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Analysis of Transmission and Distribution System of PDAM Tirta Perwitasari in Kutoarjo Region

Muhammad Asyraf Sidqi Anandityo*, Andito Dharma Atmaja**, Bimastyaji Surya Ramadan***
*Department of Environmental Engineering, Universitas Diponegoro, Semarang, Indonesia
Email: asyrafananditQyo@gmail.com
** Department of Environmental Engineering, Universitas Diponegoro, Semarang, Indonesia
Email: anditodharmatmaja@students,undip.ac.id
*** Department of Environmental Engineering, Universitas Diponegoro, Semarang, Indonesia
Email: bimastyaji@live.undip.ac.id

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Abstract:

Rapid urban development necessitates a reliable and robust drinking water supply, a vital service managed by Perumda Air Minum Tirta Perwitasari in Purworejo Regency. This Field Work Report aims to comprehensively analyze the existing drinking water transmission and distribution system, as well as the service provision, in the Kutoarjo operational area. The research employed a multi-method approach, integrating field observation, staff interviews, and literature study to gather operational and infrastructural data. Hydraulic modeling was performed using the EPANET 2.0 software to simulate network performance, with all results compared against the quality and pressure standards stipulated in the Minister of Public Works and Public Housing (PUPR) Regulation Number 27 of 2016. The analysis identified key areas requiring attention. The Kutoarjo service area currently achieves only a 42% coverage rate, indicating a need for significant expansion. Furthermore, the system is challenged by a high monthly Non-Revenue Water (NRW) rate, reported at approximately 30%. The hydraulic assessment confirmed that, generally, the water pressure and flow velocity across the network meet the required standards. Critically, however, several nodes within the distribution system recorded pressures dangerously close to the minimum legal limit. This highlights a specific vulnerability in system reliability. The report concludes with detailed recommendations focused on strategic infrastructure planning, pressure management optimization, and reducing water loss to enhance overall service efficiency and coverage.

Keywords — **Drinking Water, Transmission, Distribution, Tirta Perwitasari Drinking Water Company**

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I. INTRODUCTION

Potable water plays a pivotal role in human life. Clean water is defined as water that meets bacteriological, chemical, radioactive, and physical health requirement, enabling direct human consumption without posing a threat to their health. Adequate drinking water quality is crucial for maintaining public health, and the fundamental human right of every individual to access safe, high-quality, and sufficient clean water is of paramount importance [1].

Although various regulations and laws have guaranteed this right, unfortunately, the problem of access to clean water is still a problem in several areas, especially in rural areas. This phenomenon highlights the urgency of providing access to clean water for all levels of society. The use of a piping system is one of the main solutions to meet the need for clean water, because it allows the distribution of clean water in an efficient and effective manner to the community. Thus, the quality of drinking water remains guaranteed because it is free from the risk of contamination that may come from outside, such as soil pollution or environmental contamination [2].

Evaluation of raw water sources needs to be done in terms of quality and quantity. Over time, the quality of raw water tends to decline, so processing efforts are needed to improve its quality. Through the water treatment process, clean water quality standards can be met so that the water produced can be safely consumed by the community. Water treatment processes vary, from simple to complex, depending on the level of need for the desired water quality. The lower the quality of raw water, the more complex the treatment process required. In addition, in the raw water treatment process, an efficient transmission system is very important to ensure an adequate supply of raw water. Likewise, a good distribution system must be carefully considered to meet consumer water needs. Therefore, the water transportation and distribution system is a very important element in the provision of drinking water.

The Regional Drinking Water Company (PDAM) Tirta Perwitasari of Purworejo Regency is one of the companies that plays a role in serving and providing drinking water needs for the community in Purworejo Regency. This PDAM operates with the aim of providing safe, affordable, and reliable drinking water services to the community. Based on these things, it is the basic reason for the Implementation of Internship Work of Environmental Engineering Study Program Students of Diponegoro University at PDAM Tirta Perwitasari

II. RESEARCH METHOD

The internship activity was carried out at PDAM Tirta Perwitasari, Purworejo, located at Jl. Jenderal Sudirman No.101, Pangenjurutengah, Purworejo District, Purworejo Regency, Central Java Province 54114 which started on January 8, 2024 and ended on February 9, 2024. The implementation began with the preparation stage, the implementation stage, to the report preparation stage which can be seen in the following flow diagram:

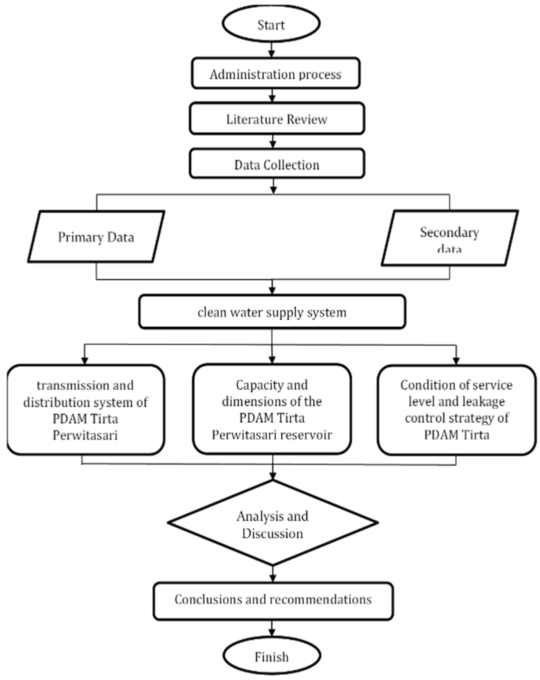

Fig 1. Work Practice Implementation Flowchart

III. RESULT AND DISCUSSION

A. Raw Water Unit Analysis

The Regional Public Water Company (PERUMDA) Tirta Perwitasari of Purworejo Regency conducts a comprehensive parameter analysis every three months and a partial parameter analysis once a month. The raw water quality in the Kutoarjo area, which has met the quality standard requirements according to the Regulation of the Minister of Health of the Republic of Indonesia Number 2 of 2023 concerning 1 Environmental Health Quality Standards and Water Health Requirements, can be seen in Table 1.

TABLE I
RAW WATER STANDARDS

no	parameter	unit	Test result				Quality Standard
			January	April	July	October	
A	Physics						
1	odor		odorless	odorless	odorless	odorless	odorless
2	color	TCU	0	10	0	0	10
3	Total Dissolved	mg/L	75	112	124	84	<300

	Solids (TDS)						
4	Turbidity	NTU	0,48	0,18	0,21	0,19	<3
5	Flavour		Tasteless	Tasteless	Tasteless	Tasteless	Tasteless
6	Temperature	°C	26	26	25	25	Air temperature ±3
B	Microbiology						
1	E Coli	Per 100 ml	0	0	0	0	0
2	Total Coliform	Per 100 ml	0	0	0	0	0
C	Residual Chlorine						
1	Residual Chlorine	mg/L	0,74	0,62	0,82	0,69	>0,2
D	Required Chemical Parameters						
1	Arsen	mg/L	0	0	0	0	0,01
2	Fluoride (F)	mg/L	<0,02	0,01	0,32	<0,02	1,5
3	Total Chromium	mg/L	0,009	0	0	0	0,01
4	Cadmium	mg/L	0	0	0	0	0,003
5	Nitrite (as NO2)	mg/L	0,019	0,002	0	0,003	3
6	Nitrate (as NO3)	mg/L	0	0	0	0	20
7	Cyanide (Cn)	mg/L	0	0	0	0	-
8	Selenium (Se)	mg/L	0,0013	0,0004	0,0014	0,0009	-
E	Chemical Parameters (Not directly related to health)						
1	pH	mg/L	7,7	7,9	7,8	8,4	6,5-8,5
2	Total Hardness	mg/L	55	95	120	37	-
3	Manganese (Mn)	mg/L	0	0	0	0	0,1
4	Aluminum (Al)	mg/L	0,01	0	0	0	0,2
5	Iron (Fe)	mg/L	0,006				
6	Chloride (Cl)	mg/L	27	33	42	45	250
7	Zinc (zn)	mg/L	0	0	0	0	3
8	Sulfate (SO4)	mg/L	0	1	1	0	250
9	Copper (Cu)	mg/L	0	0	0	0	2
10	Amonia (NH3)	Mg/L	0,05	0,005	0,2	0,001	1,5

From the results of the water examination, it can be concluded that the raw water quality for the Kutoarjo service area meets the established requirements. The quality standards used refer to the Regulation of the Minister of Health of the Republic of Indonesia Number 2 of 2023 concerning Environmental Health Quality Standards and Water Health Requirements. The measured physical, microbiological, and chemical parameters have met the quality requirements for drinking water. This proves that the raw water quality in the Kutoarjo area already complies with the quality standards, and thus, further water treatment is not required.

To meet the water needs of the service area, the Kutoarjo service area receives water supply from the Jali River spring with an average discharge of around 54.36 l/s. The water discharge is used to serve the Kutoarjo service area of 4,119 SR and fulfill the capacity of the Kutoarjo reservoir. PERUMDA Tirta Perwitasari Drinking Water Company of Purworejo Regency pumps water flow to customers continuously for 24 hours in accordance with the regulations enacted in PP Number 122 of 2015 concerning the Drinking Water Supply System

B. Transmission System Analysis

The transmission pipeline has a diameter of 150-250 mm. The distance between the raw water source and the reservoir is 240 meters. The types of pipes used are PVC and DCIP. The reasons for using pipes made from these two materials are as follows:

1. PVC Pipe (Polyvinyl Chloride)

   PVC pipes are flexible, and their typical length is 6 meters. PVC is anti-corrosive and resistant to chemical substances and is not easily flammable, making it suitable for household installations. The light construction of PVC pipes simplifies transportation and makes them more economical. They are often used as protection for electrical and telecommunication cables due to their property of electrical non-conductivity, meaning they do not conduct electrical current.

Their smooth surface does not impede water flow and can reduce the formation of sediment.

2. DCIP Pipe (Ductile Cast Iron Pipe)

DCIP pipes are a type of pipe capable of handling very high pressure. The advantages of this type include easy detection in case of leaks, and they are sufficiently strong and impervious to organic compound contamination. A drawback of this pipe type is its relatively high corrosion rate, necessitating internal and external protection, usually in the form of coating/painting, which incurs additional protection costs.

The technical design of transmission infrastructure necessitates the minimization of spatial separation between raw water intake structures and production facilities, and subsequently between production facilities and storage reservoirs/distribution networks, particularly for potable water distribution systems. This optimization is critical because distribution transmission lines must be dimensioned to accommodate peak hourly flow demands, whereas raw water conveyance pipelines are designed for maximum anticipated flow rates. In-line equipment within the transmission pipeline network typically includes check valves and gate valves.

C. Distribution System Analysis

• *Distribution System Path Analysis*

The water distributed in the service area is supplied from a reservoir utilizing a pumping system. The system employed in the Kutoarjo service area is a combination of branch and loop configurations. In the distribution process, valves are added at the branches to ensure that the flowing water is not entirely directed toward lower contours, but can also reach higher contours.

The distribution unit for the Kutoarjo service area already meets the standard, consisting of a distribution network, storage facilities (reservoirs), and master water meters. The condition of the equipment along the distribution pipeline is considered relatively good.

Rehabilitation efforts generally involve addressing issues such as non-flowing water, repairing/replacing damaged equipment, system rejuvenation, adding new pipeline routes, and addressing pipe leaks. Routine maintenance has not been implemented; maintenance is only performed on an as-needed basis (reactive maintenance).

The distribution pipeline utilizes four types of pipes, namely ACP (Asbestos Cement Pipe), PVC (Polyvinyl Chloride), HDPE (High-Density Polyethylene), and GIP (Galvanized Iron Pipe), with diameters ranging from 16 to 200 mm. The rationale for employing these four types of pipes is as follows:

1. ACP Pipe (Asbestos Cement Pipe)

ACP (Asbestos Cement Pipe) is made from a mixture of cement and asbestos. Its smallest diameter is 130 cm, and its compressive strength ranges from 3.5 kg/cm2 to 14 kg/cm2. It is unaffected by acids and salts and resistant to corrosive materials. However, it has weaknesses, including being prone to cracking and breaking during transport and being vulnerable to external loads.

2. PVC Pipe (Polyvinyl Chloride)

PVC pipes are flexible, and their typical length is 6 meters. PVC is anti-corrosive, resistant to chemical substances, and not easily flammable, making it suitable for household installations. The lightweight construction of PVC pipes simplifies transportation and makes them more economical. They are often used as protection for electrical and telecommunication cables due to their property of electrical non-conductivity, meaning they do not conduct electrical current. Their smooth surface does not impede water flow and can reduce the formation of sediment.

3. Polyethylene Pipe (HDPE)

Polyethylene pipes (HDPE) are resistant to pressures up to 20–50 atmospheres for this type of network. The advantages of polyethylene pipes are: a minimum service life of 40 years, with a maximum estimated service life of about 300 years; despite similar dimensions, the weight of HDPE pipes is 5 times less than that of steel pipes; no additional protective measures are required when laid underground, as the material is highly resistant to corrosion and chemical attack; low periodic maintenance is required; it offers high resistance to hydraulic hammer shock due to the low elasticity of HDPE; the smooth inner surface of the pipe prevents the deposition of sludge on the walls, meaning the internal diameter of the pipe does not change during pipe operation; and when the liquid inside the pipe freezes, the pipe will not burst, because the material has the capacity to expand by 5%–7%. (Vlase S, 2020)

4. Galvanized Pipe (GIP)

Galvanized Pipe (GIP) is a steel pipe covered with a protective zinc layer, with diameters ranging from 60 mm to 750 mm. This pipe type has a relatively short lifespan, lasting typically 7 to 10 years. Galvanized pipes are generally used when the network crosses railway lines.

• *Distribution Pipe Completeness Analysis*

The accessories for the distribution pipelines of the Regional Public Water Utility (PERUMDA Air Minum) of Purworejo Regency are mostly already inventoried, documented, and integrated into the PERUMDA's QGIS and AutoCAD network files. This integration allows the locations of pipeline accessories such as water meters (DMA), valves, and manometers to be easily identified.

Based on interviews and direct observation, the types of fittings/equipment found along the distribution line in the Kutoarjo service area include gate valves, air valves, reducers, flanges, pipe bridges, manometers, check valves, and various types of joints.

• *Reservoir Analysis*

The reservoir that holds water from the Jali River is a ground reservoir (or underground reservoir). The Kutoarjo Water Treatment Plant (IPA) has two reservoir units, with individual volumes of $250 \, \text{m}^3$ and $500 \, \text{m}^3$, respectively, constructed as block-shaped concrete structures. In relation to the network in the Kutoarjo service area, this reservoir functions to hold and store clean water to serve as a buffer for hourly consumption fluctuations. Its operational time is 24 hours.

The actual reservoir requirement can be calculated by first determining the percentage multiplying factor. This multiplying factor is found using the fluctuation in water usage from the water meter readings, which involves converting the fluctuation figure into a percentage (%).

To obtain the necessary pattern data, water consumption fluctuation data is required. This pattern is used for hydraulic analysis in the clean water network to determine whether there is an increase in residual pressure or the reverse. At the Tirta Perwitasari Regional Public Water Utility (PERUMDA Air Minum) of Purworejo Regency, hourly water consumption fluctuation data is not yet available, therefore, the consumption data is assumed.

Peak hour and maximum daily water consumption are closely related to time. Peak hour consumption is the largest amount of water utilized for domestic purposes during specific hours in one day, while maximum daily consumption is the largest amount of water utilized for domestic purposes on specific days in one week. Both peak hour and maximum daily consumption are crucial in determining the peak hour factor and the maximum daily factor.

In this specific calculation, the peak hour factor is determined using data provided by the Tirta Perwitasari Regional Public Water Utility of Purworejo Regency. From this data, the largest water usage in one day is found and then divided by the average hourly water usage. The results of the water consumption fluctuation analysis are presented in the table

TABLE 2
THE RESULTS OF THE WATER CONSUMPTION FLUCTUATION

No	Hour	Stand meter (L/s)	Standmeter (m3/jam)	%	Pattern
1	07.00	14	50,4	1,4	0,32
2	08.00	16	57,6	1,5	0,37
3	09.00	17	61,2	1,6	0,39
4	10.00	19	68,4	1,8	0,44
5	11.00	40	144	3,9	0,93
6	12.00	58	208,8	5,6	1,34
7	13.00	66	237,6	6,4	1,53
8	14.00	71	255,6	6,9	1,64
9	15.00	73	262,8	7,0	1,69
10	16.00	53	190,8	5,1	1,23
11	17.00	51	183,6	4,9	1,18
12	18.00	55	198	5,3	1,27
13	19.00	42	151,2	4,1	0,97
14	20.00	39	140,4	3,8	0,90
15	21.00	57	205,2	5,5	1,32
16	22.00	53	190,8	5,1	1,23
17	23.00	59	212,4	5,7	1,37
18	24.00	59	212,4	5,7	1,37
19	01.00	58	208,8	5,6	1,34
20	02.00	40	144	3,9	0,93
21	03.00	33	118,8	3,2	0,76
22	04.00	27	97,2	2,6	0,63
23	05.00	21	75,6	2,0	0,49
24	06.00	15	54	1,4	0,35

Total	1036	3729,6	100	24
Maximum	73	262,8	7,05	1,69
Minimum	14	50,4	1,35	0,32
Average	43,17	155,40	4,17	1,00

Maximum Discharge = 262,8 m^3/hour
Average Discharge = 155,40 m^3/hour
Peak Time Factor $= \frac{max\, water\ discharge}{avg\ water\ discharge}$
$= \frac{262{,}8\ m^3/hour}{155{,}4\ m^3/hour}$
= 1,691 m^3/hour

Works and Public Housing Number 4 of 2020 concerning the Standard Operating Procedure for the Implementation of Drinking Water Supply Systems, the design criterion for peak hour factor ranges from 1.15 to 3. Based on the calculation results, the Kutoarjo reservoir meets the Ministry of Public Works and Public Housing's design criterion, with a factor of 1.69.

The calculation of the maximum daily factor utilizes secondary data, specifically water usage data over a one-week period. The maximum daily factor is determined within that week. This calculation yields the value for the maximum daily factor. The daily water usage data can be found in the table.

TABLE 3
THE DAILY USAGE DATA

Date	Usage per One Day
12 Januari	3042,0
13 Januari	2937,6
14 Januari	2912,4
15 Januari	3128,4
16 Januari	3002,4
17 Januari	3016,8
18 Januari	2908,8
Total	20948,4
Average	2992,6
Maximum	3128,4

Maximum Discharge = 3128,4 m^3/hour
Average Discharge = 2992,6 m^3/hour
Peak Time Factor $= \frac{max\, water\ discharge}{avg\ water\ discharge}$
$= \frac{3128{,}4\ m^3/hour}{2992{,}6\ m^3/hour}$
= 1,05 m^3/hour

According to the Regulation of the Minister of Public Works Number 18 of 2007 concerning the Development of Drinking Water Supply Systems, the calculated maximum day factor is 1.05. It should be noted that this value falls below the regulatory minimum, as the standard criteria for the maximum day factor range from 1.1 to 1.5. The subsequent step involves determining the cumulative difference between water supply (inflow) and consumption (outflow). The percentage of withdrawal is derived based on a 24-hour operational duration. The detailed calculations regarding reservoir storage capacity are presented in the table.

TABLE 4
THE CALCULATION RESERVOIR STORAGE CAPACITY

Time	Peak Factor	Supply	Usage	Gap	accumulation
07.00	0,32	4,17	1,4	2,82	2,82
08.00	0,37	4,17	1,5	2,62	5,44
09.00	0,39	4,17	1,6	2,53	7,96
10.00	0,44	4,17	1,8	2,33	10,30
11.00	0,93	4,17	3,9	0,31	10,60
12.00	1,34	4,17	5,6	-1,43	9,17
13.00	1,53	4,17	6,4	-2,20	6,97
14.00	1,64	4,17	6,9	-2,69	4,28
15.00	1,69	4,17	7,0	-2,88	1,40
16.00	1,23	4,17	5,1	-0,95	0,45
17.00	1,18	4,17	4,9	-0,76	-0,31
18.00	1,27	4,17	5,3	-1,14	-1,45
19.00	0,97	4,17	4,1	0,11	-1,34
20.00	0,90	4,17	3,8	0,40	-0,93
21.00	1,32	4,17	5,5	-1,34	-2,27
22.00	1,23	4,17	5,1	-0,95	-3,22
23.00	1,37	4,17	5,7	-1,53	-4,75
24.00	1,37	4,17	5,7	-1,53	-6,27
01.00	1,34	4,17	5,6	-1,43	-7,71
02.00	0,93	4,17	3,9	0,31	-7,40
03.00	0,76	4,17	3,2	0,98	-6,42
04.00	0,63	4,17	2,6	1,56	-4,86
05.00	0,49	4,17	2,0	2,14	-2,72
06.00	0,35	4,17	1,4	2,72	0,00
Total		100			
Maximum Value					10,6
Minimum Value					-7,71

The calculation results revealed the maximum and minimum values. These figures were subsequently used to determine the actual reservoir capacity requirement.

1. Reservoir Capacity Requirement Multiplier

Maximum Accumulation = 10,60%
Minimum Accumulation = -7,71%
% Reservoir Requirement = (Maximum Accumulation-Minimum Accumulation)
% Reservoir Requirement = (10.60 - (-7.71)) %
% Reservoir Requirement = 18.31%

2. Average Water Requirement

The average flow requirement (Q average) is the total water needed, which is calculated by adding the raw water requirement and the estimated water loss.

Q average=water requirement+water loss
Water requirement = 45,46 l/s
Water loss = 20% × 45,46 l/s
Water loss = 9,09 l/s
Q average = 45,46 l/s + 9,09 l/s
Q average = 53,55 l/s

3. Maximum Daily Requirement (Qmax/day)

The Maximum Daily Requirement (Qmax/day) is determined by multiplying the Average Flow Requirement (Qaverage) by the Maximum Daily Factor (Fmax/day), which accounts for the fluctuations in water usage on the peak day.

Maximum daily factor (Fmax/day) =1,05
(Qaverage) = 53,55 l/s
Qmax/day = 1,05 × 53,55 l/s
Qmax/day =56,227 l/s = 4858,05 m3/day

4. Peak Hour Demand (Q_{ph})

Peak hour demand is defined as the peak hour factor (derived from the fluctuation analysis of water usage during peak hours) multiplied by the average demand.

Qpeak hour = peah hour factor × $Q_{average}$
= 1,69 × 53,55 l/s
= 90,49 l/s

5. Reservoir Capacity Requirements

The actual reservoir requirement is determined by multiplying the reservoir demand factor (derived from the reservoir demand analysis) by the maximum daily demand (Qmd), as the reservoir is supplied by the Jali River, Kutoarjo.

Volume = Reservoir Demand Percentage × Q_{md}
Volume = 2,7% × 4.858,05 m3/day
Volume = 134,56 m3 ≈ 135 m3

On-site, the reservoirs in use have capacities of 250 m³ and 500 m³. These figures exceed the calculated requirements; therefore, the existing reservoir capacity is sufficient to meet the current water demand.

D. Service System Analysis

A service unit is a water abstraction point comprising household connections, public hydrants, and/or fire hydrants. The Kutoarjo service area, managed by Perumda Air Minum Tirta Perwitasari Kabupaten Purworejo, currently serves 4,119 household connections and 14 hydrants. Each service unit is equipped with a water meter to accurately record water consumption for every customer.

calculation:
Total household connections = 4.119 SR
Total households = 4.119 KK
Total water demand = 103.415/4.119
= 25,1 m3/month/HC
= 0,84 m3/day/HC

Assuming 4 family members per household connection, then:

water consumption per person = 0,84 m3/day/HC/4 person
= 210 l/person/day

As of the end of 2023, the Kutoarjo area had a technical population of 38,864 individuals. In contrast, the Perumda Air Minum Tirta Perwitasari Kabupaten Purworejo Kutoarjo Branch serves 4,119 household connections.

total population = 38.864 person
Total HC = 4.119 HC
Percentage of service = (number of population served) / (total population) × 100%
= (4.199×4)/38.864×100%
= 42%

E. Water Loss Rate Analysis

In the transmission and distribution process of water at Perumda Air Minum Tirta Perwitasari Kabupaten Purworejo, particularly in the Kutoarjo area, water losses inevitably occur, leading to a reduction in the supplied flow rate. These losses can stem from both technical/physical and non-physical aspects.

Technical/physical causes of water loss include pipe network leaks, reservoir overflows, head loss due to pipe roughness, or damage to the transmission and distribution system. Meanwhile, non-physical aspects contributing to water loss encompass unauthorized consumption or illegal connections, inaccurate water meter readings, damaged water meters, and data handling errors.

Based on the analysis presented in the table above, Perumda Air Minum Tirta Perwitasari Kabupaten Purworejo, particularly in the Kutoarjo area, has experienced water losses exceeding 30% almost every month. However, continuous monthly evaluations have led to a consistent decrease in the monthly water loss percentage. In the Kutoarjo service area itself, the primary causes of water loss during the distribution process to customers are: customer water meters exceeding their technical lifespan (10 years), resulting in poor condition; illegal connections; and pipe leaks.

F. Hydraulic Analysis

Hydraulic analysis is used to ensure that water can flow smoothly in the drinking water transmission and distribution network. Hydraulic analysis can be calculated with the help of software, one of which is EPANET.

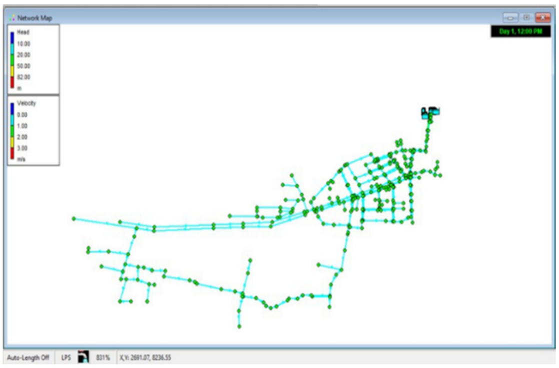

Fig 2. Distribution Transmission Pipeline Analysis at 12:00 p.m. EPANET 2.2

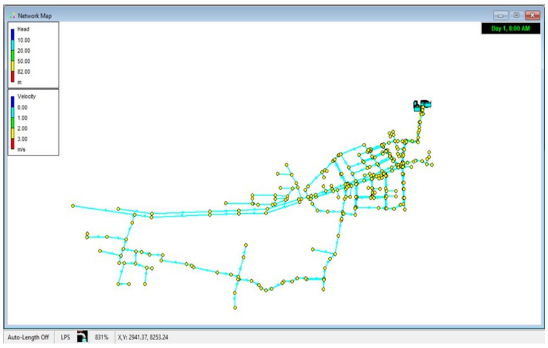

Fig 3. Distribution Transmission Pipeline Analysis at 08:00 EPANET 2.2

Link ID	Flow LPS	Velocity m/s	Unit Headloss m/km	Link ID	Flow LPS	Velocity m/s	Unit Headloss m/km
Pipe 2	76.27	2.43	32.52	Pipe 34	15.77	0.50	2.46
Pipe 3	76.27	2.43	32.52	Pipe 35	0.00	0.00	0.00
Pipe 4	76.27	2.43	32.52	Pipe 36	15.77	0.50	2.46
Pipe 5	76.27	2.43	32.52	Pipe 37	9.20	0.29	0.91
Pipe 6	76.27	2.43	32.52	Pipe 38	9.20	0.29	0.91
Pipe 7	76.27	2.43	32.52	Pipe 39	1.69	0.05	0.04
Pipe 8	76.27	2.43	32.52	Pipe 40	7.51	0.24	0.62
Pipe 10	76.47	2.43	32.68	Pipe 41	1.69	0.05	0.04
Pipe 11	76.47	2.43	32.68	Pipe 42	5.82	0.19	0.39
Pipe 16	76.47	2.43	32.68	Pipe 43	4.13	0.13	0.21
Pipe 21	51.55	2.92	63.92	Pipe 44	4.13	0.13	0.21
Pipe 22	51.55	1.64	15.74	Pipe 45	1.69	0.05	0.04
Pipe 23	51.55	1.64	15.74	Pipe 46	19.90	0.63	3.79
Pipe 24	49.86	2.82	84.23	Pipe 47	9.49	0.30	0.96
Pipe 25	48.17	1.53	19.46	Pipe 48	6.11	0.19	0.43
Pipe 26	46.48	1.48	18.21	Pipe 49	3.38	0.11	0.14
Pipe 27	46.48	1.48	18.21	Pipe 50	3.38	0.11	0.14
Pipe 28	45.63	1.45	17.61	Pipe 51	3.38	0.11	0.14
Pipe 29	45.63	1.45	17.61	Pipe 52	3.39	0.11	0.14
Pipe 30	29.86	0.95	8.03	Pipe 53	1.80	0.06	0.04
Pipe 31	15.77	0.50	2.46	Pipe 54	2.03	0.06	0.06
Pipe 32	15.77	0.50	2.46	Pipe 55	0.00	0.00	0.00
Pipe 33	15.77	0.50	2.46	Pipe 56	2.03	0.06	0.06

Auto-Length Off | LPS | 19284% | X,Y: 4310.97, 7943.42

Fig 4. Distribution Transmission Junction Analysis at 12:00 p.m. EPANET 2.2

An EPANET 2.2 analysis was conducted to verify water flow in the transmission and distribution pipelines. Based on the EPANET results, parameters such as velocity (0.3-3 m/s) and pressure (1-8 atm or 10-82 meters) were analyzed within the Kutoarjo branch area.

Node ID	Head m	Pressure m	Node ID	Head m	Pressure m
Junc 3	20.28	2.28	Junc 38	76.42	56.42
Junc 4	19.83	1.83	Junc 39	76.27	56.27
Junc 5	20.02	2.02	Junc 40	76.25	56.25
Junc 6	19.57	1.57	Junc 41	76.23	56.23
Junc 7	19.50	1.50	Junc 42	76.20	56.20
Junc 8	19.11	1.11	Junc 43	76.37	56.37
Junc 9	19.20	1.20	Junc 44	76.35	56.35
Junc 10	18.65	0.65	Junc 45	76.25	56.25
Junc 12	18.65	0.65	Junc 46	76.24	56.24
Junc 14	18.39	0.39	Junc 48	76.23	56.23
Junc 17	18.13	0.13	Junc 49	76.22	56.22
Junc 18	18.26	0.26	Junc 50	76.22	56.22
Junc 19	80.57	52.57	Junc 51	76.22	56.22
Junc 20	75.01	57.01	Junc 53	76.31	56.31
Junc 23	80.15	60.15	Junc 54	76.27	56.27
Junc 25	79.79	59.79	Junc 55	76.27	56.27
Junc 26	79.55	61.55	Junc 56	76.14	56.14
Junc 27	79.49	59.49	Junc 57	76.11	56.11
Junc 29	77.98	57.98	Junc 58	76.11	56.11
Junc 30	77.62	57.62	Junc 59	76.12	56.12
Junc 31	77.35	57.35	Junc 60	76.13	56.13
Junc 34	77.05	57.05	Junc 61	76.12	56.12
Junc 35	76.69	56.69	Junc 62	76.11	56.11

Auto-Length Off | LPS | 817% | X,Y: 4581.69, 8000.86

Fig 5. Distribution Transmission Junction Analysis at 08.00. EPANET 2.2

The majority of the pipeline network in Kutoarjo exhibits velocities ranging from 0.03-2.5 m/s and pressures between 18-38 meters, which meet the design criteria outlined in Permen PUPR No. 27 Year 2016. However, some pipeline sections show pressures approaching 82 meters. This is attributed to the installed pipes being too small and the pump head being excessively large, resulting in high pressure. Therefore, it's necessary to adjust the pipe diameter and pump head.

G. Maintenance and Rehabilitation Activity Analysis

SAs an effort to improve the quality of service and reduce the level of water loss, Perumda Air Minum Tirta Perwitasari Purworejo Regency carries out maintenance activities by rehabilitating the pipe network and its equipment, leaks, and metering

1. Rehabilitation of Pipes and Equipment

Rehabilitation of pipes and their equipment is the process of repairing pipes and their equipment in transmission and distribution units that have experienced a decline in function and require repair or replacement of spare parts. Pipe networks and their equipment that have experienced a decline in function due to age or other factors must be rehabilitated immediately because these conditions have a high potential for leakage.

2. Leak Monitoring

Leak monitoring is a process that is carried out routinely to detect leaks as early as possible. so that leaks can be minimized. Leak monitoring is carried out by monitoring the clean water supply network system that is prone to leaks. However, if the network occurs which is indicated by water seepage on the surface, Perumda Air Minum Tirta Periwtasari repairs the leak quickly. Leak detection can also be known by the formation of a District Meter Area which aims to divide the network into small hydraulic zones based on the region.

3. Metering

Leak monitoring is a process that is carried out routinely to detect leaks as early as possible. so that leaks can be minimized. Leak monitoring is carried out by monitoring the clean water supply network system that is prone to leaks. However, if the network occurs which is indicated by water seepage on the surface, Perumda Air Minum Tirta Periwtasari repairs the leak quickly. Leak detection can also be known by the formation of a District Meter Area which aims to divide the network into small hydraulic zones based on the region.

IV. CONCLUSIONS

The following conclusions summarize the findings from the analysis of Perumda Air Minum Tirta Perwitasari's drinking water transmission and distribution system in the Kutoarjo service area, specifically focusing on the condition of both systems as observed during the practical work:

1. Comprising primary, secondary, and tertiary sections, the distribution pipeline system delivers clean water from the reservoir directly to customers. This distributed clean water ensures that customer requirements for quantity, quality, and continuous supply are met around the clock (24 hours a day).
2. The quality of clean water distributed to the Kutoarjo service area meets the quality standards in accordance with PERMENKES No. 32 Year 2017. The service coverage percentage of Perumda Air Minum Tirta Perwitasari in the Kutoarjo service area reaches 42%, with a water demand of 210 liters/person/day and an average water loss rate of 30%.

The suggestion that can be given to PDAM Tirta Perwitasari in the Kutoarjo area through this Practical Work activity is that there needs to be a routine and scheduled maintenance system for transmission and distribution network equipment to anticipate things that can disrupt the production and distribution process and to adjust the diameter, type, and elevation of the pump head pipe until it is appropriate

ACKNOWLEDGMENT

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