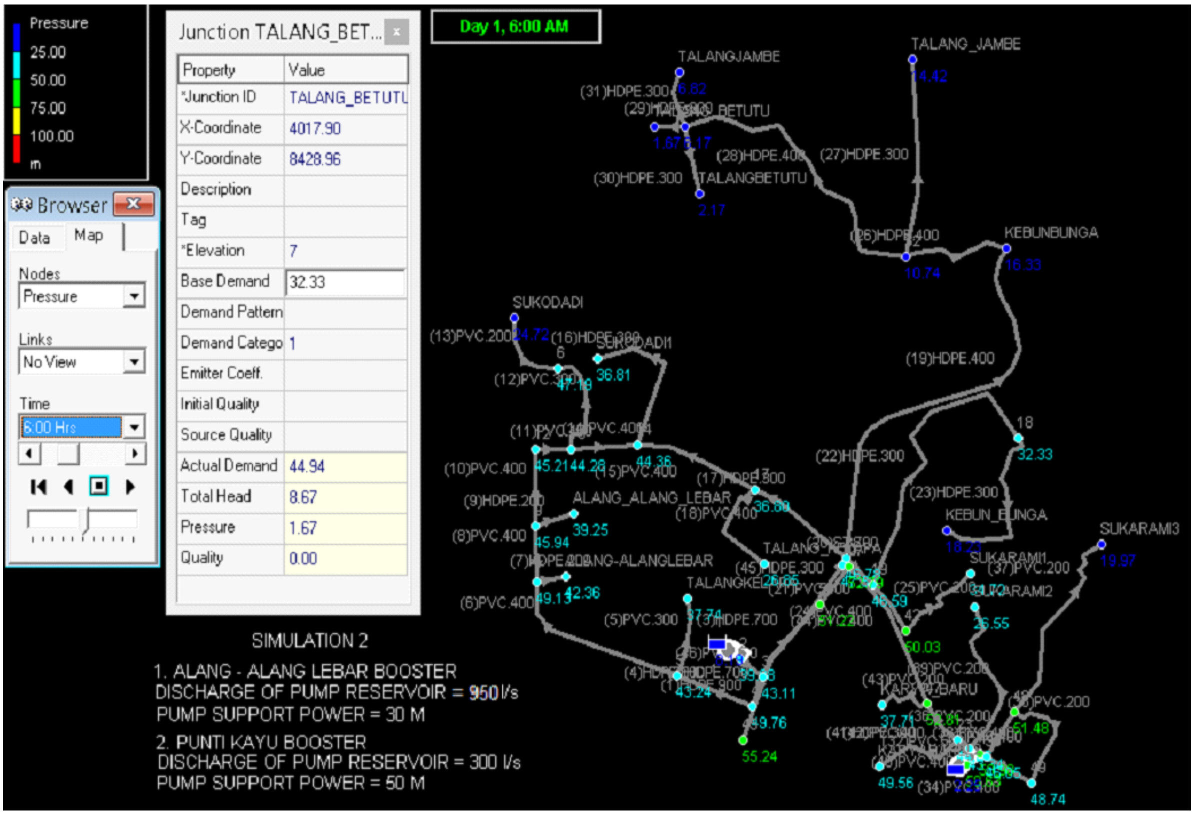


Figure 8. Pressures at end of pipes on Simulation 2 at 06:00 am

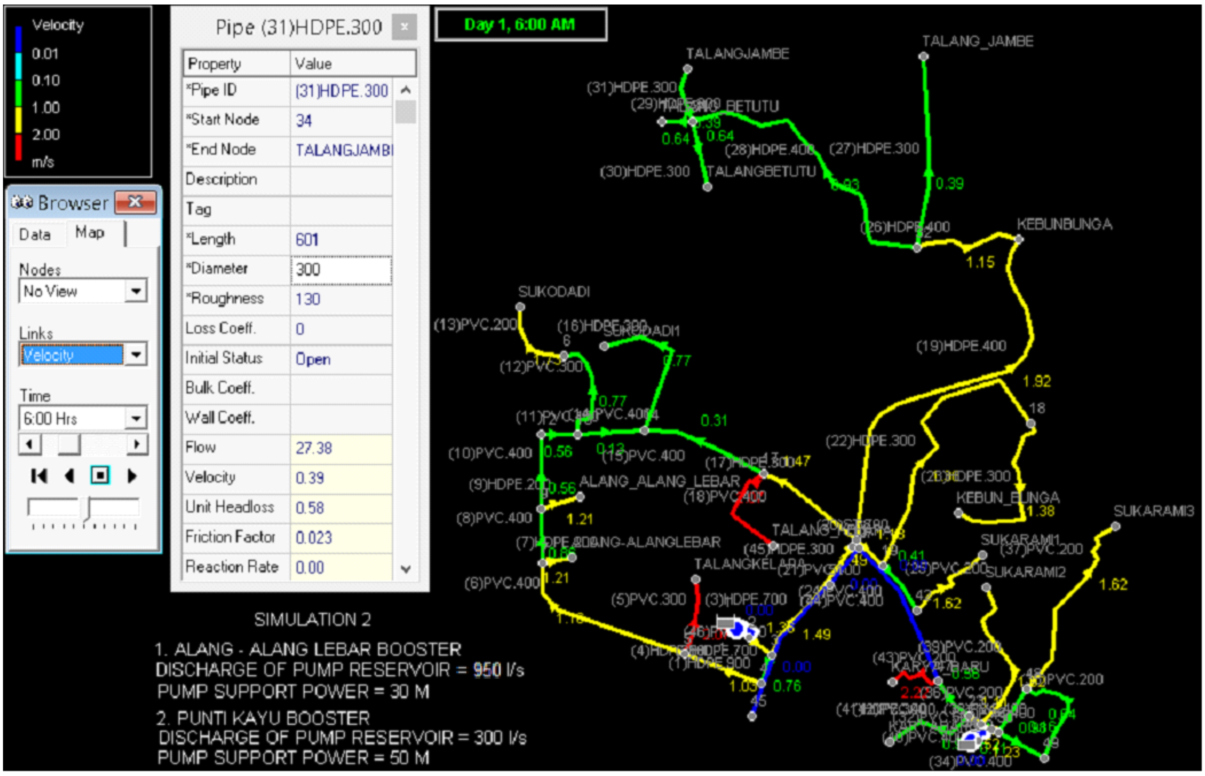


Figure 9. Flow velocity in pipes on Simulation 2 at 06:00 am

IOP Conf. Series: Earth and Environmental Science **930** (2021) 012019 doi:10.1088/1755-1315/930/1/012019

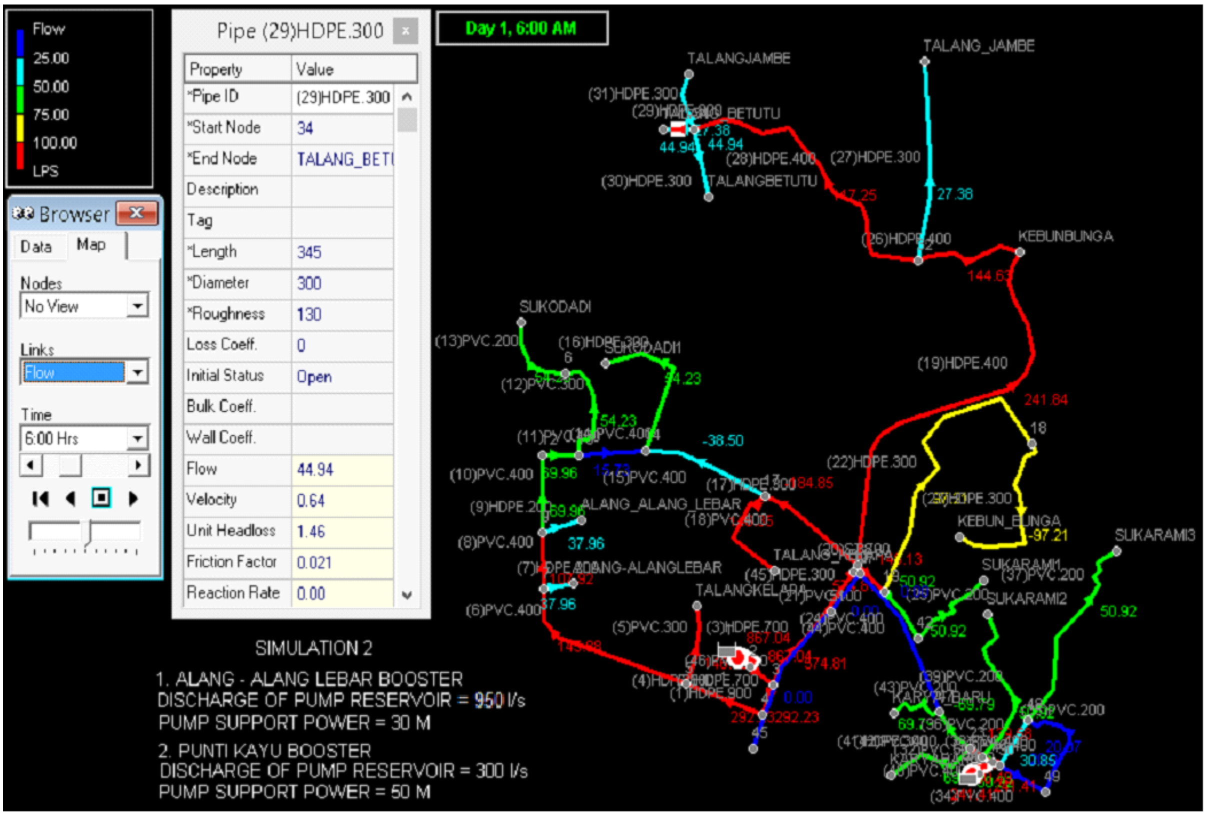


Figure 10. Flow In Pipes and Flow Direction on Simulation 2 at 06:00 am

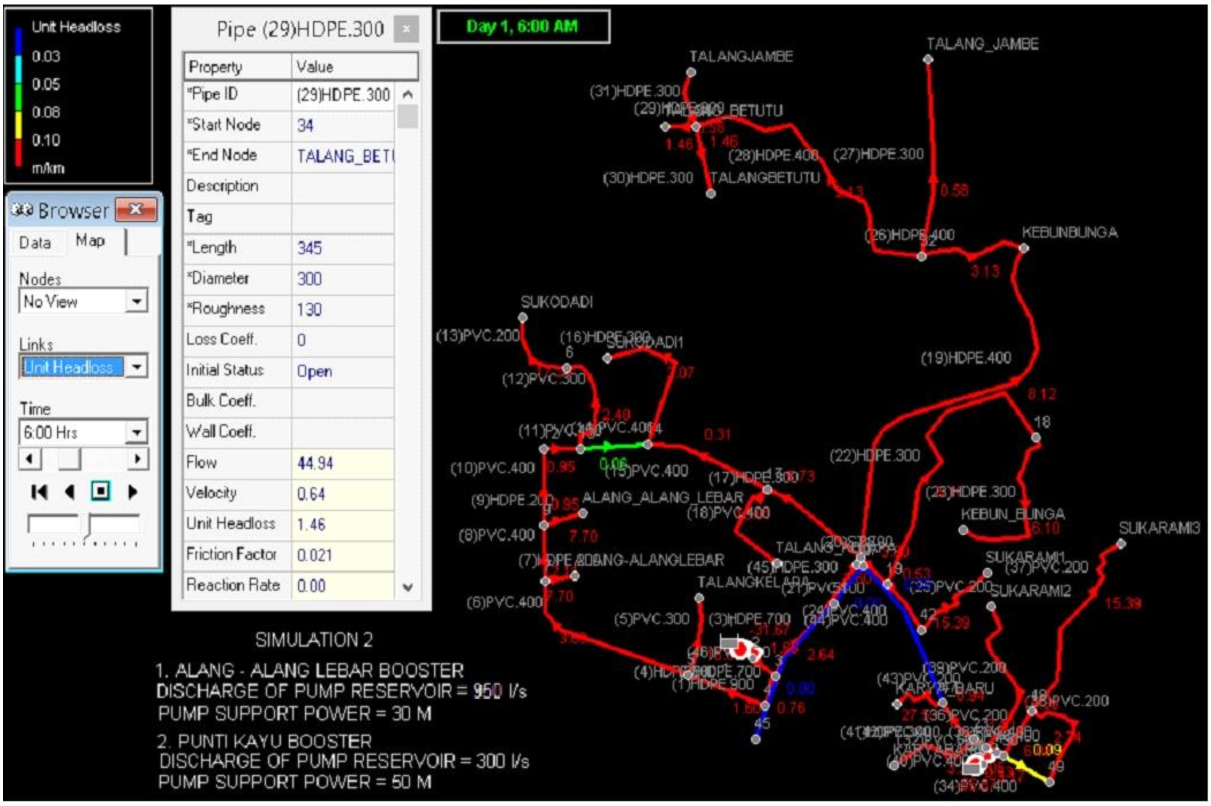


Figure 11. Loss of Pressure Pipe Distribution on Simulation 2 at 06:00 am

Simulation 1 shows that the pressure at the end of the distribution pipe at Talang Betutu village is negative at peak hours. Therefore, water cannot be delivered to the place in the morning during peak usage. Conversely, Simulation 2 shows that there is no negative pressure at any pipe during peak hours. So, it can be said that adding the reservoir pump discharge to 950 l/s dan pump head 30 m at Alang-alang Lebar booster as well as adding the reservoir pump discharge to 300 l/s and pump head 50 m at Punti Kayu booster will maintain water to be distributed well to every village in Alang-alang Lebar service unit. In addition, changing the diameter and type of pipes will improve water distribution in the pipe network.

4. Conclusion

1. Analysis of existing pipe networks in Alang-alang Lebar service unit shows that water cannot be distributed in some villages due to negative pressure found in nodes 29 and 30.
2. Projected increasing number of customers in the next 20 years causes increasing consumption water to 779.85 l/s or 847.66 l/s after considering losses.
3. Increasing reservoir pump discharges to 950 l/s at Alang-alang Lebar and 300 l/s at Punti Kayu and maintaining pump heads at both boosters. Enlarging some pipe diameters and changing the type of pipe at some locations will enable Alang-alang Lebar service unit to distribute water sufficiently and even at peak hours to all villages.

Acknowledgments

The authors acknowledge the assistance of Municipal Works of Tirta Musi in providing the required data.

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