Development of Drinking Water Supply Service in Purworejo District

Lia Kurnia Putri and Adhi Yuniarto
Department of Environmental Engineering, Faculty of Civil, Environmental and Geo Engineering,
Institut Teknologi Sepuluh Nopember, Surabaya, 60111
e-mail: adhy@its.ac.id.

***Abstract*— Water Supply Company (PDAM) in Purworejo District is a responsible instituation in serving and fulfilling the need of clean water for the local people in Purworejo. The current service coverage of the Water Supply Company in Purworejo was 52.60%. Water Supply Company in Purworejo unit had served 14 urban villages and had 5 planned development villages. However, out of 19 urban villages, the clean water distribution network system was not evenly distributed to customers and the amount of water loss was quite high. To overcome these problems, it was necessary to do an analysis and development plan for the clean water distribution network system. The application used to analyze the existing conditions and the development was the Epanet 2.0 application. The results of the existing condition analysis showed that running was not successful. The planning period will be carried out in 2018 until 2037 which is divided into 2 stages, namely year (2018-2027) and year (2028-2037). The planning was done by calculating projections of the population and public facilities to determine water requirements. The results of the development plan analysis showed that there were 2 additional blocks in stage 2 so that the total blocks formed were 24 blocks. The pipeline repairs carried out are also divided into 2 stages, namely in 2021 and in 2026. This is meant to reduce the planning costs, because the development budget used will also be divided into 2 stages.**

***Keywords*—Water Supply Company, System distribution, Development, Epanet 2.0.**

I. INTRODUCTION

WATER is one of the basic needs for human survival. Humans use clean water as potable water and daily activities such as washing, bathing, cooking and other activities. The importance of the need for clean water makes it a top priority in handling the clean water sector. The availability of water is one of the determinants of increasing community welfare. By the availability of water, it is expected to improve the health of the community and encourage the increased productivity of the community, so that there can be an improvement in economic growth in the community [1]. Therefore, the provision of water facilities and infrastructure is needed in economic development in a region.

Purworejo is referred to as the central area of growth and an economic driver as a buffer for local sources of income. In 2017, there were 10 villages in Purworejo District experienced a clean water crisis due to the dry season [2]. The continuity of water supply to meet the needs of clean water for the community (especially in areas prone to water) is an important matter that needs to be concerned. Fluctuations in the flow of water sources (rivers, springs, wells, etc.) that change each season have an impact on the sustainability of the water supply.

The PDAM of Purworejo unit serves around 12,963 house connection (*SR – Sambungan Rumah*) of the total population of Purworejo Subdistrict, which is 84,966 people. The Purworejo branch unit had served 14 urban villages and had 5 village development plans. However, out of 19 urban villages, the clean water distribution network system was still not evenly distributed to customers and the amount of water loss was still at 32.24% [3]. In addition, the distribution network of the Water Supply Company in Purworejo was still not in the form of a zoning system, making it difficult for the Water Supply Company to control water loss.

Based on the description of the problems above, the planning period will be planned for the next 20 years [4], with the aim of improving clean water services and planning the development of new networks in 5 sub-districts due to the discharge of each small citizen so that it influences the fulfillment of clean water needs; therefore, a service of the Water Supply Company in Purworejo is required.

II. METHOD

The methods used in this plan were as follows :

A. The Primary Data Collection

Real Demand Survey is used to determine domestic and non-domestic water requirements or the level of community demand as well as to know the socio-economic conditions of the customers and non-customers of the Water Supply Company. The observation and the observation of the field conditions is carried out with the aim of seeing the condition of the planning area which will be done. These observations include the road conditions, the patterns or the conditions of settlements and the existing pipelines.

B. The Secondary Data Collection

The map of spatial and the regional planning (Hamlets & Neighbourhoods), the administrative, the topography and the land use planning in Purworejo. The population data and the public facilities in Purworejo. The data of the master plan for developing the water supply system (RISPAM –Rencana Induk Sistem Penyediaan Air Minum) [5] in Purworejo. The existing data of PDAM, which includes the number of customers, the service areas, the distribution network pipes, the raw water sources and the amount of water loss.

C. Processesing Data

The population projections are carried out to calculate the number of residents to be served in the future. This projection will be carried out for the next 20 years. Only one suitable method will be selected out of those three methods. The water requirements for this distribution system uses the peak hour

discharge. Water requirements that are taken into account are the domestic and the non-domestic water requirements, and the estimated leakage. The domestic water needs are obtained from the population projections. The non-domestic water requirements are obtained from the projections of public facilities. The water leakage rates can be calculated based on the amount of water produced by the PDAM of Purworejo unit and the water sold to customers or with the help of the existing data of the PDAM.

The existing conditions at the customer level can be known from the results of running using the Epanet 2.0 software and will be evaluated.

D. Modelling by Using The Epanet 2.0 Software

The complete data is then applied using the Epanet 2.0 software in order to process data. The data entered into the Epanet 2.0 program includes the demand, the elevation, the pipe length, the pipe diameter, the pipe roughness, the pump head and the discharge. After the data is entered into the Epanet 2.0 program, the running process is carried out [6]. Running Epanet 2.0 is carried out on existing conditions, in 2027 and in 2037. The results of running this program can be a way to see the results of water conditions on the junction/node and the pipe. The junction will show the results in the form of pressure, while the pipe shows the results in the form of velocity and headloss [7].

III. RESULTS AND DISCUSSION

A. Analysis of Existing Conditions

The coverage of the unit services in Water Supply Company consists of 14 villages, namely Pangenrejo, Kedungsari, Cangkrep Kidul, Cangkrep Lor, Tambakrejo, Purworejo, Pangenjuru Tengah, Doplang, Sindurjan, Paduroso, Mranti, Mudal, Keseneng and Baledono. The source of the raw water comes from springs, wells (deep and shallow) and the surface water with a total discharge of 156.78 liters/second which can be seen in Table 1. The source of water which originates from springs and wells (deep and shallow) firstly flowed into the reservoir before being distributed to customers, both by the gravity and the pump.

Table 1.
The Production Capacity of Water Resources

Water Resources	System	Production Capacity
M.A Kalinongko	Gravity	49.19
M.A Simbarjoyo I	Pump	31.11
M.A Simbarjoyo II	Pump	1.83
M.A Kedung Kebo	Gravity	7.91
S.D Pangenjuru Tengah	Pump	1.69
S.D Tuksongo I	Pump	4.28
S.D Tuksongo II	Pump	3.94
S.D Sibak Doplang	Pump	1.83
IPA Bedung Boro	Pump	55
	Total	**156.78**

Based on the results of real demand surveys, the average water demand for each of the PDAM customer is 100 liters/second and non PDAM customers is 84.9 liters/second. Then, the flow rate calculation is carried out in each urban village served by the PDAM of Purworejo unit. After that, the service block is divided based on a predetermined zoning system. The flow rates from each of these blocks will later be included in the demand in the Epanet 2.0 program, which can be seen in Table 2.

Table 2.
Distribution of Flow Rate Blocks

Zone	Block	Flow rate (L/s)	Totally (L/s)
1	Block 101 A	2.08	14.77
	Block 101 B	2.08	
	Block 102 A	5.31	
	Block 102 B	5.31	
2	Block 201	1.36	51.63
	Block 202 A	5.66	
	Block 202 B	5.66	
	Block 203	16.71	
	Block 204	1.74	
	Block 205	2.31	
	Block 206	5.15	
	Block 207	13.04	
3	Block 301	7.54	19.97
	Block 302 A	2.23	
	Block 302 B	2.23	
	Block 303	1.39	
	Block 304	0.00	
	Block 305	0.00	
	Block 306	0.00	
	Block 307	2.01	
	Block 308	0.00	
	Block 309 A	2.28	
	Block 309 B	2.28	

The data such as the elevation, the pipe length, the pipe diameter, the pipe roughness, the pump head and the discharge also need to be included to assist in this modeling and the yellow “lightning” sign on the layout is clicked for the running process. The running results that will be displayed are the results of the nodes and the pipes. The running node shows the results of the pressure, the base demand, the demand and the head. The pressure is the residual pressure after passing through some friction, both caused by the roughness of the pipe and the length of the pipe. The base demand is the need for water or the discharge inputted in each block. The demand is the need for water or the discharge during peak hours, which is obtained by means of the base demand multiplied by the peak hour factor is 1.5. The results of running for pipes, will later produce flow, velocity and headloss units. The following is the result of running existing which is shown in Figure 1.

Based on the results of running on the existing conditions indicated that running was not successful, meaning that the system modeling was not successful and there might be some problems in the existing distribution system. The pressure condition analysis showed that the pressure was negative according to the planning criteria 5-80 mka, and also due to the too large headloss [8] . The greater the pressure loss (headloss), then the remaining pressure would also be smaller. The flow velocity according to the planning criteria was 0.3-4.5 m / sec, the results of the epanet analysis in Figure 1 showed that there was still a speed below the set value limit which was below 0.3 m/sec. The pipes with a flow velocity of less than 0.3 m/sec caused the formation of deposits that could clog the water flow. The alternative solution to overcome the piping problems is by parallelizing pipes with diameters of 150 mm and 200 mm

B. Real Demand Survey

Real demand survey is used to determine the level of demand of the customers and non-customers of the Water Supply Company towards domestic and non-domestic water needs by filling in questionnaires. We were able to find out the socio-economic conditions of the community, which includes the ability and willingness of the community to become customers of the Water Supply Company through

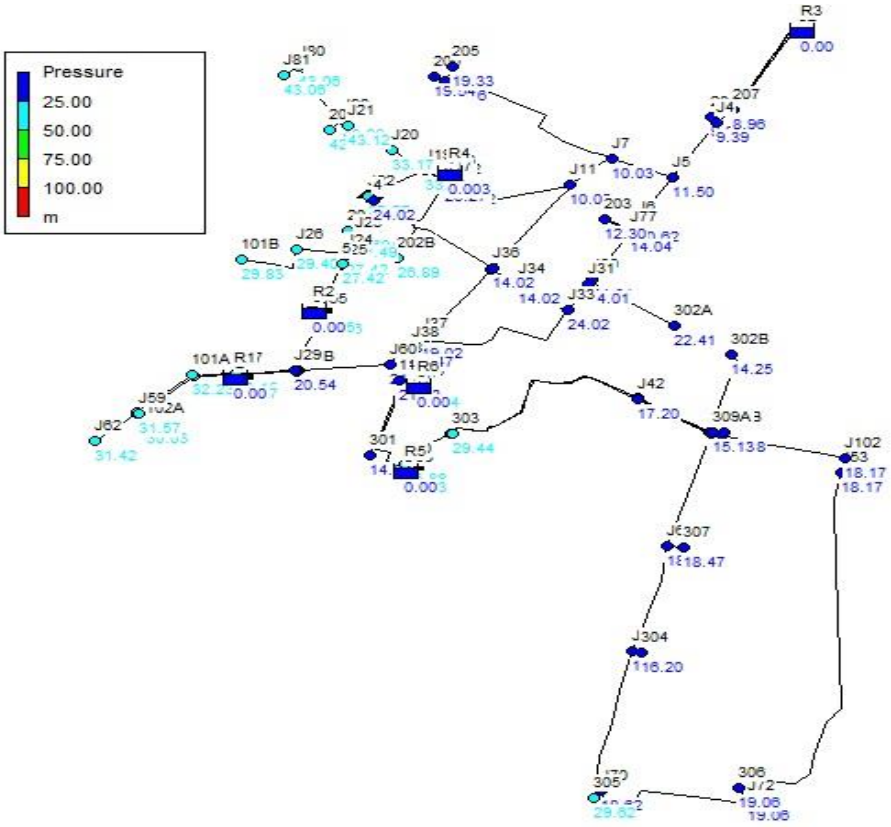

Figure 1. The Results of Existing Conditions

this questionnaire. The results of the real demand survey in this study are as follows:

1) The Number of Occupants

The number of occupants is used to calculate the average water usage in each number of the family members who live in the house in a day. Based on the survey of the real needs that were carried out (Figure 2) showed that mostly there are 3-4 people per house with a percentage of 58% or thE number of respondents were 60 people

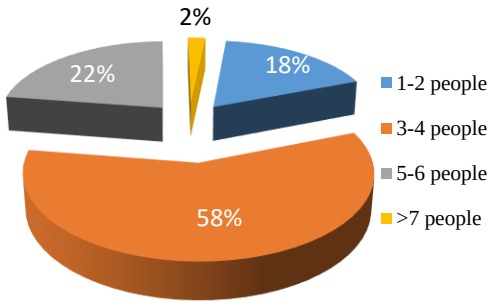

Figure 2. The Number of Occupants

2) Education Level

Education level is one of the factors that can support the understanding of the importance of water that is suitable for consumption and safe for the health of its consumers. People who are considered in the average level of education will find it easier to absorb knowledge and information about the criteria for water that is great to consume, process the water resources, and manage the drinking water. Based on the survey results of the real needs, the highest level of education of the people in Purworejo is Junior High School with a percentage of 41% from 42 respondents. It can be said that those people are less aware of the way they manage water, since people who have a higher degree of education tend to have better skills and are better able to innovate to manage and process the water resources.

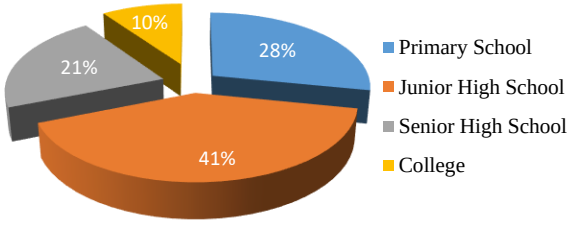

Figure 3. Education Level

3) The Occupation of Respondents

Most of the residents in Purworejo work as farmers. This is based on the results of the real demand survey that was conducted which can be seen in Figure 4. Farmers got a percentage of 27%, this is the highest value compared to the other types of occupations.

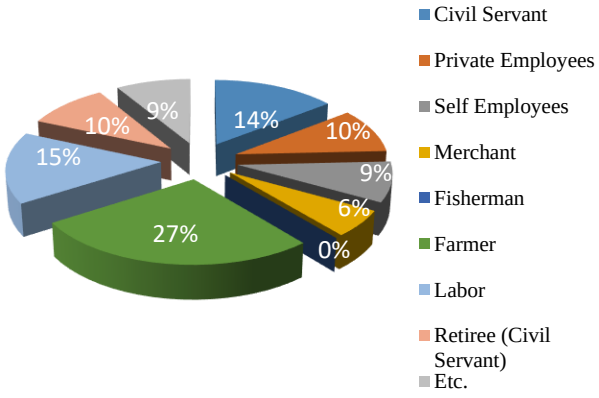

Figure 4. The Occupation of Respondents

4) The Income of Respondents (per month)

The occupation and income aspects can directly influence the community in fulfilling their life needs such as the ability to obtain clean water. The limited income of the people will be burdensome in terms of the economy if they are required to pay to get clean water to meet their daily needs. Based on the results of the survey of the actual needs that were carried out, the income of the respondents for 1 month at most ranges between Rp.500,000-2,000,000, which is a percentage of 45% or 46 people.

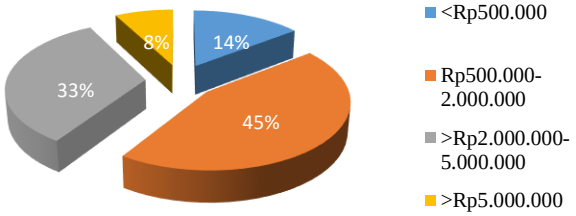

Figure 5. The Income of Respondents (per month)

5) Water Resource

Based on the results of real demand survey, most of the respondents who have become the customers of Water Supply Company still use the deep wells. It was as a result of the turbid water that caused them to be unsure to use it as drinking and cooking water. The Water Supply Company customers who use these two water sources (PDAM and deep wells) are from Sindurjan, Baledono, Mranti and Mudal Villages. The rest residents use only one water source, that is from the Water Supply Company. The non-customer respondents of Water Supply Company only use one water source, which is from the deep wells with the overall percentage of the respondents of 49.38% or 49 people. There are three main reasons as to why water of the deep well is used. First, the quality of the water is clear; second, it is cheaper; and third, the quantity of the water is sufficient to meet their needs such as for bathing, washing, cooking, and doing other activities. However, they found it difficult to get water during the dry season since the wells experienced a decrease in flow even to dry so they were helped by Regional Disaster Management Authority (BPBD-Badan Penanggulangan Bencana Daerah) in Purworejo to do water dropping.

C. Service Development Planning

1) Population Projection

The population projection was used to calculate the projections of the domestic water needs. The population projection can be calculated using the arithmetic method, the geometric method, or the least square method. The method chosen is a method with a correlation coefficient value (r) close to 1 and the smallest standard deviation (SD) value. The chosen method for calculating population projections is the geometric method with the following formula [9].

$$Pn = Po\ (1+r)^n \quad (1)$$

Where,

Pn : The number of the population in the desired projection year (people)
Po : The number of the population in the initial year (people)
r : The average percentage of the population growth each year (%)
n : The projection period

2) Facilities Projection

The facilities projection is used to project the non-domestic water requirements, using the following formula [9].

$$Fn = Pn/Po \times Fo \quad (2)$$

Where,

Fn : The number of the public facilities in the final year of the projection
Pn : The number of the population at the end of the projection
Fo : The number of the public facilities at the beginning of the projection
Po : The number of the population at the beginning of the projection

D. Planning Water Needs

The development planning is divided into 2 stages, namely stage 1 (2018-2027) and stage 2 (2028-2037). The current production capacity is 156.78 liters/second, where the average needs of each person is 100 liters/day for regions that have been served by the Water Supply Company and 80 liters/day for the planned development area. The results of the water demand was 111.87 liters/second in 2018, 138.93 liters/second in 2027 and 168.33 liters/second in 2037. Based on the calculation of the peak hour water demand showed that the water demand in 2031, is 159.58 liters/second that has exceeded the total production capacity of 156.78 liters/second, which can be seen in Figure 6. Thus, the need for additional water production is at least 20 liters/second so the PDAM can still serve the customers.

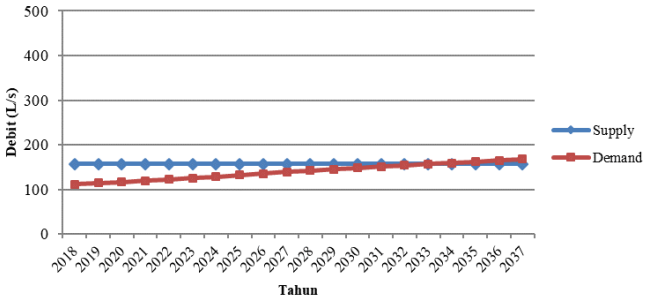

Figure 6. Supply and Demand

E. Distribution of Flow rate Blocks for Each Service

There were 2 additional service blocks in stage 2, namely block 208 and block 308 so that there would be 24 service blocks. The distribution of flow rate for each service block after the development can be seen in Table 3.

F. Analysis of Development Stage Simulation Results

The Epanet analysis in this development area is the result of the modeling distribution system conditions in 2027 and 2037. Modeling will be carried out in the first phase, namely in 2027. The results after running Epanet 2.0 in 2027 was successful. The success of this running showed that the system was running well. The existing solution to overcome the problem was analyzed, by doing parallel pipes so that there was no negative pressure. The purpose of parallel pipes was to divide the pressure and reduce the headloss unit. The bigger the headloss unit and the too long pipe was, the friction/pressure loss would also be greater [10].

The pipes to be carried out parallel in 2027 were the pipes with a diameter of 100 mm with a pipe code on Epanet, namely the 19th pipe and the 26th pipe, the pipes with a diameter of 150 mm namely the 21st pipe and the 25th pipe,

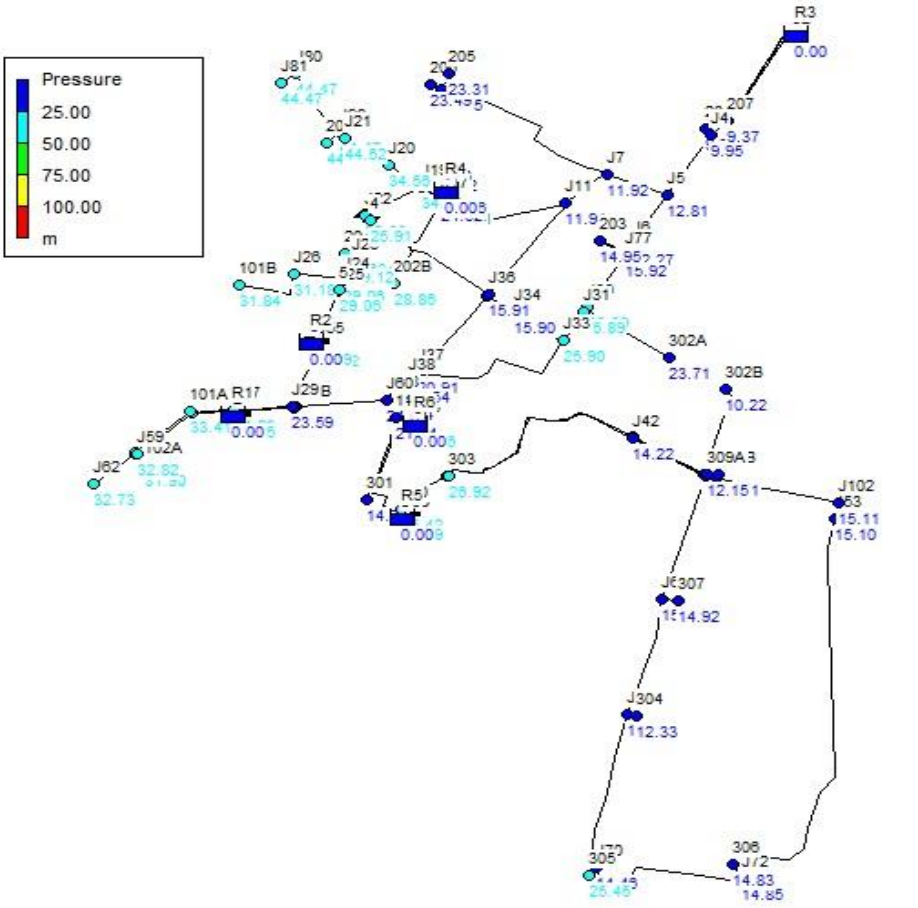

Figure 7. The Results of 2027

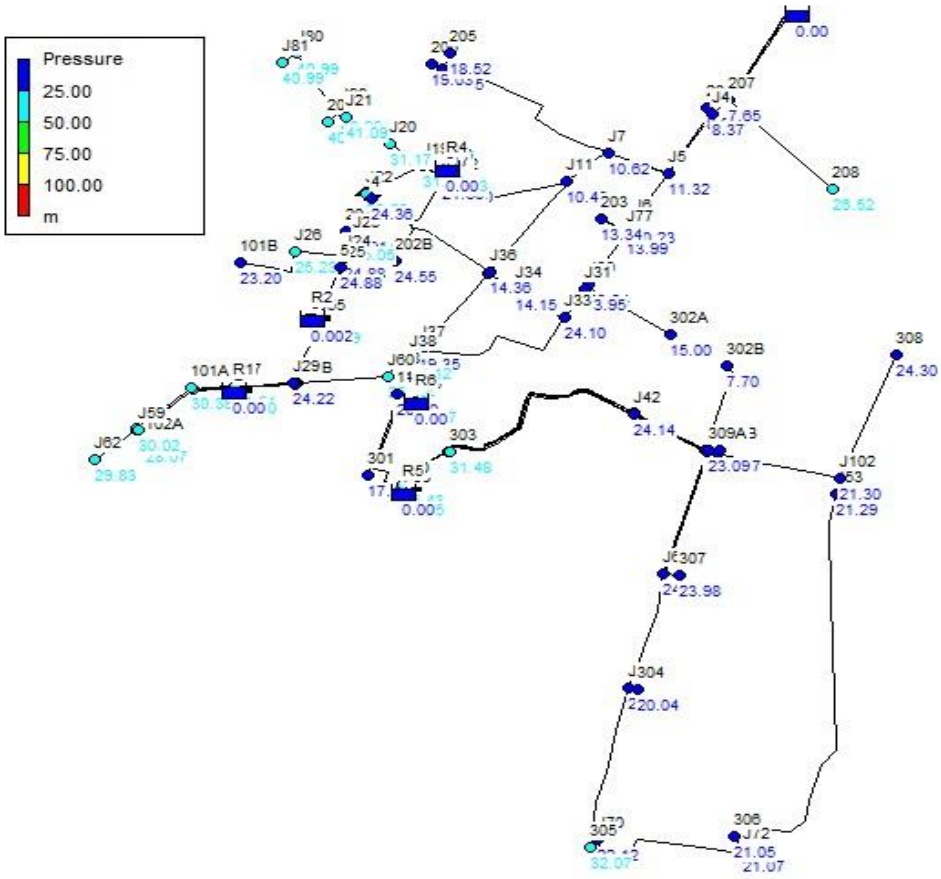

Figure 8. The Results of 2037

, the pipes with a diameter of 200 mm with the 8th pipe, the 20th pipe and the 29th pipe, the pipes with a diameter of 250 mm which are the 5th pipe and the 6th pipe, and a pipe with a diameter of 300 mm which was the 4th pipe. The results of

the running made use of the pumping and gravity system. In the first stage, there was an inprovement in the service discharge so that the pumping system is carried out in parallel at Bedung Boro WTP; therefore, the water can be well distributed to customers.

Table 3.
Distribution of Flow Rate Blocks

Zone	Block	Flow rate (L/s)	Totally (L/s)
1	Block 101 A	4.98	25.21
	Block 101 B	4.98	
	Block 102 A	7.62	
	Block 102 B	7.62	
2	Block 201	2.11	82.80
	Block 202 A	7.53	
	Block 202 B	7.53	
	Block 203	26.45	
	Block 204	5.75	
	Block 205	3.84	
	Block 206	6.04	
	Block 207	21.32	
3	Block 301	2.24	60.19
	Block 302 A	10.58	
	Block 302 B	6.52	
	Block 303	6.52	
	Block 304	14.80	
	Block 305	0.38	
	Block 306	1.14	
	Block 307	1.16	
	Block 308	6.36	
	Block 309 A	0.88	
	Block 309 B	5.70	

G. Summary of Budget Plan

The development planning was carried out in 2 stages, hence the calculation of the budget plan was also done in 2 stages, namely in 2018-2027 and in 2028-2037. The following was a breakdown of the costs needed during the planning and this had also been divided into each stage, which is shown in Table 4 and Table 5.

Table 4.
Summary in Stage 1

No.	Type	Cost
1.	Fee	Rp 199.117.957
2.	Material	Rp 582.191.188
3.	Accessories Pipe	Rp 16.415.540
	Total	Rp 797.724.685

Table 5.
Summary in Stage 2

No.	Type	Cost
1.	Fee	Rp 895.576.150
2.	Material	Rp 3.398.149.601
3.	Accessories Pipe	Rp 2.217.546
	Total	Rp 4.295.943.297

IV. CONCLUSION

The service for the clean water needs can be served up to 80% in 2037. The production capacity used is 156.78 liters/second. The production capacity is used to serve 14 urban villages in the service area of the Water Supply Company in Purworejo and then used for the development plans in five villages, namely Wonoroto, Semawung, Ganggeng, Sidomulyo and Sidorejo villages. In 2037, there is a need for additional production capacity of 20 liters/second to serve the water needs of the population, which is 168.33 liters/second. In the development plan, each zone/block system is formed and the total is formed up to 24 blocks. The establishment of this zone/block aims to monitor and share service leveling by regulating the water flow rate given to each of these regions. Based on the analysis of Epanet, an alternative solution is done so that there is no negative pressure on the conditions of excitation and planning, namely by parallelizing the pipe on the distribution network system. The cost budget needed in this planning in stage 1 is Rp. 797,724,685 and stage 2 is Rp 4,295,943,297.

AKNOWLEDGEMENTS

I am grateful to all of those with whom I have had the pleasure to work during this and other related this paper. Each of the members of my thesis committee has provided me extensive personal and professional guidance and taught me a great deal about both scientific research and life in general. I would especially like to thank Adhi Yuniarto,ST.,MT.,PhD the chairman of my committee tesis. As my lecture and supervisor, he has taught me more than I could ever give his credit for here. Nobody has been more important to me in the pursuit of this paper that the members of my family. I would like to thank my parents, my husband and my brother who love and guidance are with me in whatever I pursue. Most importantly, I wish to thank my friends, Madina, Olivia and Sheila who provide unending support.

REFERENCES

[1] G. Liu *et al.*, "Potential Impacts of Changing Supply-Water Quality on Drinking Water Distribution: A review," *Water Res.*, vol. 116, pp. 135–148, 2017.

[2] "Purworejo Kekeringan: BPBD distribusikan 1.350 Tangki Air," *Berita Harian Purworejo*, 2017.

[3] PDAM Kabupaten Purworejo, "Laporan Bulanan PDAM Purworejo," Purworejo, 2017.

[4] Dirjen Cipta Karya, *Pedoman Pengelolaan Program Pamsimas*. Jakarta, 2009.

[5] Dinas Cipta Karya dan Tata Ruang, "Rencana Induk SPAM Kabupaten Purworejo," Purworejo, Jawa Tengah., 2013.

[6] A. L. Rossman, *Users Manual Epanet 2.0*. Cincinnati - USA: Water Supply and Water Resources Division National Risk Management Research Laboratory Environmental Protection Agency (EPA), 2000.

[7] S. Maryati, A. Nisaa, and S. Humaira, "Extending Public Water Supply in Peri-Urban Area: Technical Engineering, Economic, and Environmental Consideration," in *Procedia Engineering*, 2015, pp. 243–249.

[8] "Peraturan Menteri Pekerjaan Umum dan Perumahan Rakyat Nomor 27 Tahun 2016 tentang Penyelenggaraan SPAM." Jakarta.

[9] Badan Pusat Statistik Kabupaten Purworejo, "Kecamatan Purworejo dalam Angka 2017," Purworejo, 2017.

[10] A. Masduqi and A. F. Assomadi, *Operasi dan Proses Pengolahan Air*, Second. Surabaya: ITS Press, 2016.