Civilla: Jurnal Teknik Sipil Universitas Islam Lamongan
Volume 09 Number 1 Year 2024

ISSN (*Online*) 2620-7222
ISSN (*Print*) 2503-2399

Available online at
https://jurnalteknik.unisla.ac.id/index.php/CVL

https://doi.org/10.30736/cvl.v2i2

Planning Of Raw Water Distribution Network Sumberrejo Village Candipuro District Lumajang Regency

Ahlan Tri Yogatama[1], Danayanti Azmi Dewi Nusantara[2]
[1,2]*Faculty of Engineering, Surabaya State University*
Email: [1]ahlan.21094@mhs.unesa.ac.id, [2]danayantinusantara@unesa.ac.id

A R T I C L E I N F O

Article History :
Article entry : 01-30-2024
Article revised : 02-12-2024
Article received : 03-15-2024

Keywords :
Water, Water distribution network, Epanet 2.2, Lack of water.

IEEE Style in citing this article : **[*Heading* citation]**
One, N. P., & Second, N. P. (Year). Article Title. Civilla : Universitas Islam Lamongan, v(n), Start page – End page. [heading citation contents]

A B S T R A C T

Indonesians have an average domestic water consumption of 34.2 liters/person/day while the minimum amount to meet basic human needs is 50 liters/person/day. The lack of water consumption requires a water distribution system so that minimum water consumption can be met. Sumberrejo Village is one example that does not have a water distribution network, so to meet daily water needs using ground wells. The use of earthen wells certainly has risks, namely contamination from fecal waste. Research on water distribution network planning needs to be done due to these problems. This plan aims to determine the availability of water to flow through Sumberrejo Village, water needs in the projection year, pipe dimensions, and reservoir dimensions used. This study used a quantitative descriptive method. Hydraulic analysis of piping networks using the Hazen–William method with the Epanet 2.2 auxiliary program. The results of the study found that the availability of water in Sumberrejo Village was inadequate, so it used the Gedang Sutro water source located in Sumberwuluh Village. Water demand in the projection year is 20,966 l / s at peak hour conditions. The diameter of the pipe used in this planning is 8 inches; 6 inches; 5 inches; 4 inches; 3 inches; 2.5 inches; 2 inches; 1.5 inches; 1.25 inches; 1 inch; and 0.75 inches. The reservoir used in this planning is tubular with a diameter of 11.5 m and a height of 4.5 m.

1. Introduction

The Sustainable Development Goals (SDGs), also known as global goals, were adopted by the United Nations (UN) in 2015 as a universal call to action to end poverty, protect planet Earth, and ensure that by 2030 all people enjoy peace and prosperity [1]. The UN SDGs have several goals, one of which is to ensure clean water and sanitation (SDG 6) for all people by 2030 [2]. Water scarcity affects more than 40% of the world's people, a figure projected to rise as temperatures rise. 2.1 billion people have improved water sanitation since 1990, but reduced drinking water supplies still affect every continent [1]. Water shortages are afflicting many

ISSN (*Online*) 2620-7222
ISSN (*Print*) 2503-2399

countries around the world, and increasing drought and desertification are exacerbating them. By 2050, it is projected that at least one in four people will suffer from repeated water shortages [1].

Indonesia represents about 6% of the world's water resources. Indonesia has water resources that are quite abundant when referring to this. Indonesian people have an average domestic water consumption of 34.2 liters/person/day while the minimum amount to meet basic human needs is 50 liters/person/day [3]. Lack of clean water supply also occurs in most regions of Indonesia such as East Nusa Tenggara, Java, Bali, and Sulawesi [3]. The availability of water and sanitation conditions in Indonesia continues to increase from year to year but still has not been able to reach all its citizens. BPS data shows that the percentage of households with adequate drinking water sources in East Java is 77.60% while the percentage of households with access to adequate drinking water is 95.05% [4].

The availability of raw water for drinking water in Lumajang Regency in 2018, according to the Lumajang Regent Regulation on Lumajang Regency Drinking Water Supply System Policy and Strategy for 2019 – 2023 (JAKSTRADA - SPAM) reached 37.95% for drinking water services through piped network SPAM, with details of 19.47% by regional drinking water companies (PDAMs) and 18.48% by rural drinking water institutions. The coverage of non-piped drinking water services (BJP) in the form of dug wells, pumps and rainwater is 25.41% [5]. The availability of water has not been evenly distributed in various regions because there is no SPAM channel in several areas in the Lumajang Regency. Sumberrejo Village, Candipuro District, is one example that does not have a SPAM channel, so to meet daily water needs using groundwater wells. The use of these wells can certainly be contaminated by fecal waste if they are not properly protected, thus endangering users. The location of the septic tank with a well that is too close also affects water pollution in the well. Groundwater can be contaminated by microorganisms originating from human activities (urban, industrial, and agricultural) and released into the environment through direct disposal. The activities of direct disposal are, wastewater that is not treated properly, leakage waste disposal, and septic systems [6]. Runoff or seepage of wastewater from fecal reservoirs that are not processed properly will slowly penetrate the underground water flow (aquifer) and a process of water pollution occurs [7].

Planning a good water distribution network is needed as an effort to provide clean water on a sustainable scale [8]. Water distribution networks are important systems in the community industry, whose main purpose is to deliver water to the point of consumption at the appropriate pressure and speed [9]. The water distribution system consists of elements such as pipes, tanks (reservoirs), tubs, valves, etc [10]. Planning raw water distribution can be one solution to meet the needs of drinking water in Sumberrejo Village. The plan is to support the government's program in the RPJM of Lumajang Regency for 2019-2023, regarding expanding access to safe drinking water needs to 100% for urban and spicy areas in 2023. Another program launched by the Lumajang Regency Government is to increase the implementation of piped network SPAM to 60% of the population in 2023 [5]. The government program can certainly make it easier for people to access raw water for drinking and household needs.

The standardization used in this planning is regulated by the Minister of Public Works No. 18 of 2007 concerning the Implementation of the Development of Drinking Water Supply Systems [11]. This study has a planned life of 15 years in accordance with the requirements in the Minister of Public Works No. 18 of 2007, which ranges from 15 – 20 years. Calculation of population projections using 3 methods (arithmetic, geometric, exponential). This plan used the Epanet 2.2 program to assist in its hydraulic analysis. The output produced from the Epanet 2.2 program includes discharge flowing in pipes, and water pressure from points/nodes/junctions which are used as analysis in determining installation operations, pumps, and reservoirs.

ISSN (*Online*) 2620-7222
ISSN (*Print*) 2503-2399

2. Research Method

2.1 Literature Study

Literature studies are carried out to base existing theories in this study so that they are in accordance with existing guidelines. The literature study begins with a collection of books, written materials, and references relevant to the research. Research conducted by [12] used Epanet to model hydropower plants with the Darcy-Weisbach formulation to compute the head losses with the roughness. Research conducted by [13] conducted hydraulic simulations using Epanet 2.2 to calculate pressure and flow values, to determine pipe leaks that occurred in the research area. Another study conducted by [14] used population projections to find total water needs in the study area and used Epanet for hydraulic analysis of the clean water distribution network.

2.2 Data Collection

Data collection is carried out at related agencies as a basis for conducting research. The data used must be valid and not engineered, in addition, valid data must also be in accordance with the topic to be discussed in the research. The data was obtained from BPS Lumajang Regency in the form of population data, public facilities, water availability surveys, and others. Data collection was also carried out at the PUTR Office of Lumajang Regency and the Forestry Service of Lumajang Regency in the form of topographic map data of the research area, water source data, and water discharge data.

2.3 Data Analysis

This planning has the following calculation steps:

1. Calculate the projected population of the next 15 years using 3 methods (arithmetic, geometric, and exponential). The calculation is carried out by these 3 methods and then the smallest standard deviation is taken and used as a reference for calculation;
2. Calculate the discharge used with reference to domestic and non-domestic demand data. Domestic needs are derived from population projections at the end of the planning year. Non-domestic needs are obtained from data on water needs for facilities and infrastructure. Calculate domestic and non-domestic needs, then obtain the value of water needs used;
3. Planning the dimensions of the reservoir based on calculated water demand data;
4. Plan the dimensions of the distribution pipe based on data on water needs that have been calculated and also the water discharge used.

Conclusions are obtained after data analysis based on data in the field and related agencies and also adjusted to the formulation of the problem presented, so as to produce conclusions that are relevant to the data obtained and problem formulation and are scientific.

3. Results and Discussions

3.1 Availability of Raw Water

Water sources are one of the components of the supply system for raw water [15]. The availability of raw water in Sumberrejo Village has 17 springs and several rivers. The use of rivers which are surface water in this planning is not suitable because it is vulnerable to water pollution. According to the Ministry of Environment and Forestry of Indonesia, of 619 monitoring stations across the country, 56% of them were classified as being heavily polluted [16]. The use of rivers for raw water requires complex water treatment, while planning is only on a village scale. The use of spring water is considered most suitable for this planning because the processing is in the community itself.

The springs in Sumberrejo Village obtained from data from the Lumajang Regency Forestry Service do not have water discharge data so it is necessary to calculate the discharge independently, besides that the water sources in Sumberrejo Village have a relatively lower

ISSN (*Online*) 2620-7222
ISSN (*Print*) 2503-2399

elevation. The lower elevation of the planning area makes distribution planning unable to use the gravity method and the increase in height to the reservoir will be too large if forced. The chosen water source is the Gedang Sutro water source located in Sumberwuluh Village and has a higher elevation. The spring has a large water discharge of 269 l / s based on the Lumajang Regency Forestry Service. The selection of the spring is based on having a large water discharge, the location is close to the research area, and if later it will be used for several villages under it the discharge still meets.

3.2 Calculation of Population Projections

Population projections are carried out for 15 years above 2023, which means projections will be carried out until 2038. The calculation of population projection uses 3 methods, namely arithmetic, geometric, and exponential methods. The calculation of population projections can be calculated after obtaining the population growth rate. The population growth rate is a number that shows the percentage of population growth in a certain period of time [17]. The results of population projections can be seen in **Tables 1 and 2** below.

Table 1. Population growth ratio of Sumberrejo Village

Number	Years	Village	
		Sumberrejo	R (%)
1	2014	6137	0.002
2	2015	6147	-0.005
3	2016	6114	-0.001
4	2017	6108	-0.081
5	2018	5612	-0.006
6	2019	5579	0.144
7	2020	6383	-0.014
8	2021	6293	-0.0153
9	2022	6197	0.011
10	2023	6264	
	Total (Σr)		0.0338
	R average		0.0038

Source: Research data (2023)

Table 2. Projected population growth results

Number	Years	Population Projections by Method		
		Arithmetic	Geometric	Exponential
1	2024	6287.499	6287.499	6287.543
2	2025	6310.998	6311.086	6311.175
3	2026	6334.497	6334.762	6334.895
4	2027	6357.996	6358.526	6358.705
5	2028	6381.495	6382.380	6382.604
6	2029	6404.994	6406.323	6406.593
7	2030	6428.493	6430.356	6430.672
8	2031	6451.992	6454.479	6454.841
9	2032	6475.491	6478.693	6479.102

ISSN (*Online*) 2620-7222
ISSN (*Print*) 2503-2399

Number	Years	Population Projections by Method		
		Arithmetic	Geometric	Exponential
10	2033	6498.990	6502.997	6503.453
11	2034	6522.489	6527.393	6527.897
12	2035	6545.988	6551.880	6552.432
13	2036	6569.487	6576.459	6577.059
14	2037	6592.986	6601.130	6601.778
15	2038	6616.485	6625.893	6626.591
Σ		96779.880	96829.854	96835.339
Xr		6451.992	6455.324	6455.689
SD		105.091	108.095	108.304

Source: Research data (2023)

The standard deviation obtained through 3 methods is: an arithmetic method of 105.091; a geometric method of 108.095; and an exponential method of 108,304. The smallest standard deviation calculation result is the arithmetic method, so it is used as a reference for population projections. These results are in accordance with the statement of the Minister of Public Works Number 18 of 2007, that is, the most appropriate method of calculating population projections is the method that provides the smallest standard deviation price.

3.3 Calculation of Raw Water Needs

The calculation of water demand discharge is based on the projected population in the last year of planning, in this case, the last year of planning, namely in 2038. The calculation of water needs uses parameters in the Directorate General of Copyright, Dep PU Year 2000 [18]. Such parameters are determined as follows.

1. The population of Sumberrejo Village in 2038 is 6616 people;
2. The target service level is 90%;
3. House connection (SR) used is 100 liters/person/day (small city category);
4. The water loss factor used ranges from 20% - 30% selected 20%;
5. Unit consumption for public hydrants is 30 l/o/h;
6. Non-domestic consumption is 30% of domestic consumption.

The calculation of domestic demand and total water demand can be seen in **Table 3 and 4** below.

Table 3. Calculation of domestic water demand (Qd)

Number	Village	Population in 2038	Service Level 90%	SR (l/dt)	Water Loss 20%	Public Hydrants	Qd Total (lt/dt)
1	Sumberrejo	6616	5954.837	6.892	1.792	2.068	10.752

Source: Research data (2023)

Table 4. Total water needs results

Number	Village	Qd (l/s)	Qnd (l/s)	Qtotal (l/s)	Water Needs Used (m^3/s)
1	Sumberrejo	10.752	3.226	13.977	0.01398

Source: Research data (2023)

ISSN (*Online*) 2620-7222
ISSN (*Print*) 2503-2399

Total water requirements need to be multiplied by the load factor to find the requirement at peak and maximum daily hours. There are 2 load factors, namely peak hour factor (FJP) and maximum daily factor (FHM). FJP has a load factor of 1.5 and FHM has a multiplier of 1.1. The result of this multiplication is obtained water requirements at a maximum daily factor of 0,01538 m^3/s and at peak hours of 0.02097 m^3/s. Water needs per day, per hour, and per second can be found in **Table 5** below.

Table 5. Total water requirement in seconds, hours, and days

Total	13.97732	l/s
	1207.641	m^3/day
	50.31837	m^3/hour

Source: Research data (2023)

Examples of calculating water needs per day, per hour, and per second in **Table 5** can be seen as follows.

1. The calculation of liter water needs per second is known because it has been calculated on the previous total water needs. The amount of water needed is as follows.
   Water needs l/s = 13,977 l/s;
2. The calculation of cubic meter water requirement per hour is the water requirement per second which is decomposed into cubic meters per hour.
   $$\text{Water needs } m^3/\text{hour} = \frac{\text{Q liter per second x 3600}}{1000} = \frac{13{,}977 \times 3600}{1000} = 50{,}318 \; m^3/\text{hour};$$
3. The calculation of cubic meter water needs per day is the water requirement per second which is decomposed into cubic meters per day.
   $$\text{Water needs } m^3/\text{day} = \frac{\text{Q liter per second x 3600 x 24}}{1000} = \frac{13{,}977 \times 3600 \times 24}{1000} = 1207{,}641 \; m^3/\text{day}.$$

3.4 Calculation of Reservoir Dimensions

Reservoirs or service tanks in a water distribution network, similar to points in rivers, are located and vary in size and undergo complex mixing mechanisms and several water quality variables [19]. The calculation of reservoir dimensions is carried out by knowing the volume obtained from multiplying the percentage of surplus and deficit calculations with daily water needs. The calculation of the percentage of reservoir volume can be seen in **Table 6** below.

Table 6. Calculation of the percentage of reservoir volume

Time Period	Number of hours	Hourly usage (%)	Usage amount (%)	Hourly supply (%)	Supply amount (%)	Surplus (%)	Deficit (%)
22 - 05	7	0.75	5.25	4.17	29.17	23.92	-
05 - 06	1	4.00	4	4.17	4.17	0.17	-
06 - 07	1	6.00	6	4.17	4.17	-	1.83
07 - 09	2	8.00	16	4.17	8.33	-	7.67
09 - 10	1	6.00	6	4.17	4.17	-	1.83
10 - 13	3	5.00	15	4.17	12.50	-	2.50

ISSN (*Online*) 2620-7222
ISSN (*Print*) 2503-2399

Time Period	Number of hours	Hourly usage (%)	Usage amount (%)	Hourly supply (%)	Supply amount (%)	Surplus (%)	Deficit (%)
13 - 17	4	6.00	24	4.17	16.67	-	7.33
17 - 18	1	10.00	10	4.17	4.17	-	5.83
18 - 20	2	4.50	9	4.17	8.33	-	0.67
20 - 21	1	3.00	3	4.17	4.17	1.17	-
21 - 22	1	1.75	1.75	4.17	4.17	2.42	-
	24		100		100	27.67	27.67

Source: Research data (2023)

The calculation of reservoir volume and reservoir dimensions can be seen as follows.

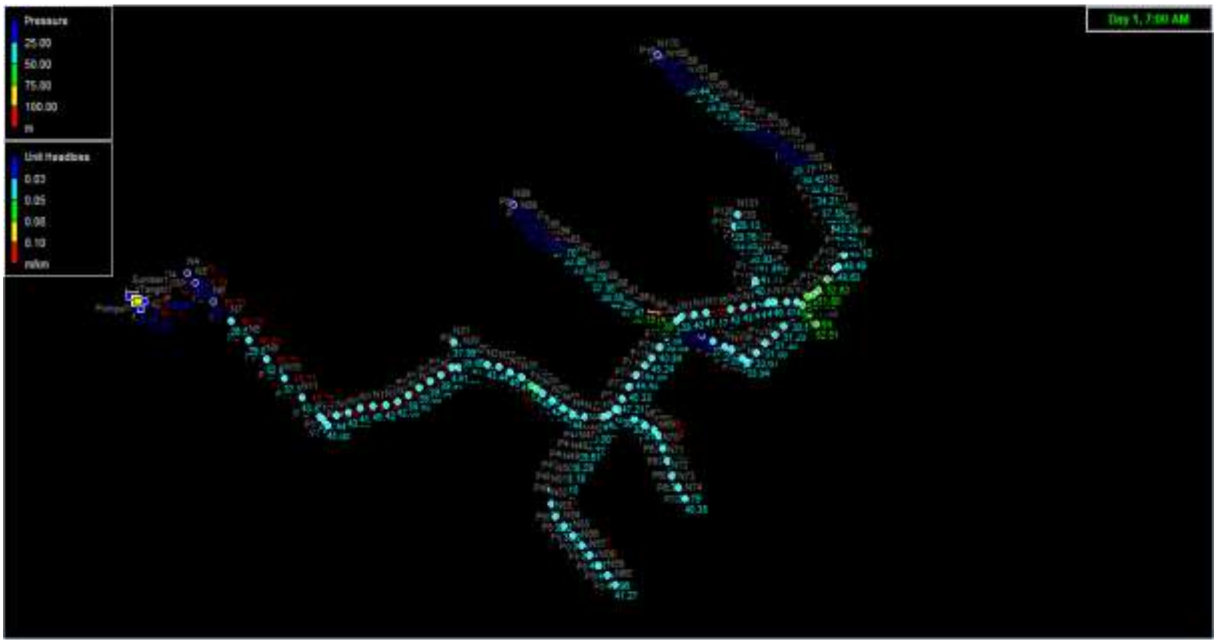
1. Calculation of the volume of the reservoir
   The calculation of reservoir volume uses water demand for 24 hours and the percentage of volume obtained in **Table 6**, is 27.67%. The calculation of the volume of such reservoirs is as follows.
   Reservoir volume $= Q_{day} \times 27{,}67\%$
   $= 1207{,}641 \times 27{,}67\%$
   $= 334{,}154\ m^3$
   The volume of the reservoir must be enlarged because additional services are possible. The volume is enlarged by one-third of the water requirement per day so that the volume of the reservoir is obtained as follows.
   Reservoir vol. enlarged $= \frac{Q\ perday}{3}$
   $= \frac{1207{,}641}{3}$
   $= 402{,}547\ m^3$
   The enlargement of the reservoir volume is based on the water needs in the service area, but because the service area is not yet known, the magnification carried out is not too significant. Reservoir optimization is important to achieve the most important performance of the reservoir system. It helps in arriving at decisions relating to storage over a certain period of time and discharge from the reservoir, taking into account variations in inflows and demand [20].
2. Calculation of reservoir dimensions
   Tube reservoir volume $= \pi \times r^2 \times t$
   Suppose the height of the reservoir is 4 meters, then the calculation is as follows.
   $402{,}547\ m^3 = 3{,}14 \times (r)^2 \times 4$
   $402{,}547\ m^3 = 12{,}56 \times r^2$
   $\frac{402{,}547}{12{,}56} = r^2$
   $\sqrt{32{,}0499} = r$
   $5{,}661 = r$
   $5{,}661 \times 2 = D$
   $11{,}322 = D$
   $D = 11{,}322 \approx 11{,}5\ m$
   The dimensions of the reservoir have not been added with the presence of dead capacity and high air space. The magnitude of the dead capacity is 0.2 m and the chamber height is 0.3 m; If added with this, the dimensions are as follows:.
   Tube reservoir dimensions $= 3{,}14 \times 5{,}75^2 \times (4 + 0{,}2 + 0{,}3)$
   $= 3{,}14 \times \times 5{,}75^2 \times 4{,}5$
   The final dimensions of the tube reservoir are 4,5 x 11,5 meter.

ISSN (*Online*) 2620-7222
ISSN (*Print*) 2503-2399

3.5 Hydraulic Analysis of Pipelines with the Epanet 2.2 Program

Hydraulic analysis of pipelines is carried out using the Epanet 2.2 program. Epanet is an open-source water network modeling tool and can be used to run simulations on pressurized water pipelines for a long and stable period [21]. Epanet can simulate hydraulic behavior and water behavior in a drinking water distribution network [22]. The Epanet program can track the flow of water in each pipe, the pressure in each node, the water level in each tank, and the concentration of chemical substances across the network over a simulation period consisting of several times [23]. The analysis is carried out by entering initial data, namely the initial layout of the plan, the elevation of each node, the water demand of each node, the elevation of each node, and the dimensions of the pipe which will later be tested and error during the analysis process in the Epanet 2.2 program.

3.5.1 Hydraulic Analysis of Piping Networks at the Highest Discharge



Source: Results of the analysis of the Epanet 2.2 program (2023)

Figure 1. The layout of pipelines at 07.00 Epanet 2.2 program analysis results

Figure 1 is a layout of a research piping network using the Epanet 2.2 program. The output of Epanet 2.2 is intended to predict pressure in the system, velocity, energy loss, pipeline flow rate, reservoir rate, inflow, outflow, and hydraulic level [24]. The requirements that must be met are a velocity of at least 0,3 - 0,6 m/s and a maximum of 3,0 – 4,5 m/s [11]; headloss is between 0 -15 m/km [25]; and the pressure is between 10 - 60 m. The results of the analysis obtained through the Epanet 2.2 program are as follows.

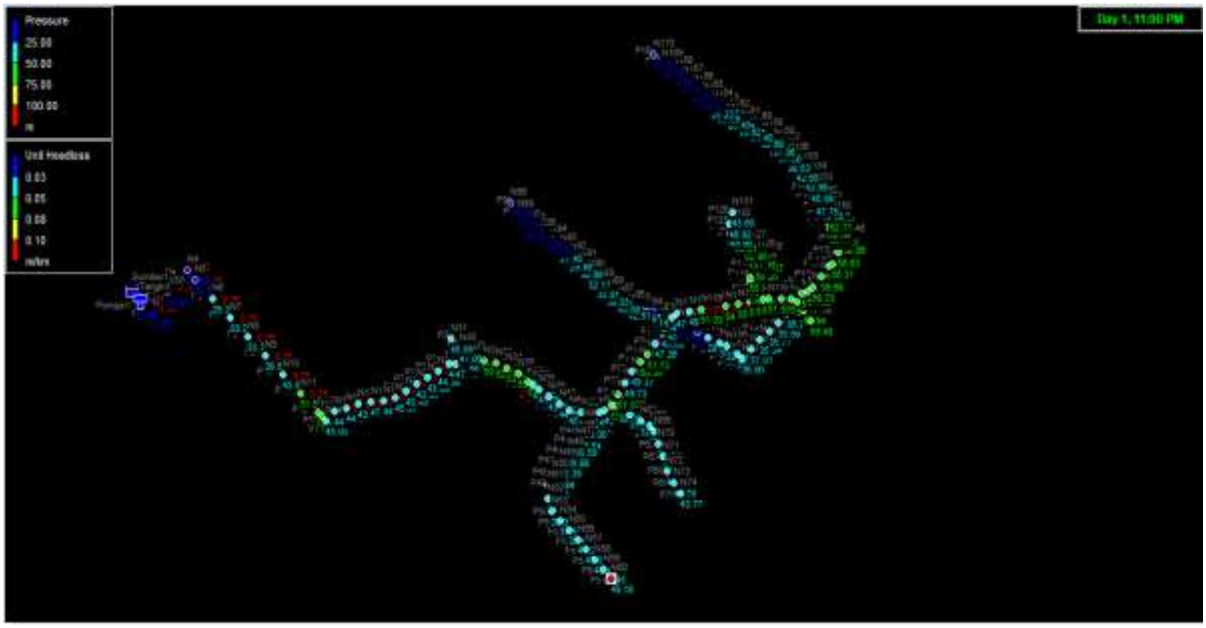
1. Results of velocity analysis
   lowest velocity = 0,32 m/s on pipe P126;
   highest velocity = 1,33 m/s on pipe P58.
2. Results of headloss analysis
   lowest headloss = 5,60 m/km on pipe P103;
   highest headloss = 17,46 m/km on pipe P121.
3. Results of pressure analysis
   lowest pressure = 16, 81 m on junction N99;
   highest pressure = 55, 11 m on junction N142.

Headloss does not meet the maximum requirement of 15 m/km. Excess headloss on pipe nodes that have high demand can harm the pipeline. Such a situation will result in large

ISSN (*Online*) 2620-7222
ISSN (*Print*) 2503-2399

pipe leaks and bursts in the distribution system [26]. Headloss does not qualify because if the dimensions are enlarged at hours other than peak hours, there may be a lack of speed in the pipeline flow. Lack of flow speed of pipes at the branching end is still possible since it does not affect the previous line. The excess headloss that occurs is not too large so it is still at a normal stage.

3.5.2 Hydraulic analysis of piping networks at the lowest discharge



Source: Results of the analysis of the Epanet 2.2 program (2023)

Figure 2. Layout of pipelines at 23.00 Epanet 2.2 program analysis results

Figure 2 is a layout of a research piping network using the Epanet 2.2 program. The output of Epanet 2.2 is intended to predict pressure in the system, velocity, energy loss, pipeline flow rate, reservoir rate, inflow, outflow, and hydraulic level [24]. The requirements that must be met are a velocity of at least 0,3 - 0,6 m/s and a maximum of 3,0 – 4,5 m/s [11]; headloss is between 0 -15 m/km [25]; and the pressure is between 10 - 60 m. The results of the analysis obtained through the Epanet 2.2 program are as follows.

1. Results of velocity analysis
   lowest velocity = 0,05 m/s on pipe P126, P57, and P30;
   highest velocity = 0,21 m/s on pipe P2 – P15.
2. Results of headloss analysis
   lowest headloss = 0,18 m/km on pipe P68;
   highest headloss = 0,59 m/km on pipe P121.
3. Results of pressure analysis
   lowest pressure = 13, 22 m on junction N170;
   highest pressure = 59,91 m on junction N36.

Velocity does not meet the minimum requirement of 0.3 – 0.6 m/s. Velocity does not meet the requirements because the water demand at that hour is very low, so there is a lack of speed in the flow of pipes. [27] obtained substandard velocity results with a range from 0.01 – 1 m/s. Unqualified velocity can actually be overcome by replacing a smaller pipe diameter, but such pipe turnover affects headloss. The change can enlarge the headloss so that it affects the value of the headloss at other hours. The lack of velocity occurs at 23.00 when the community is not active, therefore this planning can be carried out in the future. Complaints from the public

ISSN (*Online*) 2620-7222
ISSN (*Print*) 2503-2399

may occur due to lack of speed at hours with minimal water needs, this can be overcome by installing a suction pump at the hour where there is a lack of speed.

This raw water distribution network model uses HDPE pipes with a C of 140. The diameter of the pipe used is 184 mm (8 inches); 147.2 mm (6 inches); 130.8 mm (6 inches); 114.6 mm (5 inches); 102.2 mm (5 inches); 90 mm (4 inches); 73.6 (3 inches); 61.4 mm (2.5 inches); 51.4 (2 inches); 40.8 mm (1.5 inches); 32.6 mm (1.25 inches); 26.2 mm (1 inch); and 0.75 inches (20.4 mm). The diameter results were obtained from hydraulic simulations using Epanet 2.2.

4. Conclusion and Suggestion

4.1 Conclusion

The conclusions that can be given based on the research that has been done are as follows:

1. The availability of water in Sumberrejo Village is inadequate, so the water source used is in another area, namely Sumberwuluh Village which has a discharge of 269 l / second;
2. The water demand needed by the people of Sumberrejo Village in 2038 is 13,977 l / second under normal conditions; 15.375 l/s at maximum daily conditions; and 20.966 l/s at peak hour conditions;
3. The pipe used in the planning of this water distribution network is HDPE type with a diameter of 184 mm (8 inches); 147.2 mm (6 inches); 130.8 mm (6 inches); 114.6 mm (5 inches); 102.2 mm (5 inches); 90 mm (4 inches); 73.6 (3 inches); 61.4 mm (2.5 inches); 51.4 (2 inches); 40.8 mm (1.5 inches); 32.6 mm (1.25 inches); 26.2 mm (1 inch); and 0.75 inches (20.4 mm);
4. The dimensions of the reservoir used in this planning are tubular reservoirs with a diameter of 11.5 m and a height of 4.5 m.

4.2 Suggestion

Suggestions that can be given based on research that has been done are as follows:

1. The title of the study can be changed to clean water distribution if there is water quality testing at the water source used;
2. Further research can be done by examining the water quality of the water source used;
3. Water consumption patterns for 24 hours should take data from the PDAM of the area studied, because the consumption pattern of each region is different;
4. Lack of velocity occurs at some time, if there is a public complaint related to this, the installation of a suction pump is carried out at hours that experience velocity deficiency;
5. Reassessment should be carried out when the same water source is used to drain a sub-district. An assessment is carried out on whether the water source discharge meets when used for one sub-district. The dimensions of the reservoir must also be reviewed whether it needs enlargement or is sufficient with the dimensions that have been calculated in this study.

References

[1] United Nations Development Programme, "Sustainable Development Goals," *Accessed via Sustainable Development Goals | United Nations Development Programme (undp.org) on 6 August 2023*, 2023.

[2] S. Lu *et al.*, "Progress and prospect on monitoring and evaluation of United Nations SDG

ISSN (*Online*) 2620-7222
ISSN (*Print*) 2503-2399

6 (Clean Water and Sanitation) Target," *Bull. Chinese Acad. Sci. (Chinese Version)*, vol. 36, no. 8, hal. 904–913, 2021.

[3] V. Elysia, "Air dan Sanitasi: Dimana Posisi Indonesia.," in *Seminar Nasional Peran Matematika, Sains, dan Teknologi dalam Mencapai Tujuan Pembangunan Berkelanjutan/SDGs, FMIPA Universitas Terbuka*, 2018, hal. 157–179.

[4] Badan Pusat Statistik, "Persentase Rumah Tangga menurut Kabupaten/Kota, Sumber Air Minum Bersih dan Akses Air Minum Layak, 2022," *Accessed via https://jatim.bps.go.id/statictable/2023/06/13/2900/persentase-rumah-tangga-menurut-kabupaten-kota-sumber-air-minum-bersih-dan-akses-air-minum-layak-2022.html on 6 August 2023.*, 2022.

[5] Pemerintah Kabupaten Lumajang, *Peraturan Bupati Lumajang Nomor 54 Tahun 2019 tentang Kebijakan dan Strategi Daerah Sistem Penyediaan Air Minum Kabupaten Lumajang Tahun 2019-2023*. 2019.

[6] O. De Giglio *et al.*, "Enteric Viruses and Fecal Bacteria Indicators to Assess Groundwater Quality and Suitability for Irrigation," *Int. J. Environ. Res. Public Heal. 2017, Vol. 14, Page 558*, vol. 14, no. 6, hal. 558, Mei 2017, doi: 10.3390/IJERPH14060558.

[7] B. K. Achmad, E. A. Jayadipraja, dan S. Sunarsih, "Hubungan Sistem Pengelolaaan (Konstruksi) Air Limbah Tangki Septik dengan Kandungan Escherichia Coli terhadap Kualitas Air Sumur Gali," *J. Keperawatan dan Kesehat. Masy. Cendekia Utama*, vol. 9, no. 1, hal. 24–36, 2020, Diakses: 3 Maret 2022. [Daring]. Tersedia pada: http://jurnal.stikescendekiautamakudus.ac.id/index.php/stikes/article/view/512

[8] R. Afdillah dan D. A. D. Nusantara, "Evaluasi Jaringan Perpipaan Distribusi Air Bersih Dusun Jaten Desa Selotapak Kecamatan Trawas Kabupaten Mojokerto Menggunakan Epanet 2.0," *Rekayasa Tek. Sipil*, vol. 9, no. 1, 2022.

[9] J. A. Caballero dan M. A. S. S. Ravagnani, "Water Distribution Networks Optimization Considering Unknown Flow Directions and Pipe Diameters," *Comput. Chem. Eng.*, vol. 127, hal. 41–48, Agu 2019, doi: 10.1016/j.compchemeng.2019.05.017.

[10] K. Shital, M. Krunali, D. Mehta, dan V. Yadav, "Simulation of Existing Water Distribution Network by Using Epanet : A Case Study of Surat City," *Glob. Res. Dev. J. Eng.*, hal. 184–192, 2016.

[11] Departemen Pekerjaan Umum, *Peraturan Menteri Pekerjaan Umum Nomor 18/PRT/M/2007 tentang Penyelenggaraan Pengembangan Sistem Air Minum*. Jakarta: Direktorat Pengembangan Air Minum, Dirjen Cipta Karya, 2007.

[12] G. Dunca, D. M. Bucur, A. Aldea, A.-M. Georgescu, dan S.-C. Georgescu, "Epanet Modelling of a High Head Pumped-Storage," no. Figure 1, hal. 1–8, 2018, doi: 10.3390/proceedings2110608.

[13] A. Ponti, I. Giordani, A. Candelieri, dan F. Archetti, "Wasserstein-Enabled Leaks Localization in Water Distribution Networks," *Water*, vol. 16, no. 3, hal. 412, Jan 2024, doi: 10.3390/w16030412.

[14] R. Mayasari, A. B. Sabbah, dan I. Pratiwi, "Planning Of Clean Water Network In Hamlet Dempel Village Plosogaden District Candiroto Temanggung Regency," vol. 6, no. 1, hal. 97–112, 2021.

[15] I. K. A. Darmayasa, P. Aryastana, dan A. A. S. D. Rahadiani, "Analisis Kebutuhan Air Bersih Masyarakat Kecamatan Petang," *Padur. J. Tek. Sipil Univ. Warmadewa*, vol. 7,

ISSN (*Online*) 2620-7222
ISSN (*Print*) 2503-2399

no. 1, hal. 41–52, 2018.

[16] M. A. Pratama, Y. D. Immanuel, dan D. R. Marthanty, "A multivariate and spatiotemporal analysis of water quality in Code River, Indonesia," *Sci. World J.*, vol. 2020, 2020, doi: 10.1155/2020/8897029.

[17] R. Pancasasti dan E. Khaerunisa, "Analisis Dampak Laju Pertumbuhan Penduduk Terhadap Aspek Kependudukan Berwawasan Gender pada Urban Area di Kota Serang," *Tirtayasa Ekon.*, vol. 13, no. 1, hal. 130, Apr 2018, doi: 10.35448/jte.v13i1.4231.

[18] Departemen Pekerjaan Umum, *Kriteria Perencanaan Air Bersih*. Jakarta: Direktorat Pengembangan Air Minum, Dirjen Cipta Karya, 2000.

[19] M. S. Nyirenda dan T. T. Tanyimboh, "Appraisal of water quality indices for service reservoirs in water distribution networks," *Water Sci. Technol.*, vol. 81, no. 8, hal. 1606–1614, 2020, doi: 10.2166/wst.2020.215.

[20] R. Bhavya dan L. Elango, "Ant-Inspired Metaheuristic Algorithms for Combinatorial Optimization Problems in Water Resources Management," *Water (Switzerland)*, vol. 15, no. 9, 2023, doi: 10.3390/w15091712.

[21] J. K. Rakstang, "Modeling of Water Age in the Drinking Water Distribution System of Trondheim Kommune," Norwegian University of Science and Technology, 2020.

[22] B. Limbong, Suripin, dan S. Utomo, "Epanet Model Calibration of Clean Water Pipelines With Modified C Value Pipe Roughness Hazen-Williams Method," vol. 11, hal. 171–185, 2022, doi: 10.21009/jpensil.v11i1.25294.

[23] A. O. Ajibulu, "Robust Adaptive Model Predictive Control for Intelligent Drinking Water Distribution," University of Birmingham, 2018.

[24] J. C. Agunwamba, O. R. Ekwule, dan C. C. Nnaji, "Performance Evaluation of a Municipal Water Distribution System using WaterCAD and Epanet," hal. 459–467, 2018, doi: 10.2166/washdev.2018.262.

[25] E. Rohmaningsih, M. Sholichin, dan R. Haribowo, "Kajian Pengembangan Sistem Penyediaan Air Bersih Pada Daerah Rawan Air Di Desa Sumbersih Kecamatan Panggungrejo Kabupaten Blitar," *J. Tek. Pengair. J. Water Resour. Eng.*, vol. 8, no. 1, hal. 48–59, 2017.

[26] K. Eryürük, "Hydraulic Models for Calculating Head Loss in Water Distribution System : a case study in Konya Su Dağıtım Sisteminde Yük Kaybını Hesaplamak için Hidrolik Modeller : Konya ' da bir örnek çalışma," no. 28, hal. 275–279, 2021, doi: 10.31590/ejosat.996991.

[27] M. Maruf, R. A. L. Muzaddid, M. Abrar, dan A. Chowdhury, "Water Distribution System Modeling by Using Epanet Software Water Distribution System Modeling by Using Epanet Software," Islamic University of Technology, 2015.