Studi Kasus Sistem Jaringan Distribusi Air Minum PERUMDA Delta Tirta Instalansi Pengolahan Air (IPA) Tawangsari Zona Pelayanan Kecamatan Taman dan Kecamatan Waru

Case Study of Drinking Water Distribution Network System PERUMDA Delta Tirta Water Treatment Plant (IPA) Tawangsari Service Zone Taman District and Waru District

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ABSTRAK

Tingkat kehilangan air menurut Menteri Pekerjaan Umum dan Perumahan Rakyat Republik Indonesia No 27/PRT/M/2016 pada batas maksimum yaitu sebesar 20%, akan tetapi pada tingkat kehilangan air PERUMDA Delta Tirta pada zona pelayanan Kecamatan Taman yaitu sebesar 27.48, zona pelayanan Kecamatan Waru I tingkat kehilangan air sebesar 32.28% dan zona pelayanan Kecamatan Waru II tingkat kehilangan air sebesar 20.52%. tujuan pada penelitian ini untuk mengevaluasi tingkat kehilangan air pada zona pelayanan Kecamatan Taman dan zona pelayanan Kecamatan Waru. Metode evaluasi pada jaringan distribusi IPA Tawangsari dengan simulasi software Epanet 2.0 dengan tekanan air dalam pipa dan kecepatan air dalam pipa dibandingka dengan Menteri Pekerjaan Umum dan Perumahan Rakyat Republik Indonesia No 27/PRT/M/2016. Tekanan air dalam pipa pada zona pelayanan Kecamatan Taman yaitu sebesar 55.18 m, kecepatan air dalam pipa sebesar 0.1 m/s dan tekanan air dalam pipa pada zona pelayanan Kecamatan Waru yaitu sebesar 59.57 m, kecepatan air dalam pipa sebesar 1.58 m/s. Optimalisasi sistem jaringan distribusi IPA tawangsari zona pelayanan Kecamatan Taman dan zona pelayanan Kecamatan Waru yaitu dengan pergantian Head pompa. Mengganti head pompa merupakan salah satu solusi untum menghilangkan tekanan yang berlebihan, dan mengurangi kerusakan pada pipa.

Kata kunci: distribusi, Sofware Epanet 2.0, tekanan

ABSTRACT

The water loss rate according to the Minister of Public Works and Public Housing of the Republic of Indonesia No. 27/PRT/M/2016 at the maximum limit is 20%, but at the PERUMDA Delta Tirta water loss rate in the Taman Subistrict service zone is 27.48, the Waru Subdistrict service zone I the water loss rate is 32.28% and the service zone of Waru II District the water loss rate is 20.52%. The purpose of this study was to evaluate the level of water loss in the service zone of the Taman District and the Waru District service zone. The evaluation method for the Tawangsari IPA distribution network is using the Epanet 2.0 software simulation with water pressure in the pipes and water velocity in the pipes compared to the Minister of Public Works and Public Housing of the Republic of Indonesia No. 27/PRT/M/2016. The water pressure in the pipe in the Taman Subdistrict service zone is 55.18 m, the water velocity in the pipe is 0.1 m/s and the water pressure in the pipe in the Waru District service zone is 59.57 m, the water velocity in the pipe is 1.58 m/s. Optimization of the Tawangsari WTP distribution network system in the Taman Subistrict service zone and the Waru Subdistrict service zone, namely by changing the pump head. Replacing the pump head is one of the solutions to eliminate excessive pressure and reduce damage to the pipe.

Keywords: distribution, software Epanet 2.0, pressure

INTRODUCTION

Water is an essential need for human life. Humans cannot be separated from using water for daily life, such as bathing, washing, and using the toilet. Clean water is water that has been used for everyday activities. Clean water is: when it is tasteless, colorless, and odorless. In addition, clean water comes from springs such as wells, lakes, rivers, and mountain water (Aulia, 2018).

Regional water needs are handled by the Regional Public Company (PERUMDA), which oversees the Regional Drinking Water Company (PERUMDA), which has two functions: economic and social. Sidoarjo Regency has 18 subdistricts, 322 villages, and 31 subdistricts. The population of Sidoarjo Regency in 2021 is 2,064,168 people. PERUMDA Delta Tirta serves 37% of the total population in Sidoarjo Regency, with around 821,245 customers. PERUMDA Delta Tirta has seven service branches, namely Waru I, Waru II, Gedangan, Krian, Porong, Taman, and Sidoarjo Branches. The Taman Branch has 3,183 house connections, the Waru I Branch has 25,179 house connections, and the Waru II Branch has 20,451.

According to water loss rate data, PERUMDA Delta Tirta is still experiencing water loss above the maximum limit according to the Regulation of the Minister of Public Works and Public Housing of the Republic of Indonesia No 27/PRT/M/2016 that the maximum water loss rate is 20%. In the Garden Branch, the water loss rate was 27.48; in the Waru I Branch, the water loss rate was 32.28%; and in the Waru II branch, the water loss rate was 20.52%.

The application of DMA can reduce the high level of water loss, namely PDAM Yogyakarta City, Malang City, Semarang City, Bali City, and Surabaya City (Mustafidah, 2019). The main principle of DMA is to use flow to determine the level of water loss in a specific area. PDAM Kota Malang in October, the water loss in DMA Mojo 1 C was 36%, and DMA 2B4 was 40% after the DMA method for water loss in DMA Mojo 1 C was 15%, and DMA Mojo 2B4 was 38% (Dayanti & Hendriarianti, 2022).

For example, PDAM PDAM on Jalan Soekarno Hatta Palembang experienced a water loss of 33.44%. After the EPANET simulation was carried out using the DMA polygon, it decreased to 10.64% (Tanaka *et.al*., 2022). DMA creation can be divided into the following two phases: identification of DMA zones, installation of metering and control devices, and cut-off valves (Brentan, *et al.*, 2022). The division of the water distribution network into DMAs is considered one of the most cost-effective and efficient techniques to optimize the operation of the water distribution network in terms of reducing the actual rate of water loss (Kowalska *et.al*., 2022).

As a Regional Drinking Water Company that serves the water needs of the population in Sidoarjo Regency, further action is needed to improve the management of the distribution network, especially for branches that experience high levels of water loss by establishing a District Meter Area (DMA) system as an effort to address this problem. For several reasons, conducting a case study of the Drinking Water Distribution Network System PERUMDA Delta Tirta Water Treatment Plant (IPA) Tawangsari Service Zone Taman and Waru Subdistrict is necessary to reduce water loss so that it runs well and does not harm PERUMDA Delta Tirta.

METHODS

Research sites

This research was done at IPA Tawangsari JMWG+XH6, Tawangsari Timur, Tawangsari, Taman Subdistrict, Sidoarjo Regency, East Java, with service coverage in Taman and Waru Subdistrict.

Network Hydraulics Analysis

In the Regulation of the Minister of Public Works and Public Housing of the Republic of Indonesia, No 27/PRT/M/2016, the minimum velocity limit for water in pipes is 0.3-0.6 m/s, and the maximum velocity limit for water in pipes is 3.0-4.5 m/sec. Meanwhile, the minimum water pressure in the pipe is 1 atm, and the maximum water pressure in the pipe is 6-8 atm. The purpose of the evaluation is to advise PERUMDA Delta Tirta, especially the Tawangsari WTP administrator, if there are deficiencies in the distribution of clean water so that the number of services can be achieved under the Sidoarjo Regency clean water coverage plan.

Dimension Calculation

Dimensional calculations are obtained from piping dimension calculations, looking for diameters on the market, diameters that are close to the calculation results, and calculating minor headloss major and headloss minor.

Calculation of piping dimensions obtained the following equation (Alvisi & Franchini, 2014):

$$Q = \frac{1}{4} \times \Pi \times D^2 \quad (1)$$

Description:
Q = flow rate in the pipe (Lps)
D = distribution pipe diameter (mm)

Calculation for major headloss with the following equation (Mays, 1999):

$$\Delta H = \left(\frac{Q}{0.2785 \cdot C \cdot D^{2.63}} \right)^{1.85} \times L \quad (2)$$

Calculation for minor headloss with the following equation (Nenny Roostriawaty et al., 2021):

$$H_L = K \frac{v^2}{2g} \quad (3)$$

Description:
Q = flow rate in the pipe (Lps)
C = pipe roughness coefficient according to Hazen-Williams (non-dimensional)
D = distribution pipe diameter (mm)
S = headloss mayor (meter)
Δh = headloss minor (meter)
K = accessories headloss coefficient (non-dimensional)
v = velocity in the pipe (m/s)
g = acceleration of gravity (9.81 m²/s)

RESULT AND DISCUSSION

PERUMDA Delta Tirta uses a pumping distribution network system to serve all Sidoarjo Regency customers.

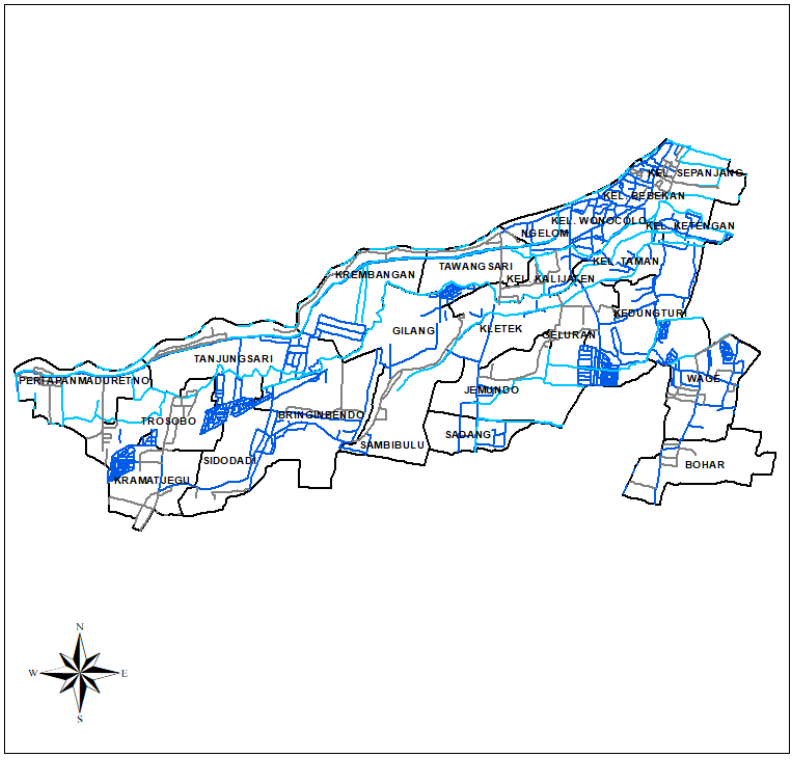

Figure 1. The existing condition of the Taman Subdistrict service zone

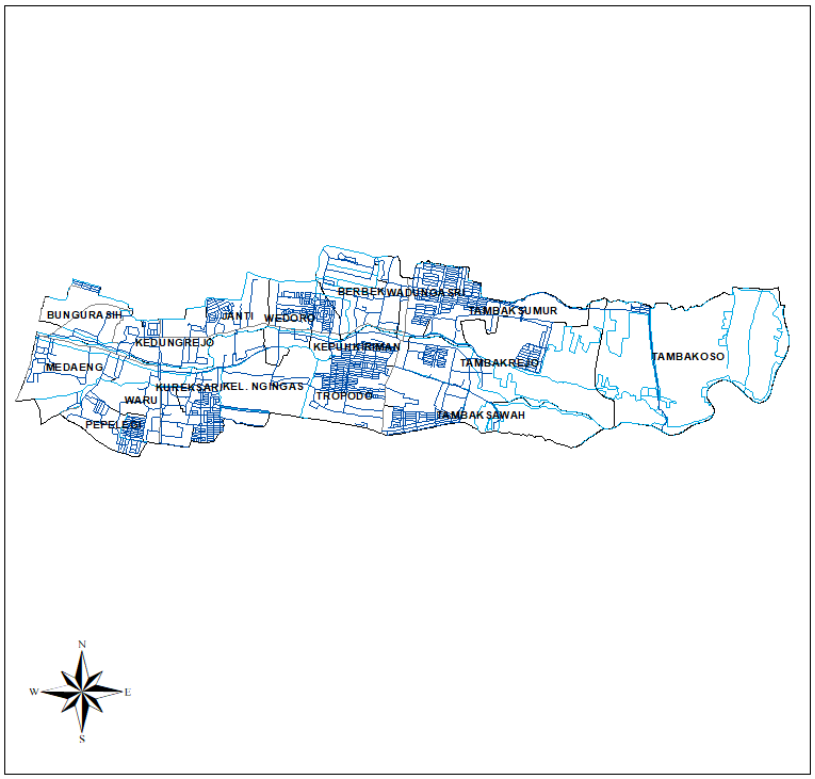

Figure 2. The existing condition of the Waru Subdistrict service zone

Distribution Network Analysis of Existing Conditions Simulation Program Epanet 2.0

The elevation in the Tawangsar IPA drinking water distribution network is 9 m. The source of raw water used to serve customers comes from the Kali Pelayaran River. The service zones of Taman and Waru

Subdistrict were carried out by hydraulic simulation of the distribution network using Epanet 2.0 software running analysis on the hydraulic simulation of the distribution network. The output results are obtained, including pipe output data, namely flow (discharge), velocity (flow velocity), and headloss (loss of pressure): data output nodes, namely pressure (pressure) and total head. The value of the pressure and velocity of the pipe flow refers to the Regulation of the Minister of Public Works and Public Housing of the Republic of Indonesia Number 27/PRT/M/2016 concerning the Implementation of a Drinking Water Supply System.

Some areas experience water pressure in the pipes above the minimum limit criteria for Regulation of the Minister of Public Works and Public Housing of the Republic of Indonesia Number 27/PRT/M/2016 Concerning the Implementation of a Drinking Water Supply System, namely 1 atm (1 atm = 10 meters). Excessive water pressure in the pipe can be overcome by using a pressure-reducing valve, while the water pressure in the pipe experiencing a lack of pressure can be overcome using a booster pump.

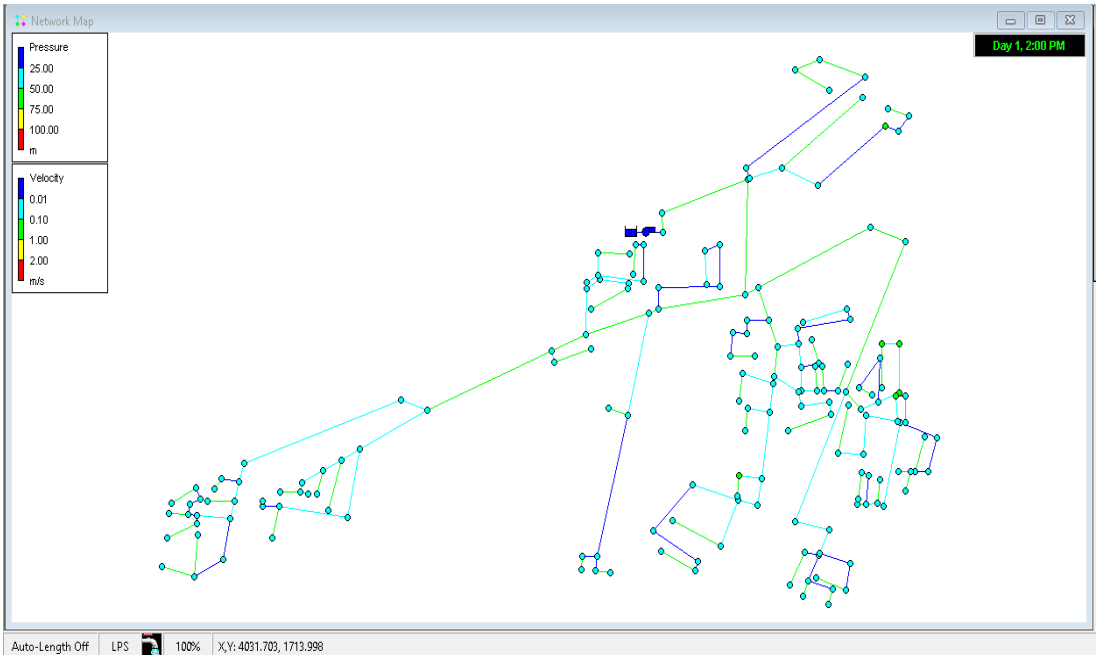

Figure 3. EPANET running results for the existing condition of the Taman Subdistrict service zone at 2 pm

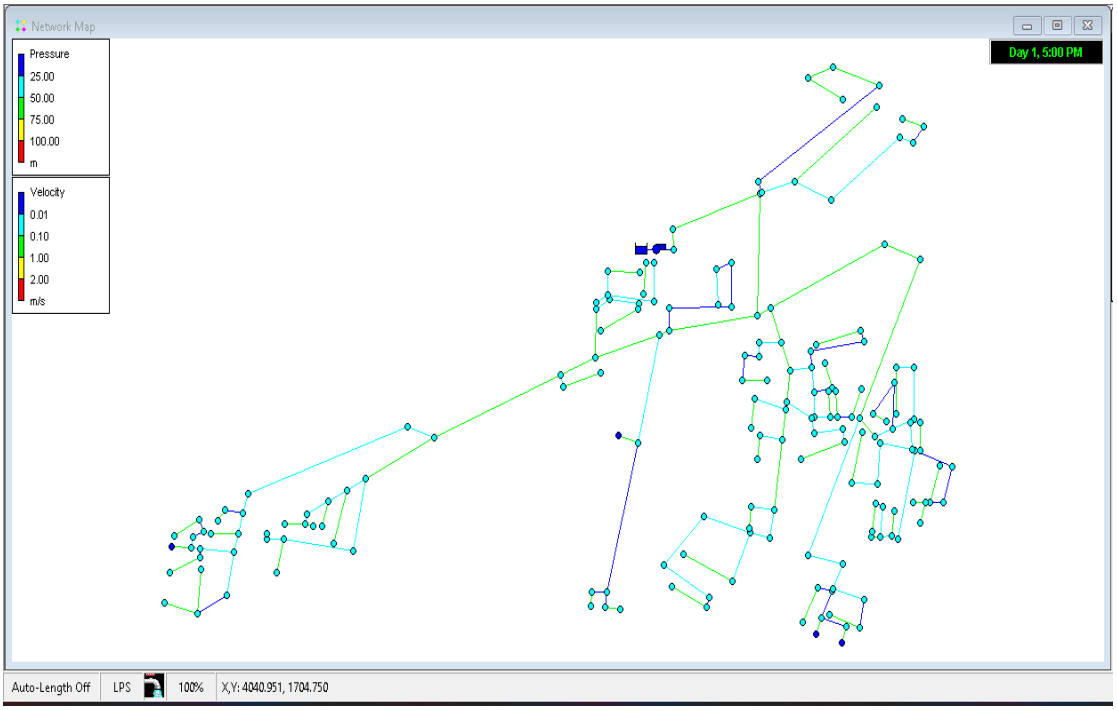

Figure 4. EPANET running results for the existing condition of the Taman Subdistrict service zone at 5 pm

Table 3 shows the distribution network system during the hours of use of minimum water consumption and peak water usage in the Taman Subdistrict service zone.

Table 3. Results of epanet 2.0 pressure analysis Taman Subdistrict

Node Junction	Elevation	Head	Pressure	Head	Pressure
		2 pm		5 pm	
Junc J1	9	55.32	46.32	42.85	33.85
Junc J2	10	55.30	45.30	42.81	32.81
Junc J3	9	55.21	46.21	42.57	33.57
Junc J4	10	55.21	45.21	42.56	32.56
Junc J5	7	55.21	48.21	42.56	35.56
Junc J6	7	55.17	48.17	42.47	35.47
Junc J7	9	55.15	46.15	42.42	33.42
Junc j8	7	54.56	47.56	40.90	33.90
Junc J9	9	55.21	46.21	42.56	33.56
Junc J10	10	55.21	45.21	42.56	32.56
Junc J11	7	53.47	46.47	38.08	31.08
Junc J12	10	55.21	45.21	42.56	32.56
Junc J13	5	55.21	50.21	42.56	37.56
Junc 14	7	55.21	48.21	42.56	35.56
Junc J15	6	55.21	49.21	42.56	36.56

The results of running the Epanet 2.0 software show that the pressure in the Taman Subdistrict service zone during usage hours is the minimum water consumption at 2 pm, and the peak of water consumption usage hours is at 5 pm. Exceeding the minimum remaining pressure limit criteria of the Minister of Public Works

Regulation No. 27 of 2016. The velocity of water in the pipeline (velocity) of the existing network is used to determine whether the distribution network's flow rate meets the criteria. Table 4 show the velocity of the water in the distribution network system during the hours of minimum and peak water usage in the service zone of Taman Subdistrict.

Tabel 4. The results of the epanet 2.0 velocity analysis in Taman Subdistrict

No Junction	*Flow l/s*	*Velocity* (m/s)	No Junction	*Flow l/s*	*Velocity* (m/s)
	2 pm			5 pm	
Jun 129	4.87	0.1	Jun-11	0.29	0.77
Jun 134	3.54	0.08	Jun 166	0.21	0.56
Jun105	0.64	0.02	Jun 176	0.21	0.56
Jun 104	0.42	0.02	Jun 109	0.17	0.44
Jun-94	0.44	0.02	Jun 178	0.64	0.01

The results of running the Epanet 2.0 software show that the velocity of the Taman Subdistrict service zone corresponds to the hours of use of the minimum water consumption at 2 pm, and during the hours of use, the peak water consumption is at 5 pm under the criteria of Minister of Public Works Regulation No. 27 of 2016, namely 0.3-0.6m/sec. According to (Mustafidah, 2019), the pressure still needs to be higher, caused by an ineffective piping design, insufficient distribution discharge, and an increase in water demand which is high beyond the initial piping design capacity.

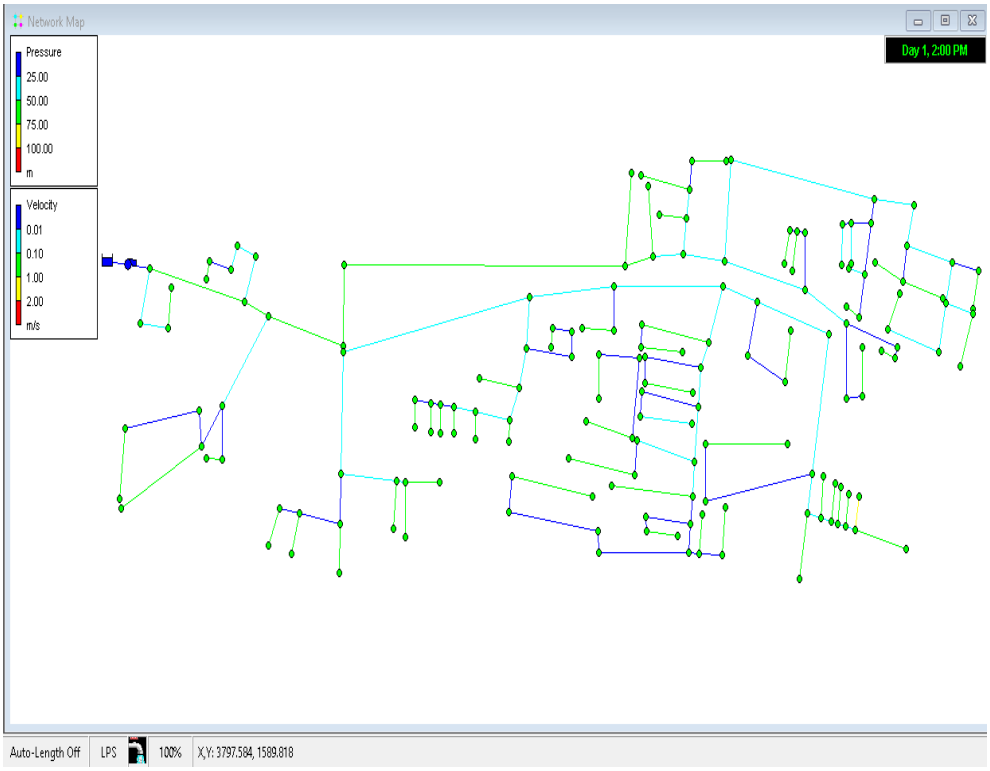

Figure 5. EPANET running results for the existing conditions of the Waru Subdistrict service zone at 2 pm

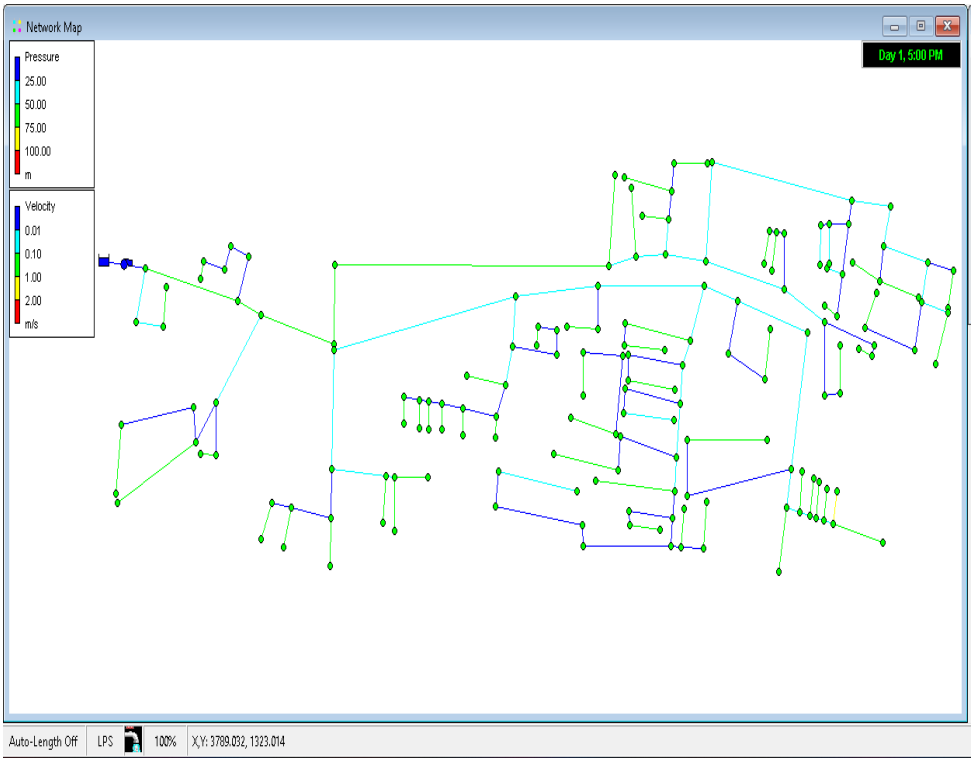

Figure 6. EPANET running results for the existing conditions of the Waru Subdistrict service zone at 5 pm

Table 6 shows the distribution network system during the hours of use of minimum and peak water consumption in the Waru District service zone.

Tabel 6. The results of the epanet 2.0 pressure analysis in Waru Subdistrict

Node Junction	Elevation	Head	Pressure	Head	Pressure
		2 pm		5 pm	
Junc J1	6	61.42	55.42	61.82	55.82
Junc J2	6	61.42	55.42	61.82	55.82
Junc J3	3	61.42	58.42	61.82	58.82
Junc J4	6	61.39	55.39	61.80	55.80
Junc J5	6	61.19	55.19	61.68	55.68
Junc J6	7	61.18	54.18	61.68	54.68
Junc J7	4	61.18	57.18	61.68	57.68
Junc J8	5	61.18	56.18	61.68	56.68
Junc J9	5	61.18	56.18	61.68	56.68
Junc J10	5	55.50	50.50	58.34	53.34
Junc J11	5	60.97	55.97	61.56	56.56
Junc J12	5	60.97	55.97	61.55	56.55
Junc J13	5	60.97	55.97	61.55	56.55
Junc J14	4	60.73	56.73	61.42	57.42
Junc J15	5	60.97	55.97	61.55	56.55

The results of running the Epanet 2.0 software show that the pressure in the service zone of Waru District at the time of use of the minimum water consumption is at

2 pm and during the hours of use, the peak water consumption is at 5 pm, the peak exceeds the minimum residual pressure criteria of Minister of Public Works Regulation No.27 of 2016, namely by 1.0 atm (1 atm = 10 meters). Adjusting the water pressure in one of the pipes can reduce water loss (Mustafidah, 2019). At (BPPSPAM Departemen Pekerjaan Umum) they explained that excessive water pressure could cause pain due to water jets, damage to plumbing equipment, and increase the possibility of water hitting. The velocity of water in the pipe (velocity) of the existing network is used to determine whether the distribution network's flow rate meets the criteria. The water velocity zone in the distribution network system uses minimum and peak water consumption in the Waru District service zone show in Table 7.

Table 7. The results of the epanet 2.0 velocity analysis in Waru Subdistrict

No Junction	*Flow l/s*	*Velocity* (m/s)	No Junction	*Flow l/s*	*Velocity* (m/s)
	2 pm			5 pm	
Jun 166	0.60	1.58	Jun 166	0.45	1.18
Jun 154	0.30	0.37	Jun 162	0.14	0.36
Jun 167	0.60	0.43	Jun 158	0.18	0.22
Jun 158	0.24	0.30	Jun-50	1.98	0.02
Jun-22	10.69	0..13	Jun-35	2.47	0.03
Jun-06	1.02	0.01	Jun-53	1.62	0.02

The results of running the Epanet 2.0 software show that the Velocity of the Waru District service zone in terms of minimum water consumption hours at 2:00 p.m. and the peak of water consumption usage hours at 5:00 p.m. is still below the criteria for Minister of Public Works Regulation No. 27 of 2016, namely 0.3-0.6 m.sec. Water flow rates that are too high will increase the possibility of water hitting, causing noise, and sometimes causing wear on the inner surface of the pipe (BPPSPAM Departemen Pekerjaan Umum).

Distribution Network Analysis with Epanet 2.0 Program Simulation Pump Change

A means of transferring a liquid from one area to another by increasing the pressure of the liquid is the definition of a pump. The way to overcome the liquid resistance is to increase the liquid pressure. Flow resistance can be in height, pressure, and friction differences, optimization by changing pumps in each serving zone.

The results of running the pressure analysis for optimizing pump replacement in the Taman District Service Zone at the hours of use of minimum and peak water consumption shows in Table 8.

Table 8. Results of pressure analysis of Taman Subdistrict Service Zone

Node Junction	Elevation	Head	Pressure	Head	Pressure
		2 pm		5 pm	
Junc J1	9	43.74	34.74	34.39	25.39
Junc J2	10	43.72	33.72	34.34	24.34
Junc J3	9	43.63	34.63	34.10	25.10
Junc J4	10	43.63	33.63	34.10	24.10
Junc J5	7	43.63	36.63	34.10	27.10
Junc J6	7	43.59	36.59	34.01	27.01
Junc J7	9	43.57	34.57	33.95	24.95
Junc j8	7	42.98	35.98	32.44	25.44

Node Junction	Elevation	Head	Pressure	Head	Pressure
		2 pm		5 pm	
Junc J9	9	43.63	34.63	34.10	25.10
Junc J10	10	43.63	33.63	34.10	24.10
Junc J11	7	41.89	34.89	29.62	22.62
Junc J12	10	43.63	33.63	34.10	24.10
Junc J13	5	43.63	38.63	34.10	29.10
Junc 14	7	43.63	36.63	34.10	27.10
Junc J15	6	43.63	37.63	34.10	28.10

The results of running the Epanet 2.0 software show that the pressure in the Taman Subdistrict service zone at minimum water consumption usage hours at 2 pm and peak of water consumption usage hours at 5 pm is still above the criteria for Minister of Public Works Regulation No. 27 of 2016 pump replacement can reduce the pressure tall.

Table 9 shows the water velocity zones in the distribution network system during the minimum and peak water consumption hours in the Taman Subdistrict service zone.

Table 9. The results of the epanet 2.0 velocity analysis in Taman Subdistrict

No Junction	Flow l/s	*Velocity* (m/s)	Flow l/s	*Velocity* (m/s)
	2 pm		5 pm	
Jun 114	0.42	0.14	3.54	0.35
Jun-65	9.86	0.12	16.43	0.21
Jun145	8.15	0.10	13.58	0,12
Jun 104	0.64	0.01	0.64	0.01
Jun-94	0.44	0.01	0.44	0.01

The results of running the Epanet 2.0 software show that the Velocity of the Taman District service zone at minimum water consumption usage hours is at 2 pm. Peak water usage hours at 5 pm pump replacement meets the criteria in Minister of Public Works Regulation No.27 of 2016, will. However, there are still several areas where the water velocity in the pipes still needs to be below the minimum limit in Minister of Public Works Regulation No. 27 of 2016.

Table 10 shows the results of running the pressure analysis on optimizing pump replacement in the Waru District Service Zone during the hours of use of minimum and peak water consumption.

Table 10. Results of the Waru Subdistrict Service Zone pressure analysis

Node Junction	Elevation	Head	Pressure	Head	Pressure
		2 pm		5 pm	
Junc J1	6	21.70	15.70	21.98	15.98
Junc J2	6	21.70	15.70	21.98	15.98
Junc J3	3	21.70	18.70	21.98	18.98
Junc J4	6	21.67	15.67	21.96	15.96
Junc J5	6	21.46	15.46	21.84	15.84
Junc J6	7	21.46	14.46	21.84	14.84
Junc J7	4	21.46	17.46	21.84	17.84

Node Junction	Elevation	Head	Pressure	Head	Pressure
		2 pm		5 pm	
Junc J8	5	21.46	16.46	21.84	16.84
Junc J9	5	21.46	16.46	21.84	16.84
Junc J10	5	15.78	10.78	18.50	13.50
Junc J11	5	21.25	16.25	21.71	16.71
Junc J12	5	21.25	16.25	21.71	16.71
Junc J13	5	21.25	16.25	21.71	16.71
Junc J14	4	21.01	17.01	21.57	17.57
Junc J15	5	21.25	16.25	21.71	16.71
Junc J16	4	21.25	17.25	21.71	17.71
Junc J17	4	21.25	17.25	21.71	17.71
Junc J18	4	20.55	16.55	21.30	17.30
Junc J19	4	19.91	15.91	20.93	16.93
Junc J20	6	21.05	15.05	21.60	15.60

The results of running the Epanet 2.0 software show that the pressure in the Waru District service zone corresponds to the minimum water consumption usage hours at 2 pm and the Waru District service zone during the peak of water consumption usage hours at 5 pm. Substitution of pumps in each service zone can reduce high pressure, before treatment the water pressure in the pipes in each zone is still above 50 atm, according to Minister of Public Works Regulation No. 27 of 2016, the water pressure criteria in the pipes for drinking pressure is 0. 5-1.0 atm. Although it is still above the criteria for Minister of Public Works Regulation No. 27 of 2016, pump replacement can suppress high pressure.

Table 11 shows the water velocity zones in the distribution network system during the minimum and peak water consumption hours for the Waru District service zone.

Table 11. Results of the epanet 2.0 velocity analysis at 2 pm

No Junction	Flow l/s	*Velocity* (m/s)	Flow l/s	*Velocity* (m/s)
	2 pm		5 pm	
Jun 166	0.60	1.58	0.45	1.18
Jun 154	0.30	0.37	0.23	0.28
Jun 167	0.60	0.43	0.45	0.32
Jun 158	1.92	0.02	0.18	0.22
Jun-22	10.68	0.13	8.01	0.10
Jun-06	1.02	0.01	0.77	0.01
Jun-51	0.48	0.01	0.36	0.01

The results of running the Epanet 2.0 software show that the Velocity of the Waru District service zone at minimum water consumption hours at 2:00 p.m. and peak water consumption at 5:00 p.m. pump change meets the criteria in Minister of Public Works Regulation No. 27 of 2016. However, there are still several areas where the water velocity in the pipes is below the minimum limit in Minister of Public Works Regulation No. 27 of 2016.

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